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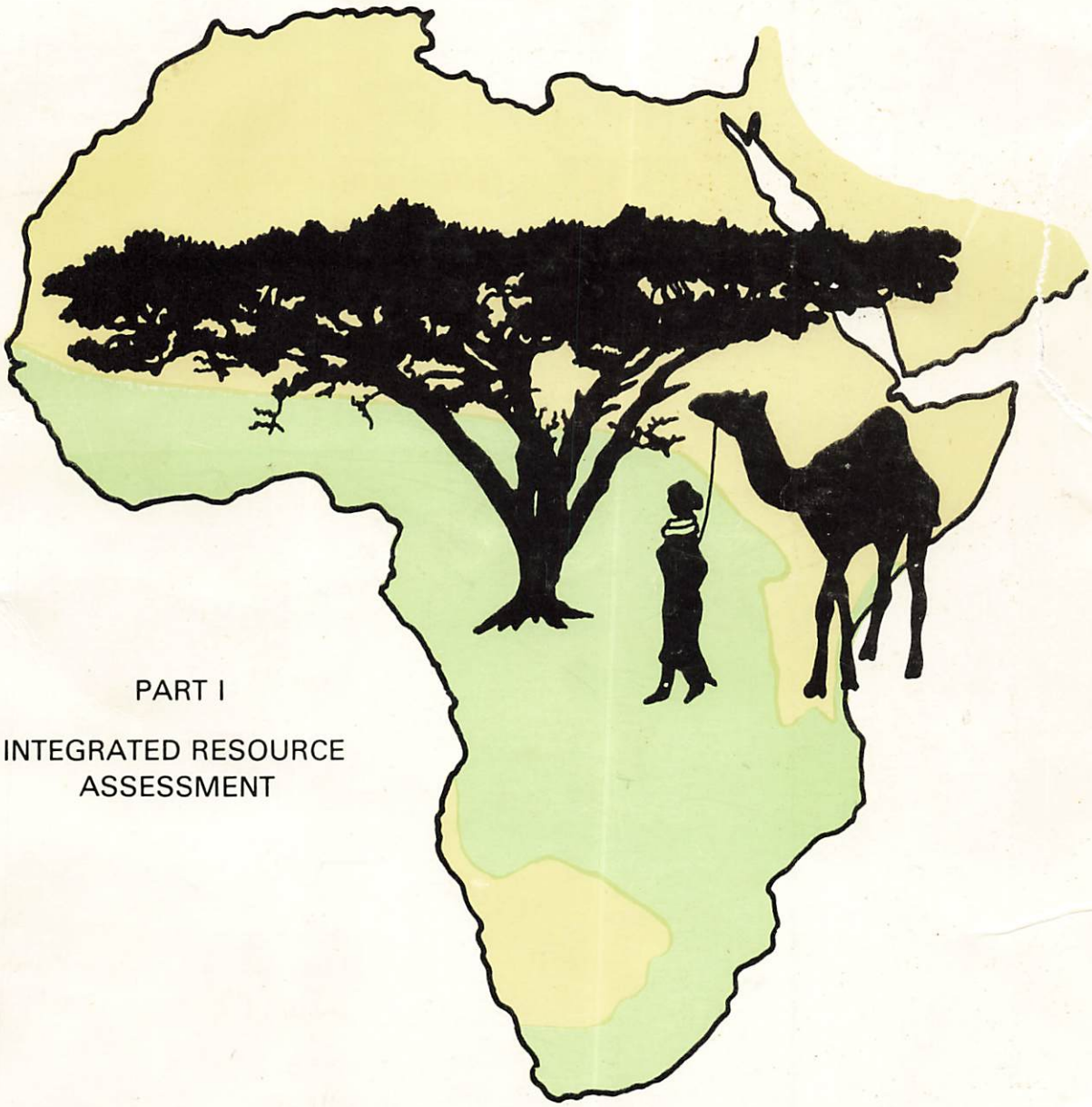

PART I

INTEGRATED RESOURCE ASSESSMENT

Integrated Resource Assessment and Management Plan for Western Marsabit District, Northern Kenya

IPAL Technical Report Number A-6

INTEGRATED RESOURCE ASSESSMENT AND MANAGEMENT PLAN FOR WESTERN DISTRICT, MARSABIT KENYA

PART I. INTEGRATED RESOURCE ASSESSMENT

PART II. MANAGEMENT PLAN

Edited by

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UNESCO-FRG-MAB Integrated Project in Arid Lands

SUMMARY INTRODUCTION TO IPAL AND THE TECHNICAL REPORT SERIES

The Integrated Project in Arid Lands (IPAL) was established by UNESCO with financial support from UNEP in 1976 with the aim of finding direct solutions to the most urgent environmental problems associated with desert encroachment and ecological degradation of arid lands. It forms part of the international UNESCO Programme, Man and the Biosphere (MAB) which has links not only with UNEP's Desertification Unit but also with FAO, in response to the Plan of Action adopted by the 1977 United Nations Conference on Desertification. It is an example of the type of pilot activity that UNESCO and UNEP, together with other organizations and a number of government, are trying to promote to provide the scientific basis for the rehabilitation and rational management of arid and semi-arid zone ecosystems, through integrated programmes of research (including survey, observation and experimentation), training and demonstration. Phase III of the project, 1980-1983, is supported by funds-in-trust to UNESCO provided by the Federal Republic of Germany.

During the first phases of IPAL, a co-ordination unit was established in Nairobi and the initial field word started in the arid zone of northern Kenya in a working area of 23,000 km^2 situated between Lake Turkana and Marsabit Mountain. The project now operates five field stations, at Mount Kulal, Olturot, Kargi, Korr and Ngurunit, with the project headquarters in Marsabit, which is the administrative centre of the District. Since its establishment the project has researched several aspects of experimental management of the region, concentrating upon the 'human ecology' of the nomadic pastoralists in dynamic interrelationship with the animals, plants and other resources of the drought-prone uncertain environment.

During the following three years (1980-1983), the investigations in progress have been extended and intensified to develop resource management plan or models for the area, taking into account the increasing human population, the trend towards sedentarization, the degradation of the primary productivity, and the increasing incidence of soil erosion all of which are factors resulting in the necessity for constant famine-relief measures in the region. Results obtained in the project are the subject of a number of training workshops and seminars in which Kenyan and regional scientists from the Sudano-Sahelian region participate.

This report is one of a series published by IPAL describing technical findings of the project and, where appropriate, giving management recommendations relating to the central problems of ecological degradation in the arid zone. The reports are divided into the following categories, distinguished by the base colours of their covers:

A general, introductory and historical: white

B climate and hydrology: blue

C geology, geomorphology and soils: brown

D vegetation: green

E livestock and other animal life: red

F social and anthropological: yellow

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PART I

INTEGRATED RESOURCE ASSESSMENT

INTRODUCTION

The UNESCO-MAB programme was created in a world climate of general awakening to all manner of environmental concerns, especially those related to the use of land-based resources. Those charged with the responsibility of managing natural resources were discovering that much of the research on these subjects had little practical value (Francesco di Castri, 1981). For example, the earth's arid zones attracted considerable scientific attention during the 1950s and 1960s, and a substantial amount of research was done there (UNESCO University of Arizona, Arid Lands Programme). Despite the availability of this information, the environmental problems were not solved. There was accelerated deterioration of the arid areas and billions of dollars of development capital, invested in various development projects, were wasted. A better scientific base for the long-term use of natural resources was needed, and concomitantly, new ways of making the efforts of scientists from different disciplines and from different countries available to the resource users from different sectors of society.

MAB was created as a result of these concerns, and charged with the main responsibility for encouraging research on environmental problems with direct and pragmatic application to improved land use and improved resource management. The training of specialists and the promotion of environmental education were recognized as essential adjuncts to the research effort. Both the natural and the social sciences are involved in this effort and the feasibility of integrating the different scientific disciplines is being tested through specified research projects.

The Integrated Project in Arid Lands (IPAL) is one such project. It was originally set up as a pilot operation to initiate investigations into the processes of environmental degradation in an arid and semi-arid region inhabited by pastoral nomads and to determine the causes of these processes. An important focus of the IPAL research has been the prediction of the ecological and socio-economic consequences for the pastoralists of continuing degradation. In the light of its findings, it was intended that IPAL should contribute to the design of management activities directed towards achieving a sustained balance between production and consumption, taking into account the requirements of the growing and increasingly settled population. It was also hoped where possible to demonstrate practical modifications and alternatives to the traditional livestock-based economy which could permit

rehabilitation of already degraded lands. Equally important in this regard was the use of project findings in education and training for the dissemination of information on rational management.

Since most of the changes and processes being investigated should be scientifically monitored over the long term, it was recognized that a project would be needed in Marsabit District mainly for this purpose, but also to undertake continued research and training relevant to resource management in the arid zone. The project was also expected to recommend, and assist in the development of, an institutional basis for the required management.

The management plan and guidelines presented here are in fulfilment of the second and last objectives of IPAL as outlined above. They are based upon six years of research, experiment, observation and survey on the resources of the arid land ecosystem of northern Kenya. Following its inception in 1976, IPAL has progressed considerably in extending the scope of its scientific competence and also the depth of its understanding of the ecological and, more particularly, the socio-economic causes of land degradation in northern Kenya. With the increasing support it has received in recent years and with the benefit of experience and advice, the project has been able to progress in steps towards its principal aim of promoting an integrated approach to resource management. Some components of the work programme, notably range assessment, human ecology, geomorphology and hydrology, were brought in as recently as a year ago and consequently conclusions based upon them are not as well supported as those based upon the longer term studies of livestock ecology. Nevertheless, despite the time constraints which have affected some parts of the IPAL programme, it is clear that the background of knowledge gained by IPAL on the ecology and economy of western Marsabit District provides an information base for development which is unusually comprehensive and coordinated when seen in the context of a developing region in Africa. It goes without saying that effective management in the future will depend upon reliable monitoring of the continuously changing ecology and economy of the region and the repeated up-dating of the management measures to keep pace with them.

The management plan is the result of a group effort by all the IPAL scientists, who made their contributions in a three-week drafting session at Marsabit, which included meetings and various deliberations. Not withstanding the fact that the people have all along been involved in IPAL investigations, after the

first draft of the plan was completed, considerable time was spent discussing its contents with the Rendille people, Government officials and leaders in Marsabit District. Their views and feelings have been incorporated in this revision of the plan. The present plan covers only the home range of the Rendille people, which constitutes the greater part of the IPAL study area. In this area the project has assembled the most complete data from its investigations. It is hoped to cover the rest of the study area later, in a regional programme which will include the other tribes.

This resource management plan is divided into two distinct parts, contained in two volumes. Volume I contains part one and Volume II the other part. The first part consists of detailed descriptions and assessment of the information about the area which is relevant to the management of its resources. This information is based on the results of the investigations and surveys of the IPAL project to date. The investigations have yielded over fifty published and unpublished papers. This part therefore contains a synthesis of those parts of this information which were thought to be most relevant to this document. Detailed descriptions of the specific methodologies were judged to be outside the scope of this plan. These descriptions are given in the various relevant publications on the project which are readily available and may be consulted when needed; only a brief mention of the methods is contained in this section.

The second part of the plan contains a clear but brief statement of the management policy that has been adopted in the plan, based on the principles laid down by the Government of Kenya for the development of its rangelands and an evaluation of people's needs followed by specific management objectives of the various resources for achieving the laid-down policy, and lastly the management proposals required to meet these objectives. Each section in this part therefore contains, first, a mention of the specific objectives for the management of that resource, then the constraints which have had to be taken into account in making the proposals, and thirdly the proposals themselves. This part of the plan was perhaps the most difficult to put together, as issues which seem obvious and straightforward in range management planning elsewhere have become unexpectedly complex in the light of the human constraints imposed upon us by the traditional pastoral economy of the Rendille people.

For example, decisions on suggested movement patterns of livestock demand the consideration not only of the normal logical and optimal use of the range resource but also of tribal ceremonies when livestock have to be at certain centres on particular days. Likewise, decisions on which animals would best utilize a certain type of vegetation are influenced by the fact that tribal culture requires dual-species herding. It would be almost impossible to achieve a separation of species, since the people use different livestock species for different purposes at the same time.

This plan is not just a grazing plan, but rather a development plan for the people and their resources. For this reason the plan has had to make reference to alternative land uses like forestry, agriculture and mining. These are activities which are not normally associated with pastoralism but they exist in the area and will form an important alternative in the employment of its human resources. The treatment of these areas has not been as detailed as the rest as these activities were not the subject of intensive IPAL research at this stage. The plan would, however, have been incomplete without their mention. Likewise the section on infrastructure makes reference to the nation as a whole. If we have to strengthen the pastoral economy, then the area will have to join the mainstream of the national economy.

Lastly, in reading this plan it must be borne in mind that it is a preliminary management plan in which the recommendations can be used as guidelines to resource use in the area. Like all management plans, to be most effective it will need to be revised periodically as more technical knowledge is acquired, as more experience is gained in the management of the resources of the area, as economic and environmental trends change, and as the local attitudes of the Rendille towards their own future are modified. The successful implementation of this management plan will depend a great deal on the flexibility of the implementors in adapting themselves to ever-changing circumstances and, above all, on the extent of involvement of the Rendille people themselves.

II

BACKGROUND

The deterioration of arid land resources has certain common characteristics wherever it occurs in the world. There is loss of vegetation cover followed by soil degradation through various forms of erosion and compaction. These in turn lead to greatly reduced productivity in the ecosystems concerned. In the case of grazing systems, there is decreased forage for livestock and a consequent reduction in animal products for the subsistence of the human population. Although this resource degradation and its consequences can be attributed simply to the combined effects of climatic change and human impact, it is important to recognize that there are variations in the nature of the human influence from one region to another (as well as environmental differences) which make each local situation unique. Northern Kenya is no exception to this rule.

Three-quarters of Kenya's land surface is arid or semi-arid, and across this region several recent socio-economic factors, contributing to resource degradation, have been identified. Through the siting and realignment of political and administrative boundaries, the development of forest reserves and national parks, and the establishment of commercial ranches, and through the influence of missions and several other modern institutions, there has been restriction of the movement of nomadic peoples and a reduction in the area they formerly occupied.

Traditional antagonisms between tribes had caused the compression of some tribal groups into a fraction of their former ranges until further encroachment was prevented some forty years ago. The antagonisms are still present and the lack of security against intertribal livestock raiding and banditry is a further cause of restriction on the movement of people and the occupation of grazing lands. A large proportion of the present Rendille territory is not used owing to fear of tribal raiding, and the resulting additional pressure upon the more secure areas aggravates their over-exploitation.

Another distinctive feature of the problem of deterioration of the arid lands of northern Kenya is the special nature of the pastoral economy. Although the people inhabiting northern Kenya have many similarities to pastoralists living in the Sahelian zone, in Kenya, arid-zone agriculture has never been

practised and thus there is little of the close interaction and interdependence between agriculturalists and pastoralists which is an important feature of the Sahel.

The problem of accelerated human population growth in arid areas is perhaps not unique to Kenya but it is certainly one of the key factors in the deterioration of the arid-land resources in the north of this country. Kenya's arid land human population has doubled in the last twenty-five years, and will, if present trends continue, double again in the next ten years. The human population pressure is further aggravated by pressure from Kenya's high-potential areas where population has exceeded the carrying capacity of the area and there is movement to the marginal lands. With the alarming increase in the human population has come a corresponding increase in the numbers of domestic livestock.

A prominent factor in the deterioration of the arid lands of northern Kenya through overstocking is the drive to satisfy normal ambitions for wealth (over and above subsistence needs), combined with a certain helplessness or fatalism about the consequences. In earlier times, when human requirements demanded only a moderate and transitory exploitation of grazing land, it was possible for minor and localized damage to heal. More recently the pressing, and at times desperate, needs of an over-grown and frequently hungry human population have imposed intolerable pressures upon the arid lands. With their delicate balances and fluctuations, these lands are experiencing, firstly, the erosion of their productive levels, and then the disintegration of their ecological structures.

As a result of the rising human populations there are increased demands upon the woody vegetation. In addition to the usual wood requirements for building and for fuel, the pastoral people in northern Kenya use large quantities in constructing night enclosures (*bomas*) to keep their animals together at night and to prevent depredations by carnivores. These *bomas* are built at both permanent and temporary camps. In the latter situation they may be occupied for as short a time as a week before the livestock are moved to a new area and a new *boma* is constructed. In the semi-permanent settlements, an accumulation of ticks and other parasites usually necessitates the periodical burning of the *boma* and movement to a site that may be as little as one hundred metres away. It is this practice that appears to have the greatest impact upon the woodlands of northern Kenya and is one of the most serious causes of the resource deterioration in the region.

In addition to the changing constraints upon pastoralism noted earlier (e.g. reduced home ranges), another important trend of far-reaching consequences for land use is that of the increasing sedentarization of formerly nomadic people. Centres of human and livestock concentration have arisen, and recently have tended to expand rapidly, around a few springs and wells and especially around the boreholes which have been installed. While the presence of fresh water is the most important factor in such concentrations, several other incentives contribute to their expansion. Many of them have become the sites of shops, schools, medical centres and famine-relief centres. However, of the greatest significance is the fact that these centres offer security from intertribal livestock raiding. Each of the concentration areas becomes a nucleus of denuded land which spreads in widening circles as the people are obliged to go farther for grazing and for the wood they need for fuel and to make fences for their livestock night exclosures. This accelerates the rate of localized degradation of the vegetation cover.

As in many other arid regions of the world, the northern part of Kenya suffers from periodic droughts, which have occurred frequently in recent historical times. Formerly these droughts were not as serious in their consequences as they are today, since the populations in the arid regions were sparse. With the recent increases in population, droughts have become more serious, claiming the lives of large numbers of livestock and, where they shared the grazing lands, wildlife as well. After periods of drought the production systems do not recover fully. Some families lose the bulk of their herds, which may have been small in the first place, and many become destitute and reliant upon famine relief. The provision of famine-relief food has become a permanent feature of the economy in Marsabit District. During serious droughts, such as that which occurred in north-eastern Africa and the Sahel between 1968 and 1976, pastoralists become wholly dependent upon the few perennial water supplies, and the destructive effects upon the vegetation of the consequent concentrations of people and livestock are most marked.

Although it is a normal traditional practice to disperse from such concentration areas when the rains come, there is an increased tendency for part of the population, especially women, children and the older men, to remain behind, keeping with them the livestock they need for milk. The young men continue to take away into the surrounding country the unproductive animals (known as the *fora* herds), males, castrates and barren females, following largely traditional nomadic practices.

The problem of the deterioration of Kenya's arid north is therefore serious and complex. It concerns the plight of people who are using the only traditional means they have known to cope with a vast problem that has been caused to a great extent by modern influences. As yet, although the problem of desertification in northern Kenya is recognized by the Government and is expected to receive considerable attention in the course of development programmes in the coming years, a number of administrative and economic constraints have, until recently, militated against the institution of appropriate corrective measures. Among the most important of these constraints have been the lack of funds available for the development of "low potential" areas, the insufficiency of suitable educational facilities, the migration of educated people out of the more remote and inhospitable regions to the towns, the lack of attraction of such regions for high-calibre civil servants, and, above all, the lack of the information on human and other resources that is essential for the rational development of the region.

Since the lives of people are at stake, no efforts should be spared to develop the resources of the arid lands of northern Kenya for the well-being of its people. However, development must take the form most suited to the sociological, economic and ecological systems to which the region is best adapted. In northern Kenya, owing to the arid and variable climate and the present culture, the greater part of the land must remain rangeland, to be utilized through grazing. Effective utilization will depend upon maintaining considerable mobility in the livestock herds.

III

PHYSICAL ENVIRONMENT AND RESOURCES

A. LAND RESOURCES

1. Geographical Location and Area

This description refers to the whole of the IPAL study area (Maps 1 and 2), approximately 22,500 km^2 lying between $1^{o}50'$ and $3^{o}30'$ N and $36^{o}10'$ and $38^{o}00'$ E, which partly covers the home ranges of the Rendille, Gabra, Boran and Samburu pastoral tribes. The management area (Map 3), which covers the home range of the Rendille people, occupies approximately 11,500 km^2 of the central plains of the study area. It is bounded on the north by the Chalbi desert and by the Gabra people, on the east by Marsabit Mountain and the Boran people, on the south by the Ndoto Mountains and the Samburu people, and on the west by Nyiru, Oldonyo Mara and Kulal Mountains and the Samburu and Turkana peoples.

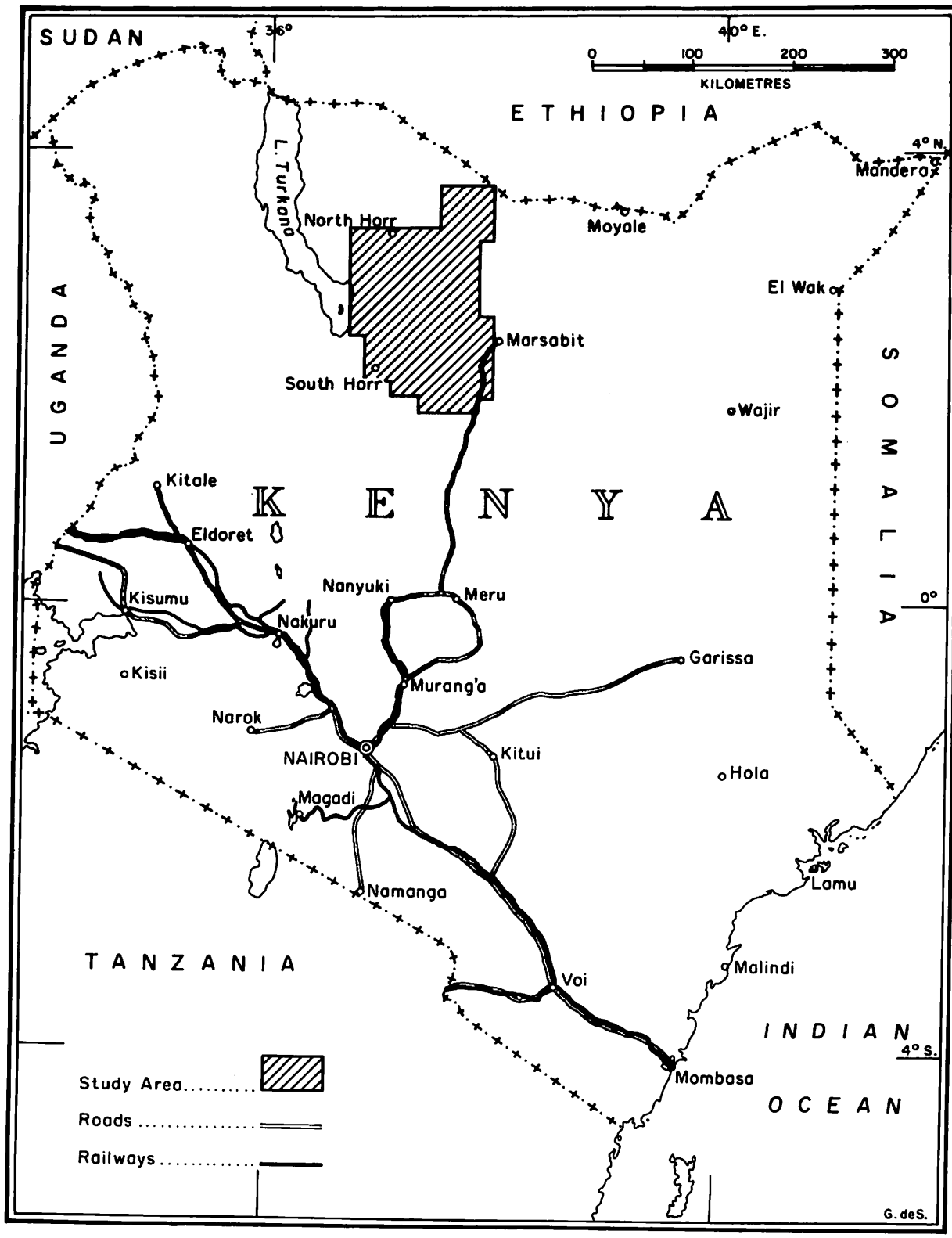
2. Major Landforms and Drainage

The present landforms are the result of geological processes, such as faulting, folding and volcanic activity, and of geomorphological processes such as erosion and deposition. Climate also influences the geomorphological processes. In arid climates the vegetation cover is small providing little protection against erosion, while soil formation through the weathering of rocks is slow under arid conditions. The slope characteristics of the landforms also exert an influence on erosion processes. For example, the footslopes of the Ndoto Mountains in the south-west, which have slopes up to 80%, show severe gully erosion. Soils are described below in relation to the landforms with which they are associated.

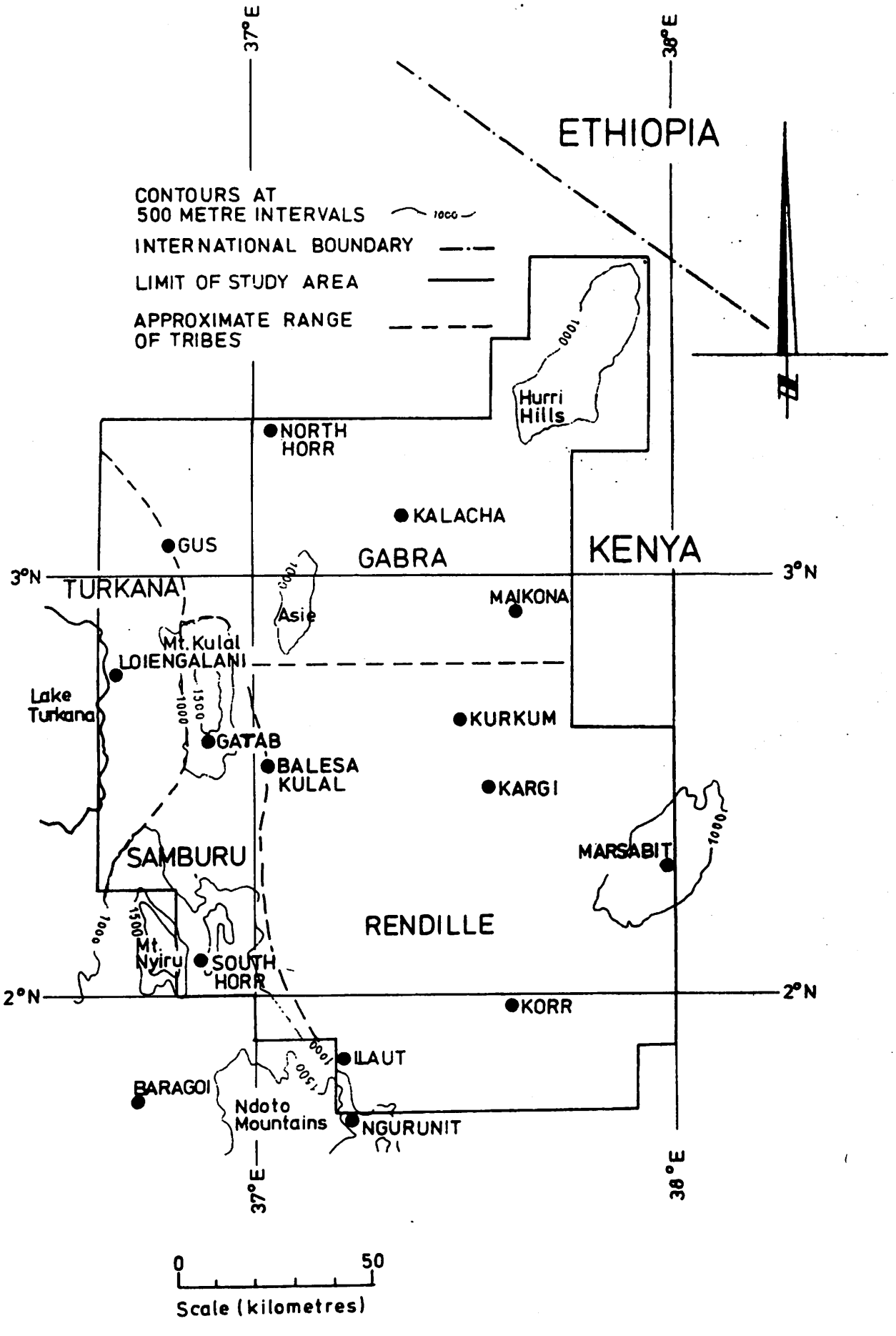
The landforms of the area are described here according to their location, altitude, relief characteristics and slopes. The relief intensity is defined as the difference in altitude over a square kilometre. Mountains and hills are defined according to their relief energy and the slopes.

The most important landmarks in the survey area are the mountains. The Ndoto Mountains in the south-west of the area rise to an altitude of about 2,500 m above sea level.

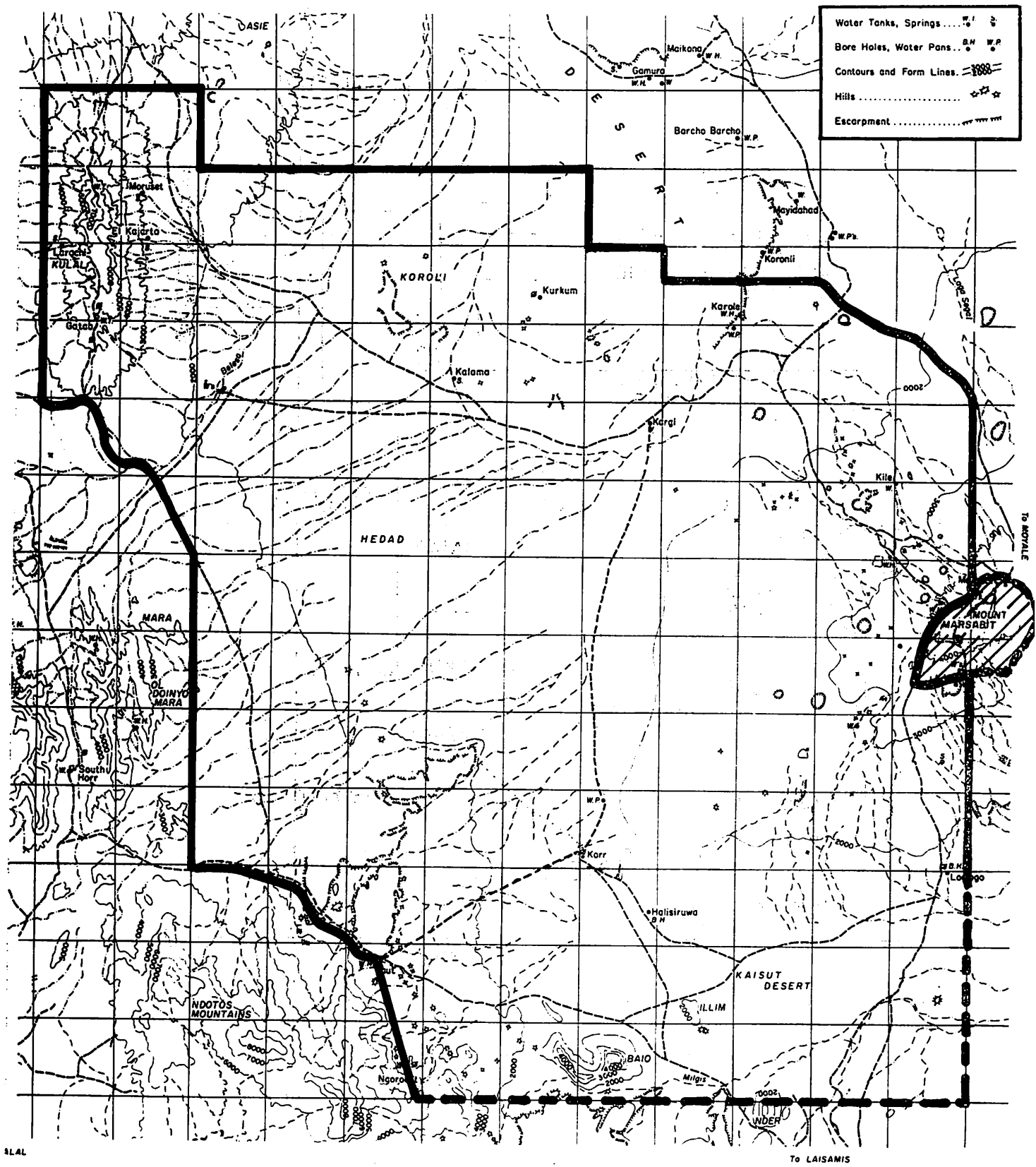
Map 1. Location of IPAL study area



Map 2. The IPAL study area



Map 3. Boundaries of the proposed Western Marsabit management area



NOTE: AREA SHOWN THUS ▨ NOT INCLUDED IN MANAGEMENT SCHEME

The two isolated mountains in the south, Bayo and Ilim, are also very conspicuous features. These mountains are all composed of Precambrian Basement System rocks. The two volcanic mountains, Kulal in the north-west and Marsabit in the east, rise to an altitude of 2,230 and 1,700 m respectively. Hills consisting of Precambrian rocks are found in the western and south-western part of the study area. Volcanic hills occur near Lake Turkana in the north-west and small volcanic hills are scattered on the slopes of the volcanic mountains and originate from adventive explosion craters.

Volcanic plateaus are very common in the area. In the southern Hedad desert a large flat plateau lies about 50 m above the surrounding plains at an altitude of around 650 m. Large areas occupied by plateaus occur on the slopes of Mt. Marsabit and west of Mt. Kulal. In the Koroli desert some dissected plateaus occur.

Footridges occur around Mt. Kulal, on the east side of Asie and to the south-east of Marsabit. At the foot of the various mountains, hills and plateaus, footslopes and a few piedmont plains can be recognized. Special features are the low-level uplands (or low hills) in the Korr and Elges area, which consists of ferromagnesium - rich gneisses.

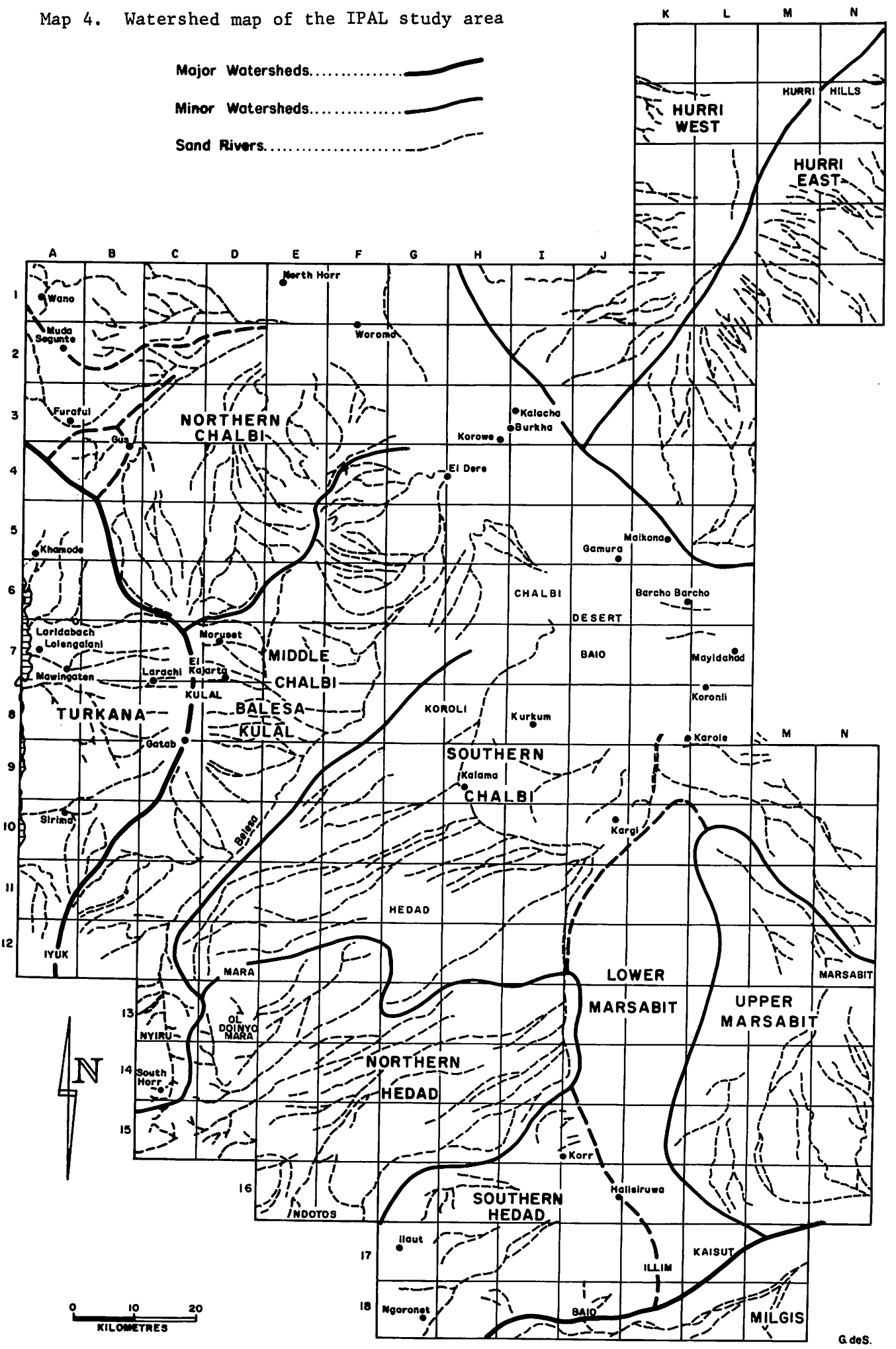
The Koroli, Hedad and Kaisut deserts in the central and southern part of the area form an extensive sedimentary plain at an altitude of around 600 m. This plain consists of sediments derived from Basement System rocks and in places also from volcanic rocks.

Many small and some bigger floodplains cross the sedimentary plain in a predominantly south-west to north-east direction.

The lowest part of the area, at around 400 m, is formed by a lacustrine closed basin in the north east, the Chalbi desert. At the edges of the Chalbi extensive areas with sand dunes occur.

The main drainage lines (Map 4) originate in the hill masses and are mostly in the form of seasonal rivers draining into the central plain, where their water evaporates and sinks. Water from most of the land in the study area drains into the old saline lake bed of the Chalbi desert in the north of the area.

Map 4. Watershed map of the IPAL study area



There are four major "desert plains" the Chalbi, the Koroli, the Hedad and the Kaisut, each distinct in its degree of soil salinity and vegetation.

3. The Geology

No comprehensive geological survey has been undertaken in northern Kenya, and only a brief sketch can be given here based on results obtained from our investigations in geomorphology, pedology and hydrology.

The oldest rocks in the study area belong to the Precambrian Basement. These rocks were uplifted during an early stage of the Tertiary in association with the formation of the eastern Rift System. The general direction is SE and NW. Further west this fault turns towards the north, following the general direction of the Rift System in the Lake Turkana area.

Probably at the same time as this uplift, the Mt. Kulal volcano became active and now forms the eastern border of the Rift. Eruptions of the volcano must have ceased by the end of the Tertiary or the beginning of the Quaternary; otherwise the dissection by deep gorges cannot be explained. The central crater now forms a big caldera dividing the elongated volcano into two summits.

The north-eastern extension of Mt. Kulal, the Asie range, is probably younger and belongs to another type of volcano with many more parasite craters. It lies on a fault line leading from Kulal over Asie towards the Hurri Hills, which form a third group of volcano mountains.

The fourth volcanic mountain is Mt. Marsabit, a stepped plateau volcano of Quaternary origin. These mountains and volcanoes surround the syncline of the Chalbi basin, which is filled continuously by sediments from the surrounding mountains. The floor of this basin, whose northern border is the Ethiopian dome, lies 200 - 250 m above sea level. The thickness of the sediments is sometimes more than 200 m and sedimentation is still continuing.

During the last part of the Tertiary and probably over periods in the Quaternary there were large fresh-water lakes in this basin. Deposits can be found near Kargi partly covered by the Marsabit lava and forming an escarpment (10 m deposits, 1 m lava). This lake is therefore older than Mt. Marsabit (extension of lake deposits on to the lava entrance).

These deposits have an importance for the groundwater supply, since they lead and filter the streams coming from Marsabit.

4. The Soils

4.1. Introduction

A soil map (Map 5), with accompanying legend, is given at the back of Volume II. The legend comprises 57 soil mapping units, and a brief description of every mapping unit is given. These descriptions reflect the characteristics of the sub-soil (usually the B horizon) above 100 cm depth. In areas where the texture of the topsoil differs significantly from the sub-soil, this has been indicated.

The terminology used in the legend and in the description of the soil mapping units closely corresponds to the outlines and definitions given in the FAO *Guidelines for Soil Profile Description* and the *Soil Survey Manual*. The colour indications are based on the Munsell Soil Charts.

The degree of salinity is mentioned in the descriptions, but only when the soil is more or less saline. In Table 1 the key to the salinity classes is given. The effects of salt depend not only on the concentration but also on the composition. Due to technical problems in the laboratories the salts present in the soils have not yet been determined.

Table 1. Key to salinity classes

ECe in mmho/cm	Name of class
0-4	non-saline
4-8	slightly saline
8-15	moderately saline
over 15	strongly saline

The sodicity is based on the exchangeable sodium percentage of the cation exchange capacity (CES determined with ammonium acetate at pH 8.2). The sodicity is subdivided into four classes and is only mentioned in the descriptions if the ESP is over 6. Table 2 shows the sodicity classes.

Table 2. Key to sodicity classes

ESP (%)	Name of class
0-6	non-sodic
6-10	slightly sodic
10-15	moderately sodic
over 15	strongly sodic

The degree of calcareousness is based on the severity of the reaction of the soil with HCl.

On the soil map the dominant slopes within a mapping unit are indicated by the code, written under the code of the mapping unit. Slopes class codes are not given for mountains and hills as their slopes are very irregular. A table for the slope classes code is given on the map.

4.2 Soil fertility

The classes given in Table 3 were used to define the soil fertility status with regard to the single elements P, K, Mg and Ca, determined with the help of a "mass analysis".

If present, P figures determined by the Olsen method were used instead of those from "mass analysis".

Table 3. Classes of fertility status with regard to the elements P, K, Ca and Mg

Class	P (Olsen)	Mass Analysis			
		Available P	Available K	Available Ca	Available Mg
	(ppm)	(ppm)	(me/100 g)	(me/100 g)	(me/100 g)
very low	0-5	0-20	0-0.3	0-2	0-1
low			0.3-0.1	2-6	1-3
moderate	5-10	20-80	1.0-2.0	6-10	3-6
high	10-20	80-200	2.0-3.5	10-20	6-12
very high	over 20	over 200	over 3.5	over 20	over 12

These classes, however, apply to the agricultural use of the land. So far, it has not been possible to find fertility ratings for extensive range management purposes. It is assumed that the fertility is only limiting when the availability of one element is very low or more than two elements are low.

In the major part of the survey area, which has an aridic soil moisture regime, the pH of the soil is between 7 and 8. The organic matter content is generally below 1%. The C/N quotient of the organic matter is 5 to 7 in the dry part of the area; in higher places with more rainfall it is around 10. The CEC of the soils was mostly above 15 me/100 g, for the coarse textured ones.

4.3 Soil physical aspects

From various soil profiles ring samples were taken to determine the water-holding capacity of the soil. Not all the results of the analyses are yet available, but it can be concluded already that for a soil with the texture of sandy clay loam (very common in the Hedad), the total available moisture is 10 to 15 volume percentage. For coarser gained soils, this value is lower and for finer textured soils it is higher. With the exception of very sandy soils and shallow soils, it can be stated that, in the plains, the water-holding capacity is high enough to store the rainfall and subsequently make it available for vegetation.

4.4 Land evaluation

The land evaluation aspects mentioned are limited to detailed indications of the limitations for extensive range management. These limitations will be incorporated into the report on range types, thus enabling us to reach proper scientifically based management guidelines. These limitations are based only on soil characteristics, drinking water availability, etc. Good management is assumed.

The limitations for grazing indicated in the chapter on Range Resources are often in conflict with actual observed practices. This is one reason why desert encroachment is a problem since pastoralists' choice of their grazing areas includes many factors other than the suitability of the land, such as the presence of trading centres, security, water, etc.

At this stage, 4 classes of limitations for grazing are given according to international classifications (FAO, 1977).

a. slight limitations
b. moderately strong limitations
c. strong limitations
d. not suitable or not to be used for grazing.

4.5 Parent material

The soils of the area are thus developed on various parent materials. Often there is a clear relationship between landform parent material and soils. The following parent materials are distinguished:

a. Undifferentiated basement system rocks (U)*

These rocks from the Precambrian are the oldest present in the survey area. They are mainly composed of gneisses (magmatitic) and granites, with local limestone bands. Although the rocks are mainly felsic, weatherable minerals are present, such as feldspars and micas. Although they are found only in a small area in the south-west of the survey area, they provided the bulk of the sediments present in the plains.

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* The code refers to the second capital in the codes of the soil mapping units as shown on the soil map.

b. Gneisses, rich in ferro-magnesian minerals (F)

These gneisses also belong to the Basement System, but are richer in weatherable minerals than the foregoing rocks listed under a. above. Some types are: hornblendes biotite, amphibolite, garnet and feldspars. These rocks occur in the Korr and Elges areas.

c. Quaternary sediments from Basement System rocks (U)

These sediments are unconsolidated and still contain weatherable minerals such as micas and feldspars. They occupy an extensive area. In the central and eastern parts of the sedimentary plains admixtures with volcanic ashes occur. The quantity of ash in the sediments is not yet known, but a mineralogical investigation is in preparation. Secondary minerals present are mainly palygorskite, illite, montmorillonite, vermiculite and kaolinite.

d. Volcanic rocks (V)

Of the Tertiary/Quaternary volcanic rocks, the basalts are the most obvious. However, pyroclastic materials like tuffs and volcanic ashes play an important role in the formation of the soils. Volcanic rocks occupy about 50% of the survey area.

e. Sediments derived from various volcanic rocks (V)

These sediments are derived from basalts and pyroclastic materials. Owing to the climatic conditions these sediments are not highly weathered. Secondary minerals formed are mainly montmorillonite and illite. These sediments are present only in restricted parts of the survey area at the foot of the volcanic mountains.

f. Sandstones (S)

The Quaternary sandstones are quartzitic in character, and some layers contain rounded quartz gravel. It is likely that these sandstones have been a major source for the dune sediments. The sandstones are only present in a small area in the north-east.

g. Undifferentiated unconsolidated sediments (A)

These young Quaternary sediments occupy the flood plains and are derived from Basement System rocks, although often with some admixture of volcanic sediments. In the volcanic regions the sediments are derived from volcanic rocks, but in some places they are mixed with other materials.

h. Unconsolidated sediments consisting of various parent materials (X)

These sediments are often a mixture derived from Basement System rocks, volcanic rocks and aeolian sediments. They occupy only small areas in the north-east.

4.6 Description of the soils and their evaluation

a. Soils of the mountains

(i) Soils of the residual mountains

The residual mountains consist of Basement System rocks and occur at the south-western limits of the survey area. In many places at the edge of the mountains, bare rock is exposed as a result of heavy use by pastoralists which has led to severe erosion. Besides the bare rock exposures two soil types occur (MUC)*:

- an excessively drained, shallow, stony loamy sand to sandy loam soil with a low available nutrient content (eutric lithosals, stony phase);
- a well drained, deep to very deep, very friable sandy clay loam soil with a low available nutrient content (ferralo-chromic luvisols).

Further to the west, deeper soils occur, lying, however, outside the survey area.

(ii) Soils of the volcanic mountains

The soils of the volcanic mountains are developed on various volcanic rocks. Basalts are the most obvious, but tuffs and volcanic ashes also play a role in soil formation. They occur on or near the tops of Mt. Kulal, Mt. Marsabit and Mt. Asie. Some of the flatter parts on Mt. Kulal (MV2p) have well drained, moderately deep to very deep, friable clay soils which are in places stony (eutric nitrosols and chromic luvisols, partly stony phase). These soils have favourable physical and chemical properties, but are low in available K and P. On the top of Mt. Kulal (MV4p) well drained, shallow, very rocky, very stony clay soils occur (eutric cambisols, stony and lithic phase and eutric lithosols, stony phase). On the flatter parts of the summit the soils may be deep.

On the top of Mt. Marsabit (MV1), well drained, deep to very deep, very friable clay soils occur which are in places very stony and in places have a stony surface (chromic cambisols and chromic luvisols, partly stony phase). The soils have favourable physical and chemical properties, though the available K is low.

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* The codes between brackets refer to the code used on the soil map.

Somewhat lower on Mt. Marsabit (MV2p), well drained, shallow to moderately deep, strongly calcareous, very stony clay loam soils with a very stony surface occur (eutric cambisols, stony and partly lithic phase). The physical and chemical properties of these soils are, in general, good. However, the stoniness and the steep and irregular slopes severely limit the accessibility of the area. The shallowness of the soils limits the production potential and imposes restrictions on the possible use of this area.

b. Soils of the hills and minor scarps

(i) Soils of the residual hills

The residual hills consist of Basement System rocks and occur in the western and south-western parts of the survey area (HUP). About 70% of the surface of the hills is bare. The rest is occupied by excessively drained, shallow, stony, loamy sand to sandy loam soils (eutric lithosols, stony phase).

(ii) Soils of the scarp and the volcanic hills

The scarp (HVP) occurs near Lake Turkana and forms a part of the East African Rift Valley system. Adjoining the scarp are volcanic hills (HVP). The soils, developed on volcanic rocks, are somewhat excessively drained, shallow to deep, strongly calcareous, very stony clay with an exceedingly bouldery surface. The soils are saline and sodic in places (haplic vermosols, boulder mantle and partly sodic and saline phase).

The steep slopes and the surface characteristics make this area almost inaccessible. The chemical properties and in places the shallowness have a negative influence on the vegetation production.

Small volcanic hills and adventive craters occur on the slopes of the various volcanic mountains (HPP). They consist mainly of pyroclastic materials and their soils are excessively drained, shallow and stony.

c. Soils of the plateaus

The parent material of all the plateaus consists of volcanic rocks, mainly basalts with pyroclastic materials, inclusive volcanic ashes.

(i) Soils of the stepped plateaus

The stepped plateaus occur on the Marsabit lava. Near the top of the mountain, south of Marsabit (LeV2), well drained, deep to very deep, very friable clay soils occur which are in places stony (chromic luvisols and chromic cambisols, partly stony phase).

These soils have favourable physical and chemical properties, but the available P is low. Owing to good structure and permeability, and also to a low slope angle, erodability is low.

North of Loglogo (LsV3p), well drained, moderately deep, friable to firm, slightly calcereous, very bouldery and very stony cracking clay soils occur (chromic vertisols, stony phase).

The physical and chemical properties of these soils are not favourable; available K and P are both low. Their productivity is therefore limited. The major part of the area is occupied by a complex of three soil units (LsVC):

- somewhat excessively drained to well drained, shallow to moderately deep, very friable, strongly calcereous, very sandy loam to sandy clay loam soils, with an exceedingly stony surface, in places lying over petrocalcic materials (calcaric regosols and haplic yermosols, stone mantle and partly lithic and/or petrocalcic phase);
- well drained, very deep, strongly calcareous bouldery or stony surface (haplic and luvic yermosols, boulder mantle, saline and sodic phase);
- basalt outcrops.

The soils are low in available K, low to high in available P, and high in available Ca and Mg. The organic C content is around 0.5%. The rockiness and the surface characteristics strongly limit accessibility, especially for people, camels and cows. In places shallowness, salinity and sodicity limit the production of perennial vegetation.

The plateaus are partly covered with unstable, wind-blown sands. In places the sand is concentrated in small, often unstable, dunes (LsXp) (calcaric regosols, bouldery phase).

(ii) Soils of the non-dissected plateaus

The non-dissected plateau south-east of Maikona (LnVI) has well drained, deep to very deep, very friable, strongly calcereous, strongly saline, strongly sodic, clay loam soils which are in places very stony. The soils have an exceedingly bouldery surface (haplic yermosols, boulder mantle, saline and sodic phase). Of the available nutrients, K and P are low; Ca and Mg are moderately high to high. The organic C content is very low (0.1-0.2%).

The exceedingly bouldery surface limits accessibility. The salinity, sodicity and limited fertility restrict vegetation growth. The lava plateau west of Ilaut has comparable soils which, however, are not saline and sodic (LnV2) (haplic yermosols, boulder mantle phase). These soils are well supplied with available nutrients.

However, the exceedingly bouldery surface strongly limits accessibility. The plateaus south-west and north-west of Mt. Kulal (LnV3p) have well drained, moderately deep to deep, friable, strongly calcareous, slightly to strongly saline, strongly sodic, clay loam to clay soils, with an exceedingly bouldery surface (orthic, solonetz, boulder mantle and saline phase and haplic yermosols, boulder mantle, saline and sodic phase).

d. Soils of the dissected plateaus

The soils of the dissected plateaus occur west of Kargi (LdVP) and are well drained, shallow, very stony clay loam soils with exceedingly stony surfaces. They are moderately calcereous in places (haplic yermosols, stone mantle and lithic phase). The soils are sufficiently supplied with available nutrients, though K is low. The organic C content is around 0.7%. The exceedingly stony surface strongly limits accessibility. The shallowness of the soils limits the growth of perennial vegetation.

e. Soils of the footridges

The soils of the footridges, developed on volcanic rocks, are mainly basalts and pyroclastic materials, including volcanic ashes. The footridges south-east of Mt. Marsabit (RVp) have well drained, moderately deep to very deep, friable, very stony soils (chromic luvisols, stony phase).

The sloping and dissected character of the area makes the soils highly erodable. The stoniness causes only slight problems. It can be concluded that these soils show only moderate limitations for grazing. The footridges around Mt. Kulal have, depending on their topographical position, an association of three soil types (RVA):

- on the upper slopes: well drained, shallow, very stony clay loam to loam soils with a stony to exceedingly stony surface. The soils are in places strongly calcareous (haplic and calcaric phaeozema, stony and lithic phase).
- on the middle to upper slopes: well drained, shallow to deep, very stony clay loam to clay soils, which are in places moderately to strongly calcareous (eutric cambisols, stony and partly lithic phase);

- on the lower slopes: well drained, shallow to moderately deep, strongly calcareous, very stony and/or very gravelly sandy loam to sandy clay loam soils, with a very stony and/or very gravelly surface. The soils are moderately well supplied with available nutrients. The organic C content ranges from 1 to 2%.

The sloping and dissected character of the area makes the soils highly susceptible to erosion. Their shallowness in the greater part of the area strongly limits the production of perennial vegetation.

The stony character of the surface limits accessibility. The soils on the footridges of the Asie mountains (RVC) vary in depth, texture and consistency. The surface is exceedingly stony.

f. Soils of the footslopes

(i) Soils of the footslopes developed on sediments derived from Basement System rocks

At the foot of the Hafarin hills (FU1), well drained, very deep, friable, slightly sodic, sandy loam to sandy clay loam soils occur, with topsoil of loamy sand (luvic yermosols, sodic phase). The soils have weakly developed, medium coarse, sub-angular blocky structure. They are low in available nutrients, except for P which is moderate to high. The organic C content is 0.1 to 0.2%, which is very low.

The only limitation for plant growth may be the low fertility. At the foot of the mountains and hills in the western and south-western part of the study area the soils form an association of coarse-textured and medium-textured types (FUA). The coarse-textured soils occur on the upper and middle slopes. These soils are somewhat excessively drained, moderately deep to very deep, very friable, loamy sand to sandy loam soils without structure (luvic and cambic arenosols). The soils are moderately well supplied with available nutrients, but available Mg is low. The organic C content is about 0.3%. The medium-textured soils occur on the lower slopes. They are well drained, very deep, friable, sandy loam to sandy loam soils without structure (luvic yermosols). When dry the consistency of the soils is hard, but they are friable when moist. Available Mg and K are low; available P and Ca are moderately high. The organic C content is 0.1 - 0.2%, which is very low.

The sloping character of the terrain, especially the upper slopes (2-8%), means they are erosive. The limited fertility may effect plant growth as well.

(ii) Footslopes at the foot of the volcanic mountains, hills and plateaus

The footslopes occur at the foot of Mt. Marsabit, Mt. Asie, the Longipi hills and the Kurkum lava plateau. The soils are developed on various volcanic rocks. In general, around Mt. Kulal (FVIP, FV3P), well drained, shallow to moderately deep, very friable, strongly calcareous, slightly to moderately saline soils occur with a stony surface (calcic and haplic yermosols, stony, saline, sodic and partly stony phase). The soils are moderately well supplied with available nutrients except for K, which is low. The organic C content ranges between 0.2 and 0.5%.

The limited rooting depth and the salinity and sodicity of the sub-soil give rise to limitations for plant growth, especially for perennial vegetation. The stony surface gives some accessibility problems. The slope makes the soil susceptible to erosion.

The footslopes of the Asie mountains and the Longipi hills (FV2P, FVC) have well drained, moderately deep to deep, strongly calcareous, moderately to strongly saline, slightly to strongly sodic, clay loam to clay soils, with an exceedingly bouldery or exceedingly stony surface. In places the soils are very stony (haplic yermosols, boulder mantle, saline, sodic and partly stony phase).

The footslopes of the Longipi hills also have many rock outcrops. The outcrops and the exceedingly bouldery surface make the footslopes of these hills virtually inaccessible.

g. Soils of the piedmont plains

These soils are developed on colluvium derived from various volcanic rocks (basalts and proclastic materials, including ashes).

West of Mt. Kulal (YV1p), well drained, moderately deep to deep, very friable strongly calcareous, slightly sodic, very stony to very gravelly sandy clay loam soils, with an exceedingly stony surface occur (calcic xerosols, stone mantle and sodic phase).

The soils are moderately well supplied with available nutrients, but low in K. The organic C content is about 0.3%.

The exceedingly stony surface causes accessibility problems. The piedmont plains south-west of Mt. Kulal have a complex (YUC) soil pattern. There are well to moderately well drained, moderately deep to very deep, strongly calcareous, moderately to strongly saline, strongly sodic, very stony to slighly gravelly sandy clay loam to clay soils, with a stony to exceedingly stony surface (luvic, calcic and haplic yermosols, saline, sodic and stony phase). The soils are well supplied with available Mg and Ca, low in available K, and low to high in available P. The organic C content is about 0.2-0.4%.

The physical and chemical properties of the soil limit accessibility and plant production in various ways.

h. Soils of the uplands

These (low-level) uplands occur around Korr and in the Elgess area. The parent materials are gneisses which are high in ferro-magnesian minerals (belonging to the Basement System). The well drained, deep to very deep, friable, sandy loam to sandy clay loam soils are in places stony and/or saline (UF1). The consistency of these soils is hard when dry but friable when moist, and they have a weakly developed prismatic structure. The soils are moderately well supplied with available nutrients. The organic C content ranges between 0.2% and 0.4%.

These soils occur on the lowest part of the slopes and have only very gentle slopes (0.2%). The danger of erosion is low. The potential of these soils is high. At present, however, the area is seriously overgrazed and much wind erosion takes place.

The soils of the upper and middle slopes (UFA) form an association of shallow, very stony, loamy sand to sandy loam soils, with in places an exceedingly stony surface (cambic arenosols, lithic, and partly stone mantle phase), and well drained, moderately deep, friable, slightly gravelly to gravelly sandy loam to sandy clay loam soils, with in places an exceedingly stony surface (luvic and haplic yermosols, partly stone mantle phase). The soils are moderately well supplied with available nutrients and high in P. The organic C content is 0.1 to 0.3%.

The sloping character of the area (slopes 2-8%) makes the soils susceptible to erosion, and the stoniness of the surface affects the accessibility of the land. The shallowness of the soils strongly limits the production of perennial vegetation.

i. Soils of the plains

(i) Soils of the volcanic plains

A volcanic plain occurs between Mt. Kulal and Asie (PvVP). There are well drained, moderately deep to deep, friable, strongly calcareous, strongly sodic, stony and/or gravelly sandy clay loam to clay soils, with a stony and/or very gravelly surface (calcic and luvic yermosols, stony phase). The soils are moderately well to well supplied with available nutrients but available K is low.

The stony and/or gravelly surface limits accessibility only slightly. The sodicity limits the production of perennial vegetation.

(ii) Soils of the erosional plains

The erosional plains are subdivided into a flat non-dessected part and a dessected part. They occur south of Maikona (PnSP, PdSP). Excessively drained, shallow, extremely rocky, stony and very gravelly sandy clay loam soils occur (eutric lithosols, stony phase).

The relief (in the dissected part), the rockiness and the stoniness strongly limit accessibility. The shallowness of the soils strongly limits the growth of perennial vegetation.

Part of the erosional plains is covered with an association of two soils (PnSA) of which the somewhat excessively drained, deep to very deep, very friable, slightly gravelly coarse loamy soils are dominant (cambic arenosols). In the depressions, imperfectly drained solonetz soils are present. The soils are low in available nutrients and even the sandy soils are strongly sodic.

This area has an undulating relief which gives rise to erosion. The low fertility, the sodicity and the coarse texture limit vegetation production.

(iii) Soils of the sedimentary plains

The soils of the sedimentary plains are developed on sediments derived from Basement System rocks. Volcanic ash admixtures occur in the major part of these plains, except in the south and west.

South of Kargi (PsUK), shallow to moderately deep, moderately calcareous, sandy loam soils, lying over petrocalcic material, occur. The surface is gravelly (cambic arenosols petrocalcic phase). The soils have a low available K content, a low CES (4-6) and an organic C content of 1.1-0.2%, which is very low.

The shallowness of the soils restricts the growth of perennial vegetation. Their limited fertility and coarse texture limit the production of vegetation.

A big unit (PsU1) in more or less the central part of the Hedad has well drained, very deep, slightly to moderately sodic, sandy loam to sandy clay loam soils, with a topsoil of sand to loamy sand. The soil is in places slightly saline and/or strongly calcareous (luvic yermosols, sodic phase; in places saline phase).
Structure and consistency are as follows:

Structure: A-horizon: single grain to weak sub-angular blocky
B-horizon: porous massive
Consistency: A-horizon: soft when dry, loose when moist
B-horizon: hard when dry, friable when moist

The soils are moderately well to well supplied with available nutrients. The organic C content is about 0.2%. A small unit (PsU2) south of Kargi has similar characteristics, but the rooting depth is limited by petrocalcic material in the deeper subsoil.

Another big unit in the northern part of the sedimentary plains (PsU4) has well drained to moderately well drained, very deep, slightly to strongly saline, strongly sodic, sandy clay loam to sandy clay soils, with a topsoil of loamy sand to sandy loam (orthic solonetz, saline phase). The structure and the consistency of the soil are as follows:

Consistency: A-horizon: loose when dry and moist
B-horizon: very hard when dry, friable when moist
Structure: A-horizon: single grain
B-horizon: strong, columnar.

The soils have a low to moderately high available nutrient content, and available P is high. The organic C content is 0.1 to 0.2% which is very low.

In many places these soils are already eroded down to the B-horizon, and as the infiltration rate of the B-horizon is low, runoff will cause more erosion. The exposed, very hard, B-horizon strongly limits regeneration of vegetation, since seeds will be blown off and in many places sodium toxicity exists. The sandy top layer, which in places reached a depth of more than 100 cm, supports annual vegetation reasonably well. However, perennial vegetation needs to send roots down into the sub-soil and here sodicity and salinity limit the production potential.

In the southern and western part of the area an association of two soil types occurs (PsUA1, PsUA2). The dominant type is a somewhat excessively drained, very deep, loose to very friable sand to loamy sand soil, occurring on slightly higher-lying parts (cambic arenosols). The soils are low to moderately high in available nutrients, but high in available P. The organic C content is 0.2 to 0.3%. In the shallow depressions, well drained, friable, sandy loam to sandy clay soils occur which are in places strongly calcareous and/or slightly sodic.

The coarse texture of the dominant soils limits water availability for plants. However, runoff will be very low since the permeability is very high. Only an already established deep-rooting vegetation is favoured by these conditions.

(iv) Soils of the lacustrine plains

In the Chalbi desert, poorly drained, strongly calcareous, strongly saline, strongly sodic, fine sandy loam to clay soils occur (P1X1, P1XA). After heavy rains the area is flooded.

j. Soils of the floodplains

The soils of the floodplains are variable in texture, salinity and sodicity. In places where rivers fan out (AA3), well drained, very deep, moderately to strongly calcareous, stratified sand to loam soils occur, with a topsoil of silt loam to loam (calcaric fluvisols). After heavy rains they may be flooded.

These soils are low in available K, low to high in available Mg, and well supplied with available Ca and P. The organic C content at 0.1 to 0.3% is very low.

The coarse texture and the stratification limit water availability for vegetation. The soft surface is highly erodable. Annual vegetation however, will grow abundantly in this unit.

k. Soils of the dunes

The dunes occur on both sides of the Chalbi desert. The parent material is sand mixed with some volcanic ashes. Somewhat excessively drained, very deep, loose, moderately to strongly calcareous, strongly sodic, medium to fine sand soils are present (cambic arenosols, sodic phase). The soils are low in available K and Mg, whereas available Ca and P are moderately high to high. The organic C content is below 0.1%. The interdunal flats have an imperfectly drained, very deep, friable to firm, strongly calcareous, strongly saline, strongly sodic, sandy clay loam to clay soil. This soil occupies about 20% of the mapping unit.

The undulating relief gives rise to erosion hazards. The coarse texture limits water availability, which in turn limits the growth of perennial vegetation. The high sodicity limits the production potential of vegetation. The inter-dunal flats are strongly saline and support little vegetation.

B. CLIMATE

1. Livestock Husbandry in Arid and Semi-arid Climates

There are a number of climatic features which determine the conditions of livestock husbandry in an arid or semi-arid area, most of them directly related to the rainfall regime of the specific region.

First of all there is the relationship between climate and primary production of the vegetation cover. The vegetation of an area is largely determined by the amount and the time distribution of rainfall. Species composition, density, etc. are directly connected with rainfall. It is of course clear that there are other factors operating to determine the vegetation of an area, but climate is usually the most important. Normally the vegetation should be in equilibrium with the climate, which means that the vegetation is such that it can survive in periods of drought or heavy rainfall.

In saying that the primary production of plants is directly related to rainfall, we mean that within certain limits production will increase with an increase in the amount of rainfall. The limits are partly set by the rainfall characteristics - for example, its distribution in time. Rainfall of lower intensity but longer duration, well distributed in time, will favour an increase in primary production, whereas short, intensive falls may have only a short and unimportant effect.

Grazing and browsing are spatially organized forms of land-use which require a rainfall well distributed in its spatial variance, otherwise there would be no possibility of grazing all the year round. Nomadism in northern Kenya is an adaptation to the spatial distribution of rainfall. If there is a clear division, as in a mountain-plain area with periodical transitions in grazing, we speak of a transhumance system.

There is another important relationship involving climate: that between rainfall and livestock. In most pastoral areas all over the world, rainfall determines the supply of drinking water for people and animals. The vegetation in a grazing area may be in excellent condition, but if there is no drinking water for the animals it is useless. Today, such areas can often be made useable by digging wells, drilling boreholes or constructing water-storage systems, but a considerable technical and financial input is necessary.

Although variations in temperature affect livestock, high temperatures during the day time stop animals feeding and cause them to look for shade. Even digestibility seems to be affected by high temperatures (Van Soest, 1981). The IPAL study area includes two general climatic types for grazing systems but both have a bimodal rainfall regime. This is better for pastoralism than a single rainy season since the amount of rainfall is distributed in two periods over the year.

Another favourable feature is the presence of several high mountain areas: Mt. Kulal, the Hurri Hills, Mt. Marsabit and the Ndoto and Nyiru mountains. The benefit lies in two factors. First, there is a prolongation of the duration of the rainy season in these higher areas and also an increase in the amount of rainfall with altitude. This gives the pastoralists the possibility of shifting quickly from an arid to a sub-humid grazing area. For example, the distance by road from Kargi (arid) to Marsabit (sub-humid) is only 70 km. Second, these mountains play an enormously important role in directing the water supply for the whole study area. Because of the longer duration of the rains in the high areas, water continues to flow down to the lowlands even when there has been no local rain for a long time. The different vegetation types (e.g. the upland humid forests) slow down the runoff and retain water. It is certain that most of the subsurface water of the lowlands comes from the surrounding mountains.

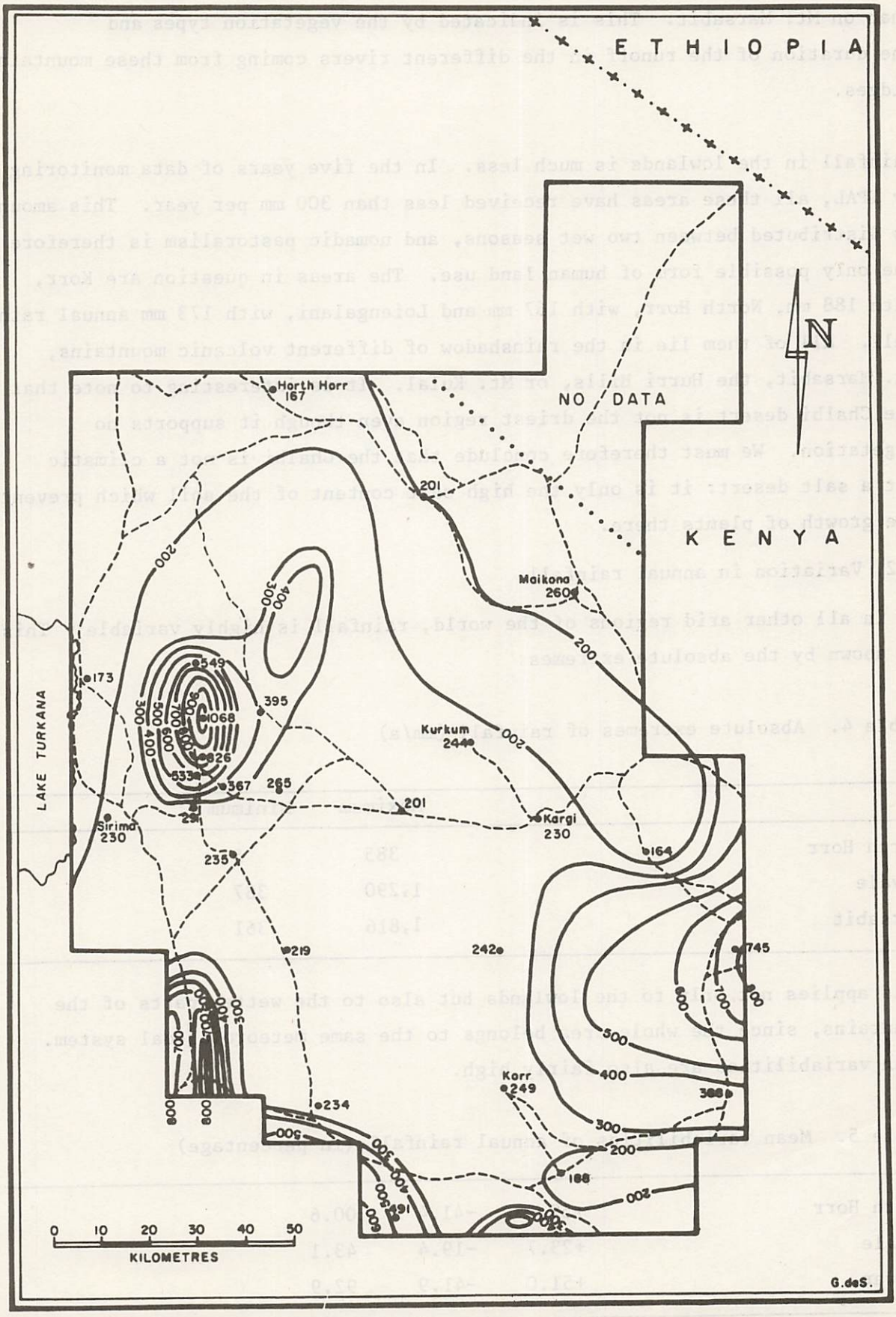
2. Rainfall

2.1 Mean annual rainfall pattern (see Map 6)

Annual rainfall in the IPAL area is divided between two major rainy seasons. The long wet season normally starts in March/April and lasts till May. The short rains may start in October (as in 1982) and last for two months. The period of observation has been too short to allow us to give a percental distribution of rainfall.

In the annual mean Mt. Marsabit receives more than 700 mm, which is the second highest for the study area. As a supplementary source of water there is an "outcombing" of clouds and fogs, which occur quite frequently, especially on the eastern slopes. All the other mountains inside the area receive less rain. For the same altitude Mt. Marsabit receives more than Mt. Kulal. One explanation may be that Mt. Marsabit is the first mountain that the air masses strike on their way to the west. Also, this mountain forms a wave system such that Mt. Kulal seems to lie just in the depression of the third wave, so that there

Map 6. Mean annual rainfall in the IPAL study area 1976-1984



is a downward directed wind. There are no raingauges in the upper parts of the southern mountains, but we can assume that the rainfall here is higher than on Mt. Marsabit. This is indicated by the vegetation types and the duration of the runoff in the different rivers coming from these mountain ridges.

Rainfall in the lowlands is much less. In the five years of data monitoring by IPAL, all these areas have received less than 300 mm per year. This amount is distributed between two wet seasons, and nomadic pastoralism is therefore the only possible form of human land use. The areas in question are Korr, with 188 mm, North Horr, with 167 mm and Loiengalani, with 173 mm annual rainfall. All of them lie in the rainshadow of different volcanic mountains, Mt. Marsabit, the Hurri Hills, or Mt. Kulal. It is interesting to note that the Chalbi desert is not the driest region even though it supports no vegetation. We must therefore conclude that the Chalbi is not a climatic but a salt desert: it is only the high salt content of the soil which prevents the growth of plants there.

2.2 Variation in annual rainfall

As in all other arid regions of the world, rainfall is highly variable. This is shown by the absolute extremes:

Table 4. Absolute extremes of rainfall (mm/a)

	Maximum	Minimum
North Horr	385	5
Moyale	1,290	387
Marsabit	1,816	361

This applies not only to the lowlands but also to the wetter parts of the mountains, since the whole area belongs to the same meteorological system. Mean variabilities are also fairly high.

Table 5. Mean variabilities of annual rainfall (in percentage)

North Horr	+59.2	-41.4	100.6
Moyale	+23.7	-19.4	43.1
Lodwar	+51.0	-41.9	92.9

This serves quite well to illustrate the statement that the average is merely of statistical value. Compared with other arid regions of the world, the variabilities are very high (much higher, for example, than in the Sahel or the arid regions of the Sudan or the Mediterranean area).

There has been no general trend in the annual rainfall pattern. Figure 1 gives the available rainfall data in the study area (for more details see Technical Reports).

So far no general cycle in the occurrence of droughts or wet years is detectable, so that a forecast is not possible. Applying the formula for net primary production per year used by ILCA (N.P.P.* = $\frac{3}{4}$ median - 100) we can determine the primary production rate. The median of the rainfall for the lowlands is around 250-300 mm/a. This means that the net primary production determined by climatological means can vary in the mean by a results factor of 3.5.

Owing to the fact that at least 25% of the years are below the lower mean variability (that is drought years) this gives us a security of 75% when we determine our stocking rate on this base. It is worth noting that these figures are obtained from long-term studies mostly outside the IPAL study area, but with similar climatic characteristics. The spatial distribution of rainfall is highly variable. Normally the higher mountains get more rainfall than the lowlands but there is not absolute certainty that this will be so. This is shown, for example, by the second wet season in 1980 when, over the whole of northern Kenya, rainfall was exceptionally low.

The variability of spatial distribution has consequences for the creation of a controlled grazing system. Owing to the fact that all over the lowland rainfall is unrealiable it is only possible to define the grazing use of different areas for specific seasons.

Figure 2 illustrates the distribution of rainfall at Marsabit and also indicates the onset and duration of the west seasons. It also confirms the low reliability of rainfall. Table 6 gives the probabilities of tainfall at Marsabit.

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*N.P.P. = Net primary production.

Figure 1. Variability of annual rainfall at Marsabit

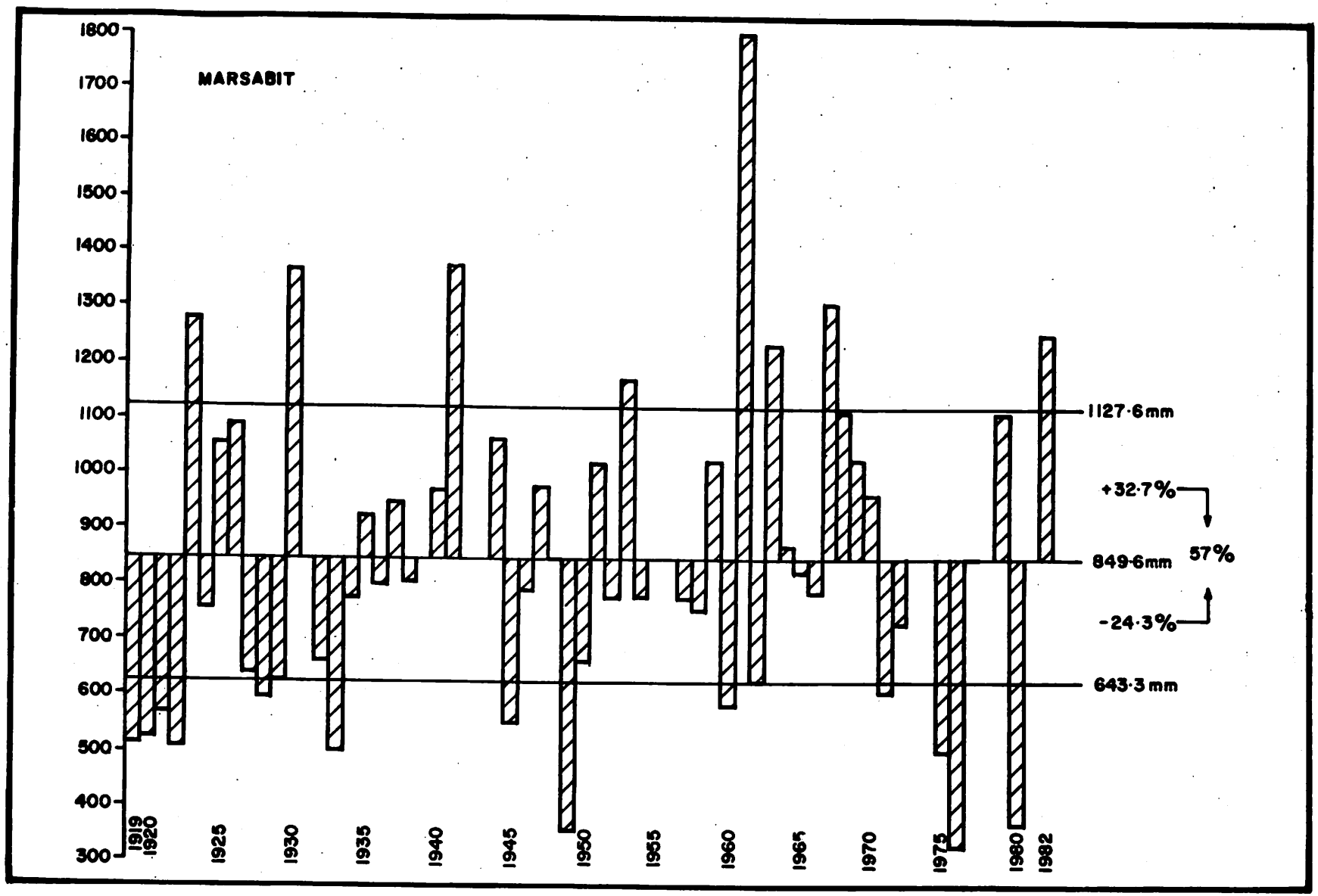


Figure 2. Distribution of rainfall and onset and duration of wet seasons at Marsabit

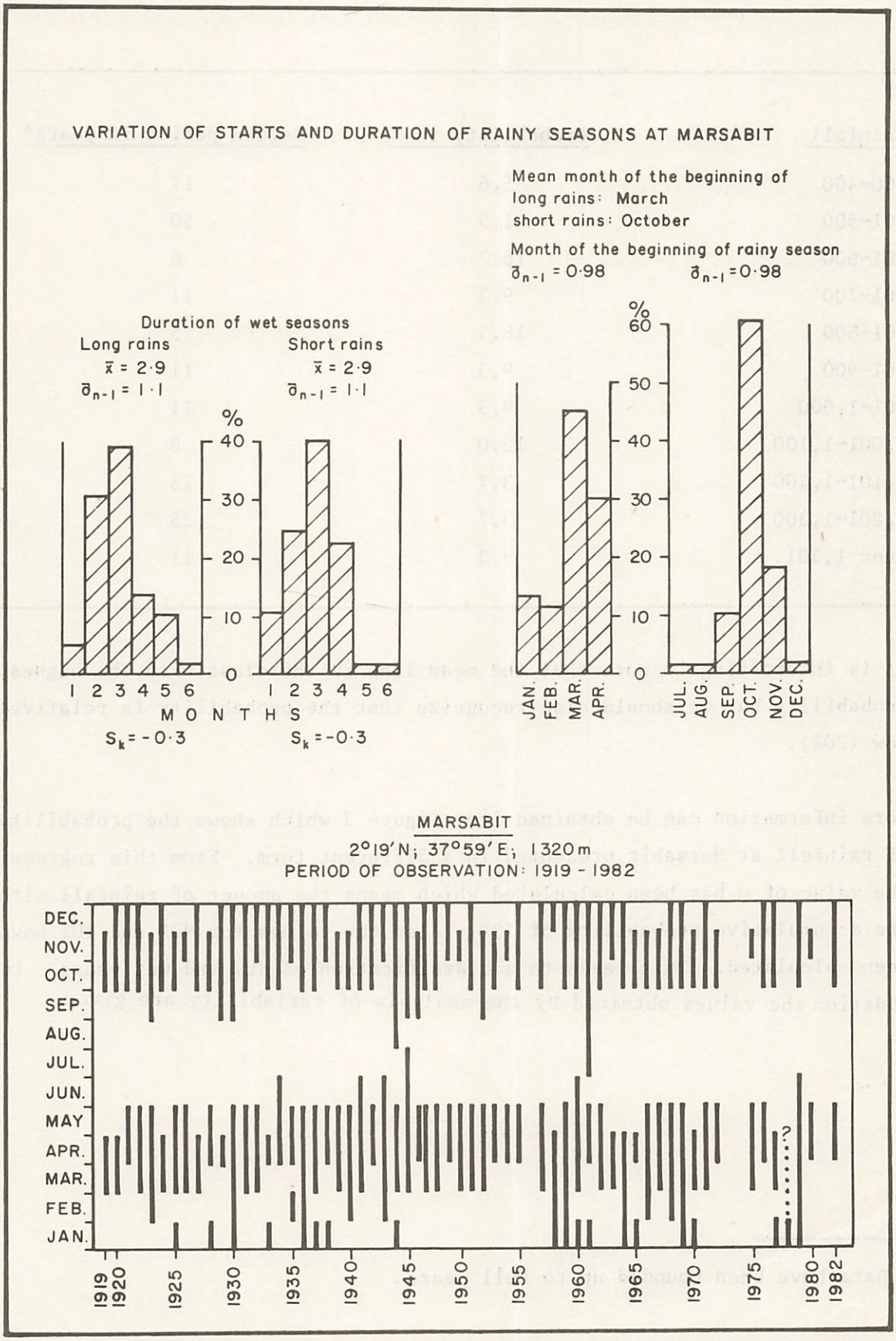


Table 6. Probabilities of annual rainfall and their return periods at Marsabit

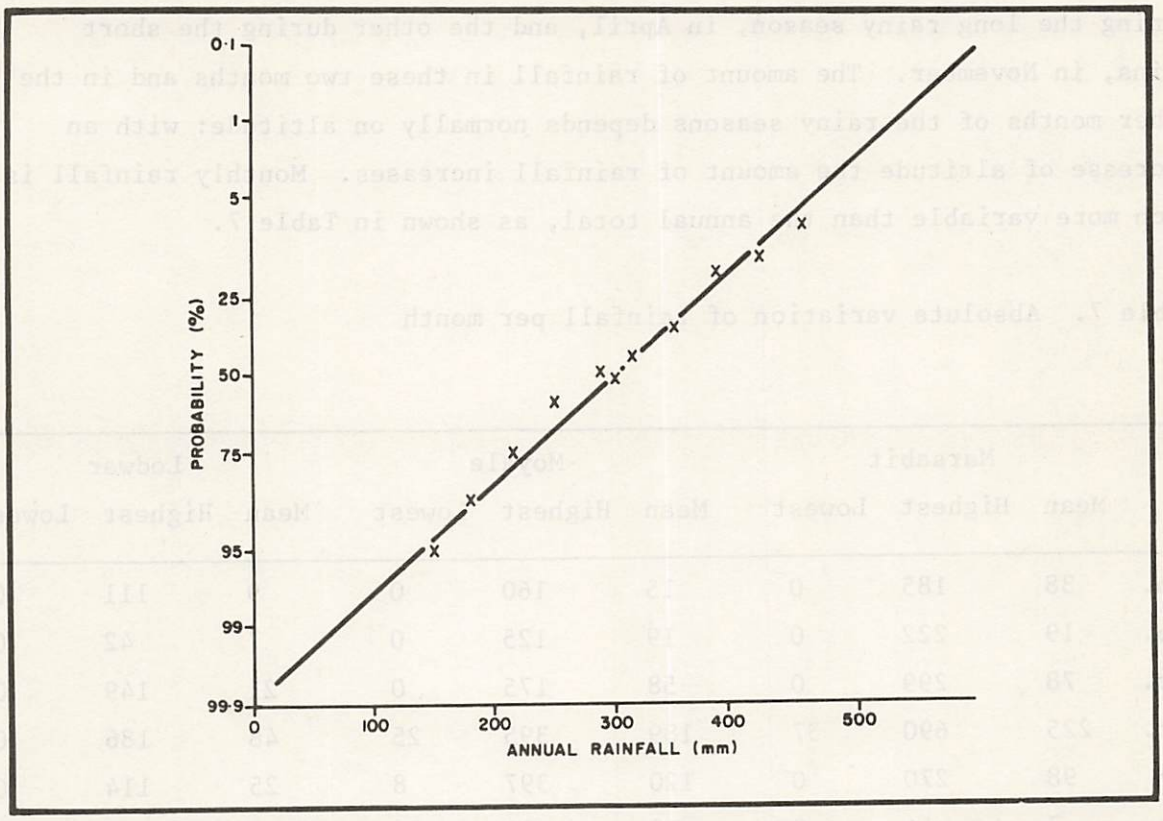
Rainfall	Probability in %	Return period in years*
300-400	5.6	17
401-500	1.9	50
501-600	16.7	6
601-700	9.3	11
701-800	18.5	5
801-900	9.3	11
901-1,000	9.3	11
1,001-1,100	13.0	8
1,101-1,200	3.7	25
1,201-1,300	3.7	25
Over 1,301	9.3	11

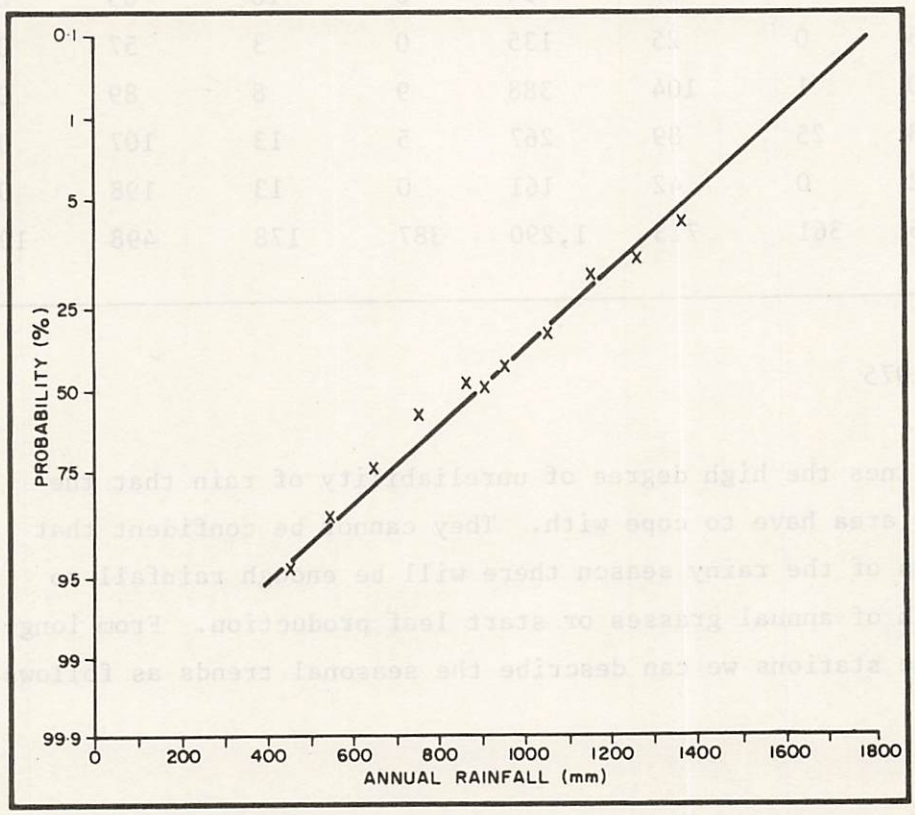
It is interesting to note that the mean lies in the class with the highest probability but we should also recognize that the probability is relatively low (20%).

More information can be obtained from Figure 3 which shows the probability of rainfall at Marsabit presented in a different form. From this regression the value of μ has been calculated which means the amount of rainfall with the accumulative probability of 50%. Also the values for 90% and 10% have been calculated. This leads to a classification of dry and wet years. In addition the values obtained by the analysis of variability are given.

* Data have been rounded up to full years.

Figure 3. Probabilities of annual rainfall at Marsabit





2.3 Monthly rainfall

There are two peaks in the rainfall regime of northern Kenya. One occurs during the long rainy season, in April, and the other during the short rains, in November. The amount of rainfall in these two months and in the other months of the rainy seasons depends normally on altitude: with an increase of altitude the amount of rainfall increases. Monthly rainfall is much more variable than the annual total, as shown in Table 7.

Table 7. Absolute variation of rainfall per month

	Marsabit			Moyale			Lodwar		
	Mean	Highest	Lowest	Mean	Highest	Lowest	Mean	Highest	Lowest
Jan.	38	185	0	15	160	0	9	111	0
Feb.	19	222	0	19	125	0	7	42	0
Mar.	78	299	0	58	175	0	21	149	0
Apr.	225	690	37	189	395	25	48	186	0
May	98	270	0	120	397	8	25	114	0
Jun.	7	44	0	18	92	0	7	116	0
Jul.	16	137	0	17	89	0	14	132	0
Aug.	18	183	0	17	94	0	10	63	0
Sept.	13	66	0	25	135	0	3	57	0
Oct.	123	390	1	104	388	9	8	89	0
Nov.	154	623	25	89	267	5	13	107	0
Dec.	70	232	0	42	161	0	13	198	0
Year	859	1,816	361	713	1,290	387	178	498	19

Source: E.A.M.D. 1975

This further underlines the high degree of unreliability of rain that the pastoralists of our area have to cope with. They cannot be confident that in the normal months of the rainy season there will be enough rainfall to stimulate the growth of annual grasses or start leaf production. From long-term observations at some stations we can describe the seasonal trends as follows:

The first, long rainy season starts in March and reaches its maximum in April. In May, rainfall is already less and tends towards zero in June. June to September are almost without rain in all parts of the study area. Local showers, especially in the mountains, can bring some modification, but normally they do not affect the growth of fodder plants. October is the beginning of the short wet season, with its peak in November. December to February are almost completely dry, with possible local showers.

It is interesting to compare the bimodal rainfall regime of northern Kenya with a place with only one rainy season. In an area with the same amount of rainfall, but with only one rainy season, land use will be based more on agriculture (for example, at 350 mm, millet cultivation). There will be competition between agriculture and nomadic pastoralism. In northern Kenya we find only nomadic grazing systems, because the amount of rainfall in one rainy season is not sufficient to provide enough water for the full growth of crops. This is at present only an assumption, but the bimodal rainfall regime seems to account for the fact that northern Kenya is less threatened with desertification than other areas with a single rainy season and consequently a fully established agricultural system.

The high monthly variability illustrates again the general unreliability of rainfall. It also illustrates a general problem affecting arid lands all over the world:

- the water supply is well distributed only in a few years;
- the only regularity is in the degree of fluctuation between extremes: there is a deficit of water for long periods and an enormous surplus of water for very short periods.

It is one of the tasks of hydrology to point to solutions to this problem. To obtain information about the character of monthly rainfall an analysis of variability was carried out using the formula:

$$\frac{S \times 100}{\bar{X}} = v$$

(S = standard deviation, $\bar{X}$ = mean)

approved by Nieuwolt for the tropics. Note that this method is intended to indicate the magnitude of the variability in each area, and also to compare the variabilities at various stations. If the result obtained by the formula is higher than 60, the station and month are classified as highly variable.

Table 8. Monthly variabilities at various stations

Station	Periods of records	Month J	F	M	A	M	J	J	A	S	O	N	D
Moyale	1915-81	180	130	79	52	58	87	95	89	146	229	182	261
Lodwar	1919-81	231	143	137	97	121	220	169	248	288	230	181	253
North Horr	1959-81	170	174	119	92	146	358	228	315	367	229	139	191
Marsabit	1974-81	165	182	90	73	70	158	92	105	92	90	70	68
Gatab	1971-81	164	108	106	95	67	140	145	230	264	133	100	94
Kargi	1976-81	131	123	101	103	122	*	*	*	200	49	74	50

* No rainfall recorded in the period of observation.

The variability of rainfall also affects spatial distribution. Examples for this are given in IPAL Technical Report B3 (1983). Generally, we can say that the area is too small to exhibit general discrepancies in the rainfall in the north. But there are differences when we compare the lowlands and the mountainous areas.

An example of a dry wet season is given in Table 9. The period was extremely dry; there was also only a small amount of rainfall in the previous months and in December, and even the mountain stations did not receive enough rainfall.

Table 9. Rainfall in November 1980 at selected stations expressed as percentages of the means (1976-81).

Stations	Percentages
North Horr	+25.4
Loiangalani	-17.0
Marsabit	-62.7
Gatab	-57.3
Kargi	-26.0
Korr	-33.2
Ngurunit	-22.8

Such events demonstrate the importance of rainfall probability as a predictive parameter.

2.4 Probability of rainfall

For the entire IPAL area the data available are insufficient to permit the estimation of rainfall probabilities, since a data base of at least 10 years is needed.

We are using instead data obtained for Marsabit and Moyale, which have data bases of 50 and 56 years. Because both stations lie in relatively wet areas it is necessary to divide the amounts of rainfall by 3 and by 2 respectively. The resulting medians of 338 mm/yr and 259 mm/yr are representative for the lowlands of Marsabit District.

Probabilities are calculated for the following monthly rainfall values:

a) less than 25 mm, which will not permit plant growth;
b) over 50 mm, which is the minimum required for plant growth;
c) over 100 mm and over 200 mm, which will lead to severe soil erosion and floods.

Only in April are the probabilities high that in the majority of years there will be more than 50 mm of rainfall. In November, the peak of the short rains, these areas are likely to receive more than 50 mm in 30% of all years but almost the same probability applies to less than 25mm. In other months the situation is much worse. In the mountains the probabilities are better distributed. This is shown by the data for Marsabit and for Moyale (Table 10).

Table 10. Probabilities of rainfall at Moyale and Marsabit

Moyale (n = 56, Median = 676 mm/yr)

	J	F	M	A	M	J	J	A	S	O	N	D
Median (mm)	8	10	39	157	114	16	13	13	9	95	77	28
Probabilities:												
Less than 25 mm	.87	.74	.34	0	.02	.78	.79	.85	.68	.12	.10	.27
Over 50 mm	.07	.11	.46	.97	.87	05	.02	.03	.17	.72	.71	.28
Over 100 mm	.02	.02	.21	.84	.61	0	0	0	.02	.47	.36	.09
Over 200 mm	0	0	0	.03	.11	0	0	0	0	.13	.02	0

½ Moyale (n = 56, Median = 338 mm/yr)

	J	F	M	A	M	J	J	A	S	O	N	D
Median (mm)	4	5	20	79	57	8	7	7	5	48	39	14
Probabilities:												
Less than 25 mm	.93	.89	.54	.03	.13	.13	.95	.98	.97	.83	.29	.72
Over 50 mm	.02	.02	.21	.84	.61	0	0	0	.02	.46	.36	.09
Over 100 mm	0	0	0	.30	.11	0	0	0	0	.13	.02	0
Over 200 mm	0	0	0	0	0	0	0	0	0	0	0	0

Marsabit (n = 50, Median = 777 mm/yr)

	J	K	M	A	M	J	J	A	S	O	N	D
Median (mm)	17	4	43	209	70	3	7	7	7	103	116	47
Probabilities:												
Less than 25 mm	.16	.77	.28	0	.28	.93	.83	.80	.82	.16	.04	.30
Over 50 mm	.25	.14	.44	.91	.60	0	.03	.06	.04	.68	.80	.44
Over 100 mm	13	.05	.21	.78	.41	0	.02	.02	0	.50	.54	.26
Over 200 mm	0	.02	.04	.44	.14	0	0	0	0	.23	.20	.07

⅓ Marsabit (n = 50, Median = 259 mm/yr

	J	F	M	A	M	J	J	A	S	O	N	D
Median (mm)	6	1	14	70	23	1	2	2	2	34	39	16
Probabilities:												
Less than 25 mm	.86	.98	.63	.14	.52	.1	.98	.96	.1	.38	.36	.65
Over 50 mm	.05	.02	.12	.66	.28	0	0	.02	0	.29	.38	.13
Over 100 mm	0	0	0	.02	0	0	0	0	0	.04	.09	0
Over 200 mm	0	0	0	.02	0	0	0	0	0	0	.02	0

Source: ILCA 1979

3. Aridity and humidity

3.1 General

Aridity is a major factor in any investigation into the problems of desertification. In the environmental balance of an arid landscape the most important aspects of climate are the relationship of humidity and aridity and the duration and degree of aridity. A further important factor which influences the processes of desertification is the special relationship of climate to the actual morphodynamics. By adopting the approach of assessing the hydro-dynamic balance we can reach conclusions on the land-use potential of a landscape unit, which in northern Kenya should be related to the range condition. For the determination of arid and humid months the formula of Schreiber is used. Data for Marsabit are in Figure 4.

The relative humidity minima in the lowlands are just below 40% which means that the air is highly unsaturated. This underlines the high values of potential evaporation. This confirms in a way that in the short rains the origin of the rainfall is more convective in nature than in the long ones.

It is evident from the records of the two automatic weather stations in the IPAL study area that evaporation and evapotranspiration, like rainfall, are not constant climatic factors. The recorded data show that there are possible correlations between evaporation and rainfall, and this is very important in connection with cloud cover. Evaporation does not depend so much on temperatures as on solar radiation and on wind.

Figure 4. Probabilities of arid months at Marsabit

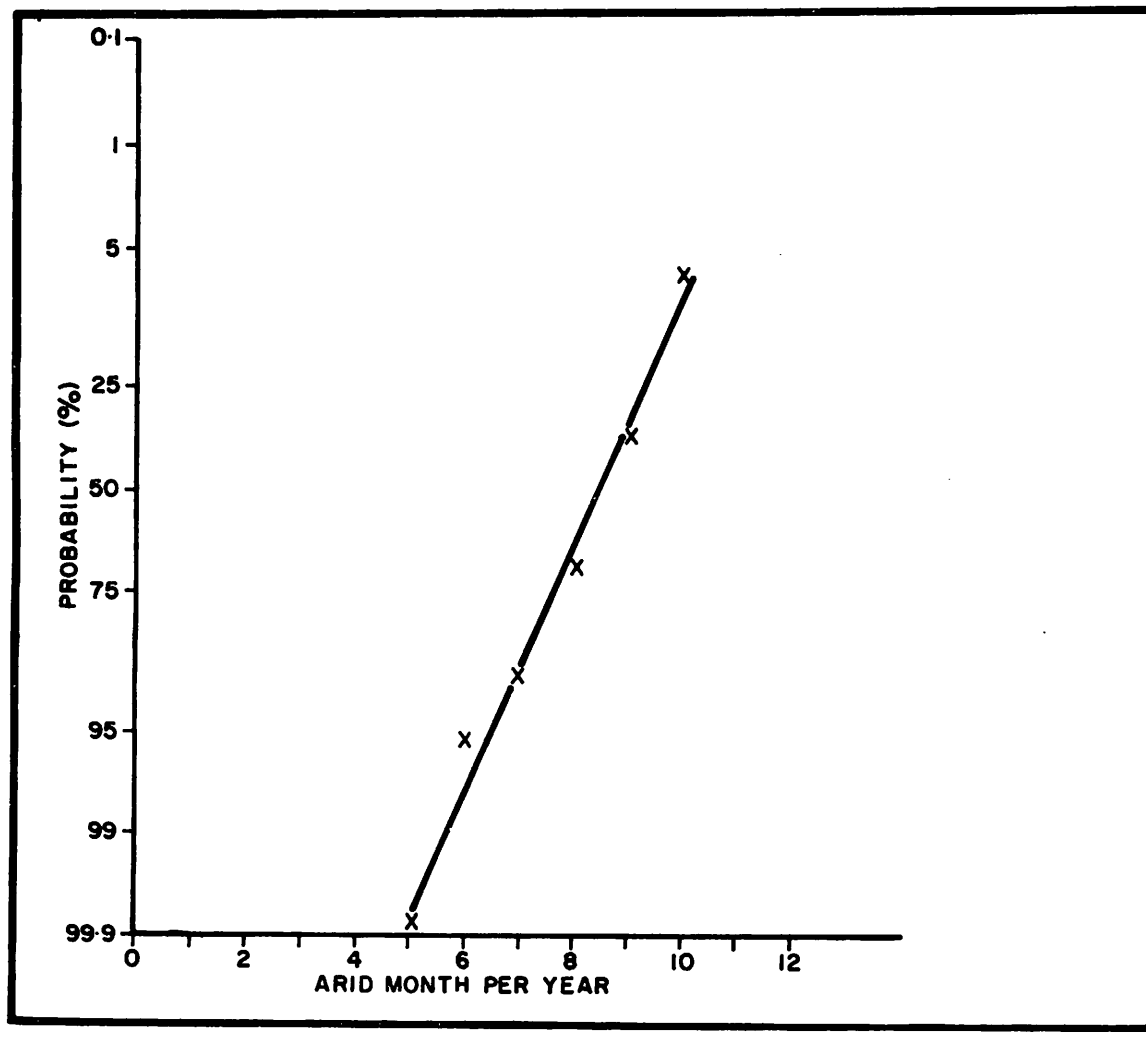


Table 11. Monthly evaporation and rainfall in Lodwar

	Evaporation			Rainfall	
	Highest	Lowest	Mean	Mean	Mean
January	392	272	311	9	-302
February	361	221	292	7	-285
March	405	231	324	21	-303
April	339	209	275	48	-227
May	385	183	285	25	-260
June	349	233	287	7	-280
July	333	213	283	14	-269
August	342	233	292	10	-282
September	363	281	326	3	-323
October	381	291	343	8	-335
November	345	195	284	13	-273
December	339	194	276	13	-263
Year	3,890	3,075	3,578	178	-3,400

Note: Evaporation rates have been obtained by measuring the water loss of a pan with a depth of 25 cm according to the standards of the W.M.O. The results obtained are not the actual evaporation of this area but they show the amount of water which could evaporate.

The rainfall data for Marsabit are discussed and further analysis of this factor is presented in a Technical Report. Compared with Marsabit, Gatab shows some differences, especially in the long rainy season. It is almost certain that this apparent difference is caused by the shorter period of the records. The people of Gatab do not consider that January is a wet month. The high average rainfall recorded in this month is caused by two very wet periods in January in 1978 and 1979 when there were 140 and 204 mm of rainfall respectively.

At Olturot November is classified as the only month which is humid. This is due to the fact that in 1982 there was a very wet period in November. In 1977 and 1978 there were also large amounts of rain in November which means

that in more than 50% of the years rainfall was higher than the threshold value (see Fig. 5). This was not the case in the months of the long rains. So far this result seems to be valid, but this conclusion may change when longer periods of record become available.

Olturot belongs to the wide plains of the lowlands of the IPAL area. The annual rainfall map shows that more than 8,100 km^2 are represented by this type (rainfall between 200 and 300 mm/a). It is the commonest climatic subtype in the IPAL area and probably also throughout Marsabit District.

The temperature of the air is directly correlated with the amount of water vapour the air can contain. As it is difficult to measure the absolute amount of moisture in the air; we normally measure the relative humidity instead. Measurements have been made at Olturot using the dry and wet bulb method. Data were recorded by the automatic weather station. From the print-out sheets the hourly data have been extracted and averaged for 5 years.

Table 12 shows average temperature change for each month of the year. The amplitude of diurnal fluctuation is much higher than the annual fluctuation in tropical temperature regimes. With the beginning of the rainy seasons the moisture content of the air increases reaching its maximum in April and November. The maximum relative humidity during the day occurs in the early hours of the morning just before sunrise. This happens in every month of the year. The minima are recorded in the late hours of the afternoon. This can also be correlated with the daily temperature fluctuations.

The records over the five years since the installation of the station shows that, even in the months of the rainy season, the relative humidity has never been higher than 90% (see Figure 6). Therefore no additional water is available for condensation in the form of dew. Owing to the high temperatures, the dew point is not reached in the lowlands of the IPAL area even at night. By contrast, in the mountains we find condensation, normally shown by mist or very low clouds, even in the dry seasons. As already mentioned they provide a large amount of moisture which is in addition to the normal precipitation.

Figure 5. Monthly rainfall and threshold values of rainfall

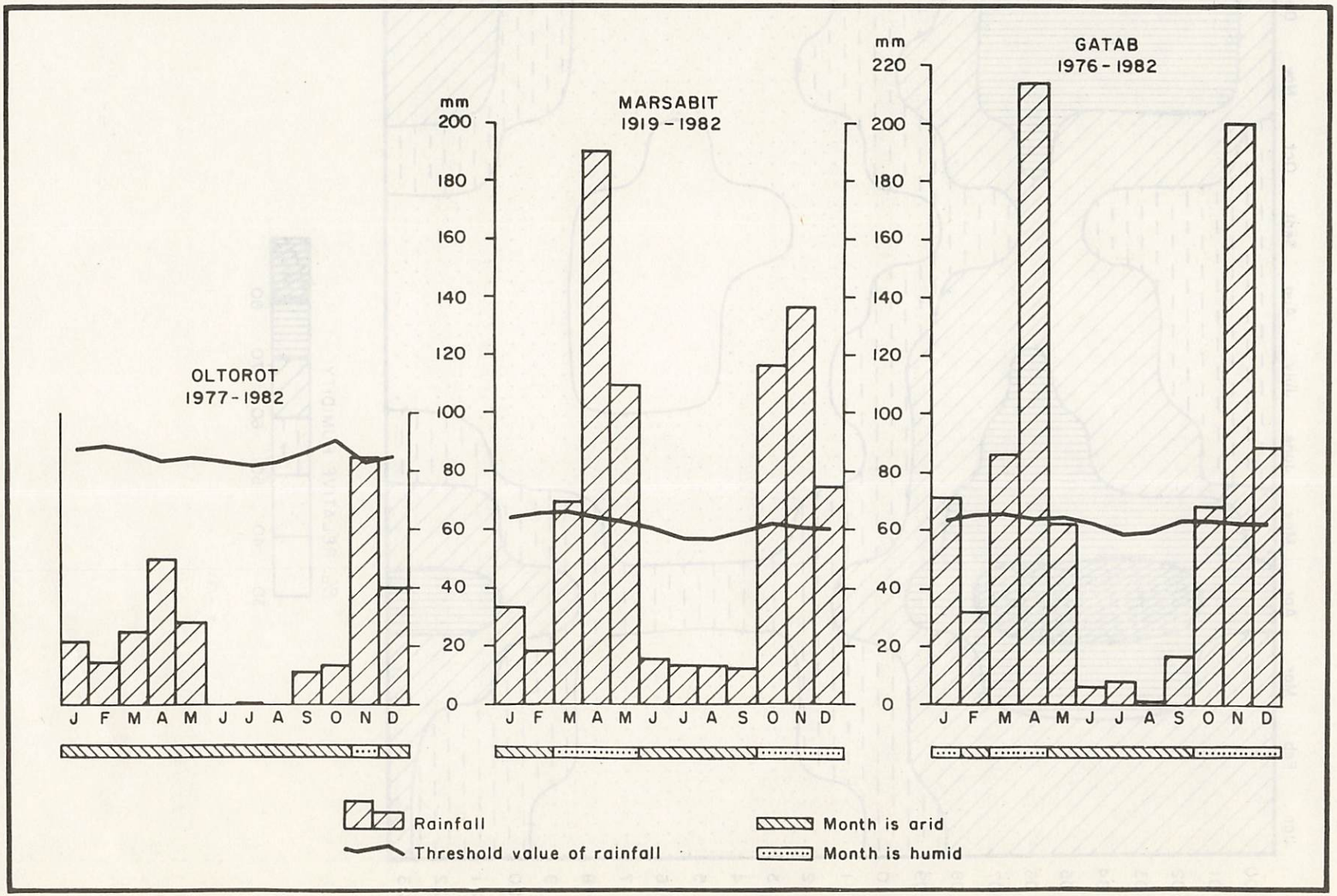
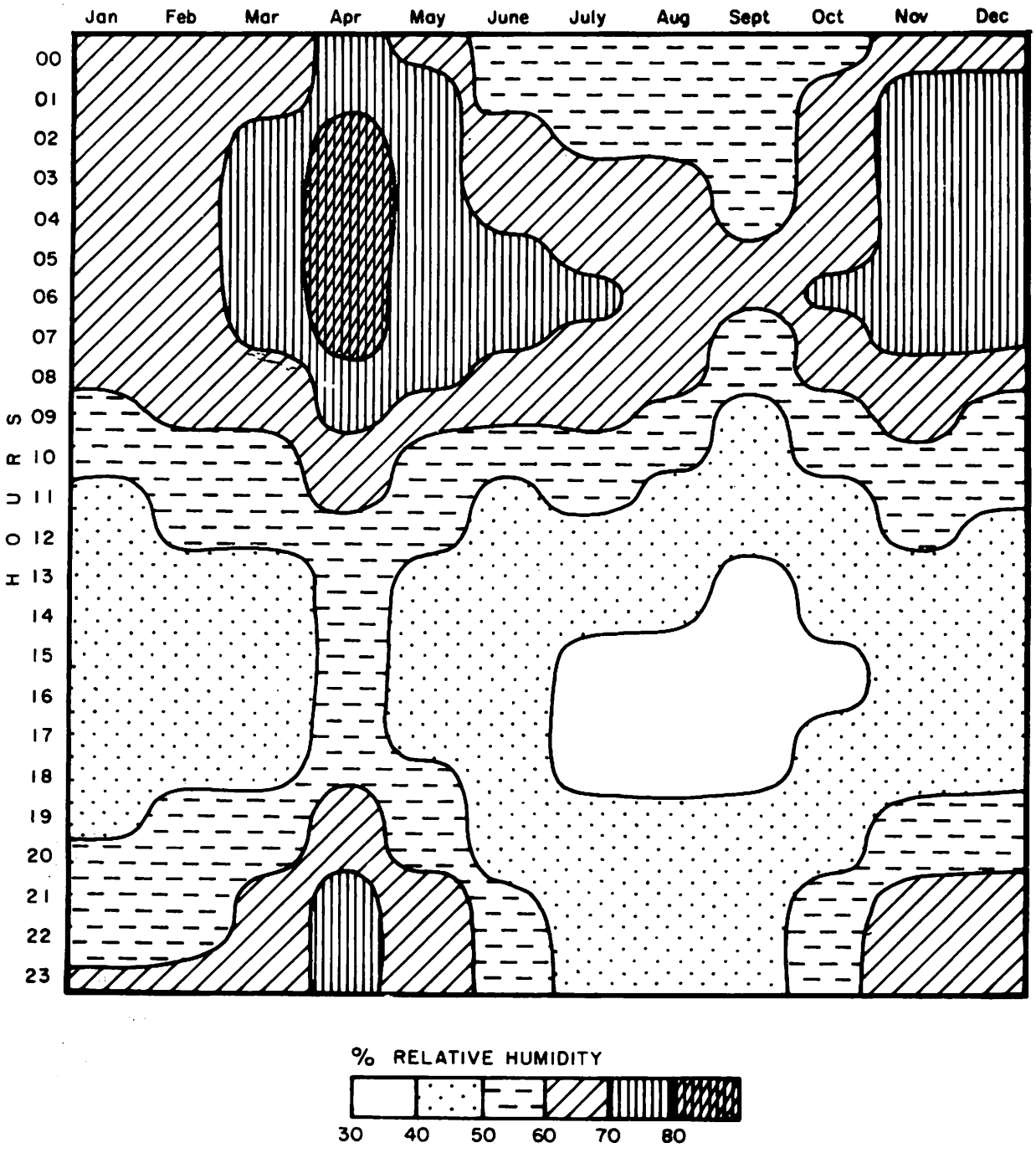


Figure 6. Relative humidity at Olturot



4. The temperature regime

The yearly diurnal variations of temperatures in the IPAL area have been described already, for a shorter period, by Edwards et al. Owing to the low variability of this climatological factor, results obtained from a longer period of recording would not increase the accuracy.

Temperatures vary only within a small range, much less than 10%, and only a few additional remarks are needed here. The basic information can be obtained from the material in IPAL Technical Report B-1. The network for measuring maximum and minimum daily temperatures is limited. More stations have been established during this consultancy but the period of data records is still less than one year so results from these stations are not included here.

One aspect should be taken into account concerning the altitude lapse rate. This can be done by comparing the stations of Olturot and Gatab (distance c.20 km) with altitudes of 600 m and 1,700 m respectively.

Table 12. Mean monthly temperature (1976-1982) in degrees centigrade

	J	F	M	A	M	J	J	A	S	O	N	D	Y
Olturot	28.4	28.5	28.1	27.4	27.5	27.3	26.8	27.4	28.1	28.9	27.3	27.9	27.8
Gatab	19.0	19.8	19.7	19.0	19.3	18.8	17.6	17.9	19.0	19.1	18.7	18.8	18.9
Difference	9.2	8.2	8.4	8.4	8.2	8.5	9.2	9.5	9.1	9.8	8.6	9.1	8.9

The altitude difference of the two stations is 1,100 m. Over the whole year we have a mean temperature difference of 8.9°C, which is equivalent to a gradient of 0.8°C/100 m. During the year there is a variation caused by air humidity and rainfall. That is why the mean gradient in March, April and May (i) and November is somewhat lower than during the other months.

The higher temperatures in the lowlands dictate a shorter interval for the watering of animals, but there is in general no big change over all the lower parts of the study area.

Temperatures in areas with lava cover are higher than those with sandy soils because the dark lava absorbs the radiation and heats up the air near the surfaces. So at Kargi in June 1982 a temperature of 45°C in the shade was measured at 2 p.m. This fact will have to be considered when, in the future, we are able to draw temperature maps of Marsabit District.

5. Wind

5.1 Wind direction and speed

Wind is one of the factors which are often disregarded in a climatological study for use in range management. This is reasonable in higher latitudes, but in arid or semi-arid countries wind is of special importance.

First, there is a relationship with evaporation: with an increase of wind speed up to a certain level evaporation will increase too because unsaturated air is brought to the evaporation site. Second, in areas with low vegetation cover the wind can erode fine materials and blow them away; scelettic soils, dunes and sandfields are the result.

The wind system in the IPAL study area, based on the records of Gatab and Balesa Kulal/Olturot, has been analysed by Edwards et al. The results are still valid. For Olturot there are now more data available and there are also data available from Korr. They show that the results from Olturot cannot be transferred to most parts of the study area, since the station lies in the influence zone of a local wind system. The nearby Mt. Kulal affects wind direction and speed for two reasons:

- it presents a wall to the air masses coming from the east;
- owing to its altitude it induces a local wind system with different patterns by day and by night.

Regarding the mean wind directions, it seems that this system is not as well developed in the middle of the year, but further investigations are necessary. The area of this local wind system covers the eastern slopes of Mt. Kulal and the plains, but extends less than 10 km east of the slopes. That is why more attention is given to the data from the weather station at Korr.

5.2 Diurnal variation of wind

Diurnal variations are only clearly measurable in the area of Olturot, where there is a mountain-plain unit system. From 9 a.m. the wind has a strong easterly component which persists till sunset. This easterly component is a result of the general circulation in the area and the uplift of air on the slopes of Mt. Kulal. This also affects the wind speed, which increases during the day time. After sunset the wind direction begins to shift towards the north and finally to the west. At around 4 a.m. the direction begins to move backwards till at around 8 a.m. the wind returns to the east. Seen over the whole period (9 a.m. - 9. a.m.), the shifting follows a sin-curve. There are variations during the different months forced by the general circulation and the movement of the sun.

On the other hand, the wind directions at Korr are constant; easterly winds (120°-130°) prevail throughout the year. After dawn there is a slight tendency to shift towards the south, but it is not very marked. This prevailing wind direction is very well shown by the direction of the small sand dunes.

6. Evaporation

For arid or semi-arid countries rainfall is the most important climatic factor. Its direct counterpart is evaporation. The problems encountered in measuring this factor are well known and will not be discussed here.

The evaporation rates in northern Kenya are very high. The potential evaporation rates for Lodwar (obtained by measurements) vary between 3,075 and 3,890 mm/a. These data are also valid for the lowland plains of Marsabit District. Normally no month has values less than 300 mm potential evaporation, which is fairly high and reaches the values for the Saharan regions.

More valuable than potential evaporation rates are the data for evapo-transpiration. These too are difficult to obtain. There is no lysimeter for direct measurements in the northern districts of Kenya, so that we have had to rely on calculated data.

Table 13. Actual evaporation rates for selected months at Marsabit and Lodwar, compared with rainfall in mm.

	January	April	July	October	Year
Marsabit					
E_a	113	109	87	108	1,322
R	38	225	16	123	859
D	-75	+116	-71	+15	-463
Lodwar					
E_a	5	49	27	28	329
R	9	48	14	8	178
D	+7	-1	-13	-20	-151

(E_a = actual evaporation; R = rainfall; D = difference)

Source: Bake 1983

Table 13 shows that the water balance is negative for the complete year. But in the wet season there is a water surplus which infiltrates into the groundwater storage. It depends also on the characteristics of the rainfall - whether it is a shower or a storm, or something else.

Regarding Table 13, the objection might be made that no water can evaporate that is not available or did not fall. This is of course true, in one way. But we have to deal here with a formula for obtaining at least an estimation of the natural conditions. Also, evaporation takes place from open water surfaces, from water courses, and from plants which are using groundwater. Again, in Marsabit we have, even in the dry seasons, a constant water supply in the upper parts of the mountain, especially on the eastern side, from clouds and mist.

C. GEOMORPHOLOGY

The major landforms have already been described in Section A and are shown here in a small-scale map (Map 7).

1. The Role of Vegetation in Morphodynamics

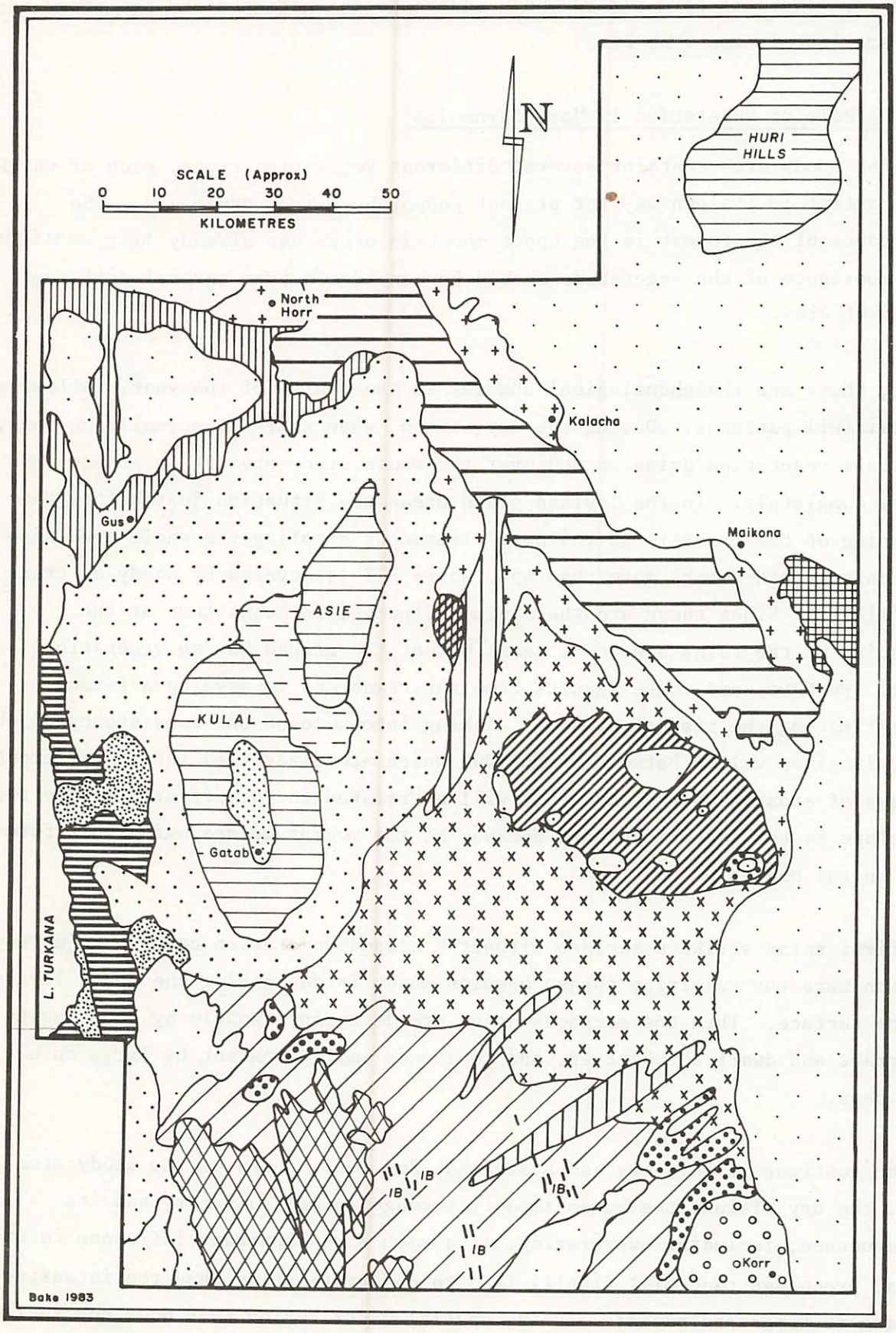
The IPAL study area contains several different vegetation types, each of which is important in its own way for present geomorphological processes. The importance of the forest in the upper mountain areas has already been mentioned. The importance of the vegetation should be considered from several different points of view.

First, there are the phenological changes in the course of the year, following the rainfall patterns. During the dry season, when there is normally no rain, the grass vegetation dries up and over the whole study area it is grazed off almost completely. In the lowland plain areas the situation just before the beginning of the rains is as follows. Transects sampling the whole area show that bare ground covers more than 45%, while 20% is covered by woody or grass herb/litter. Since these are the minimum figures, it means that at the beginning of the rainy season at least 65% of the ground has no vegetation cover. We have used these results from the transects to develop a formula for estimating the risk of erosion. Taking into account the consistency of the soil, it gives values between 0 and 100, which are classified into 6 different classes of erosion hazard, and this will be related to the different range types. The slope factor is not included because at the moment we are using this formula only on the plains.

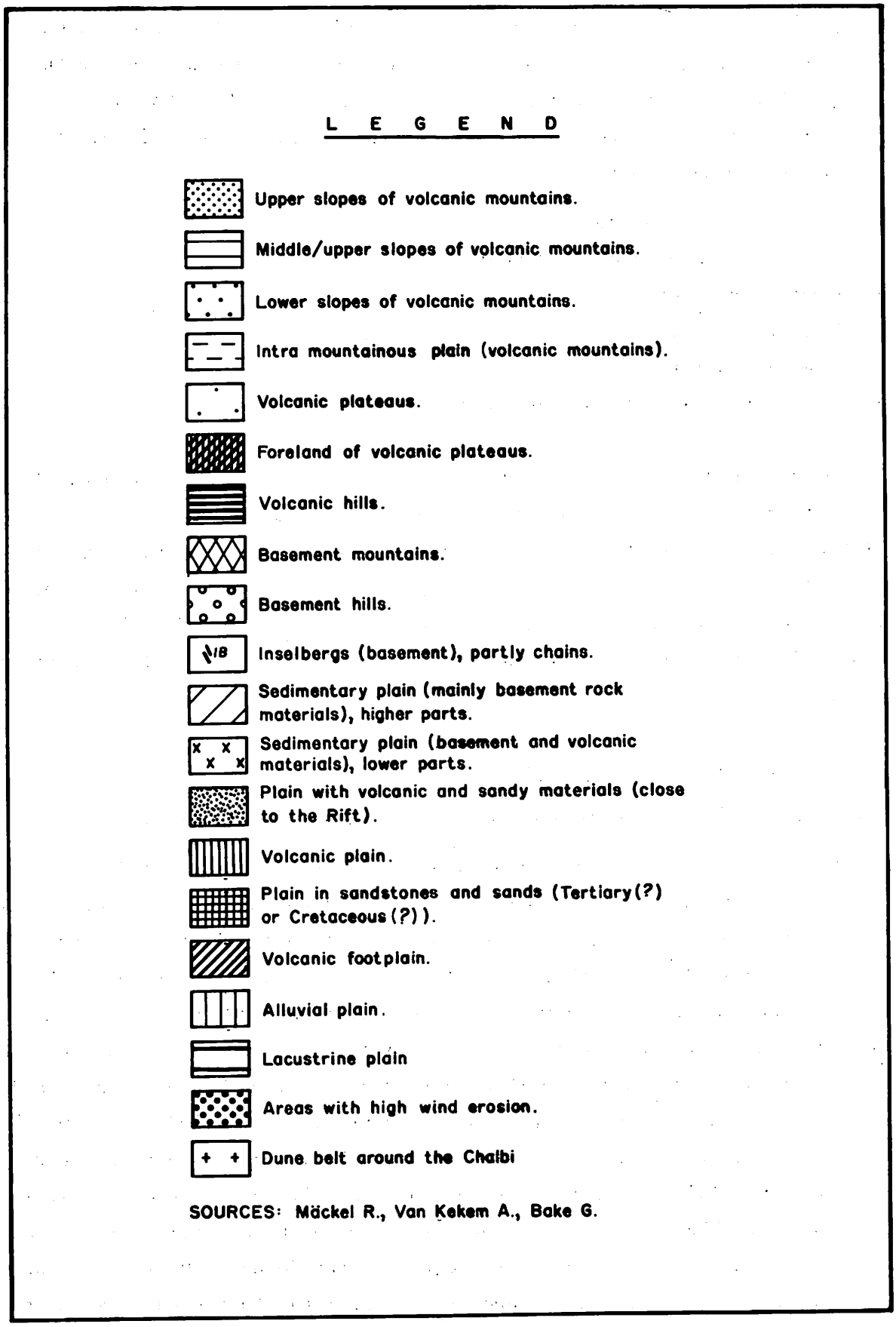
The first rains strike a surface without a closed vegetation cover. We merely mention here the resulting splash erosion which is destroying the upper layers of the surface. Then the morphodynamics are determined mostly by the density of the grass and dwarf-shrub cover, and to a much smaller extent by large shrubs and trees.

We can continue in this way and state that for most, parts of the study area (e.g. the dry plains) the human impact, through animal husbandry and its consequences, including overgrazing, is a much more important influence in the actual processes that will finally lead to desertification than the intensive cutting of trees and bushes. In its spatial distribution this does not include the forest areas of the mountains and the riverine vegetation, where strict conservation is an absolute necessity.

Map 7. Major landforms of south-western Marsabit District



Map 7. Legend


L E G E N D
Upper slopes of volcanic mountains.
Middle/upper slopes of volcanic mountains.
Lower slopes of volcanic mountains.
Intra mountainous plain (volcanic mountains).
Volcanic plateaus.
Foreland of volcanic plateaus.
Volcanic hills.
Basement mountains.
Basement hills.
Inselbergs (basement), partly chains.
Sedimentary plain (mainly basement rock materials), higher parts.
Sedimentary plain (basement and volcanic materials), lower parts.
Plain with volcanic and sandy materials (close to the Rift).
Volcanic plain.
Plain in sandstones and sands (Tertiary(?) or Cretaceous(?)).
Volcanic footplain.
Alluvial plain.
Lacustrine plain
Areas with high wind erosion.
Dune belt around the Chalbi
SOURCES: Mäckel R., Van Kekem A., Bake G.

2. Areas with High and Very High Erosion Hazards

Because an overall geomorphological map covering the entire study area under various aspects is not ready so far, a small sketch showing areas with high erosion hazards in the Rendille grazing block is attached (Map 8). The classification of an area as one with a high risk of erosion is mainly based on the following aspects:

- consistency of the soil
- soil development state and degradation
- vegetation cover
- steepness of slope
- climatic factors
- human impact (which included animal husbandry)

These factors do not have the same value in each site. For example, if there is a steep slope this factor is dominant and will determine that there is a high or even very high erosion hazard. In other areas the human impact and, directly related, the vegetation cover, govern the erosion status. Therefore it is prefered to give a short comprehensive description of each area listing the relevant factors and trying to analyse them from the geomorphological point of view.

3. Description of the Different Areas

3.1. Area 1 (upper middle slopes of Mt. Kulal) (range unit 18)

Mt. Kulal, a volcano of the tertiary and early quaternary periods, is situated in the west of the grazing block, it is orientated mainly south-north following the general fault direction of the Eastern Rift Valley in this region. The long volcano is divided in the summit area by a caldera and (along fault lines) by deep gorges into two major peaks. The gorges are relics of a former much wetter climate of the middle to upper Pleistocene. The eastern slopes (see Figure 7) can be divided into three different sections (upper, middle and lower slopes). The upper slopes reach down to approximately 1,200 m (4,000 ft), the middle ones to 750 m and the lower ones to 600 m, respectively, where they run out into the plains. The upper slopes decline with a degree of almost 15° in the average. These steep slopes are grazed by Samburu cattle which frequently enter even the officially protected areas of the forest. Destruction of the grass cover, mainly by grazing and trampling, leads to severe erosion of the volcanic soils and ashes so that only residual rock waste remains. In this part of Mt. Kulal these processes are accelerated because the rainfall is high.

Map 8. Areas with high erosion hazard

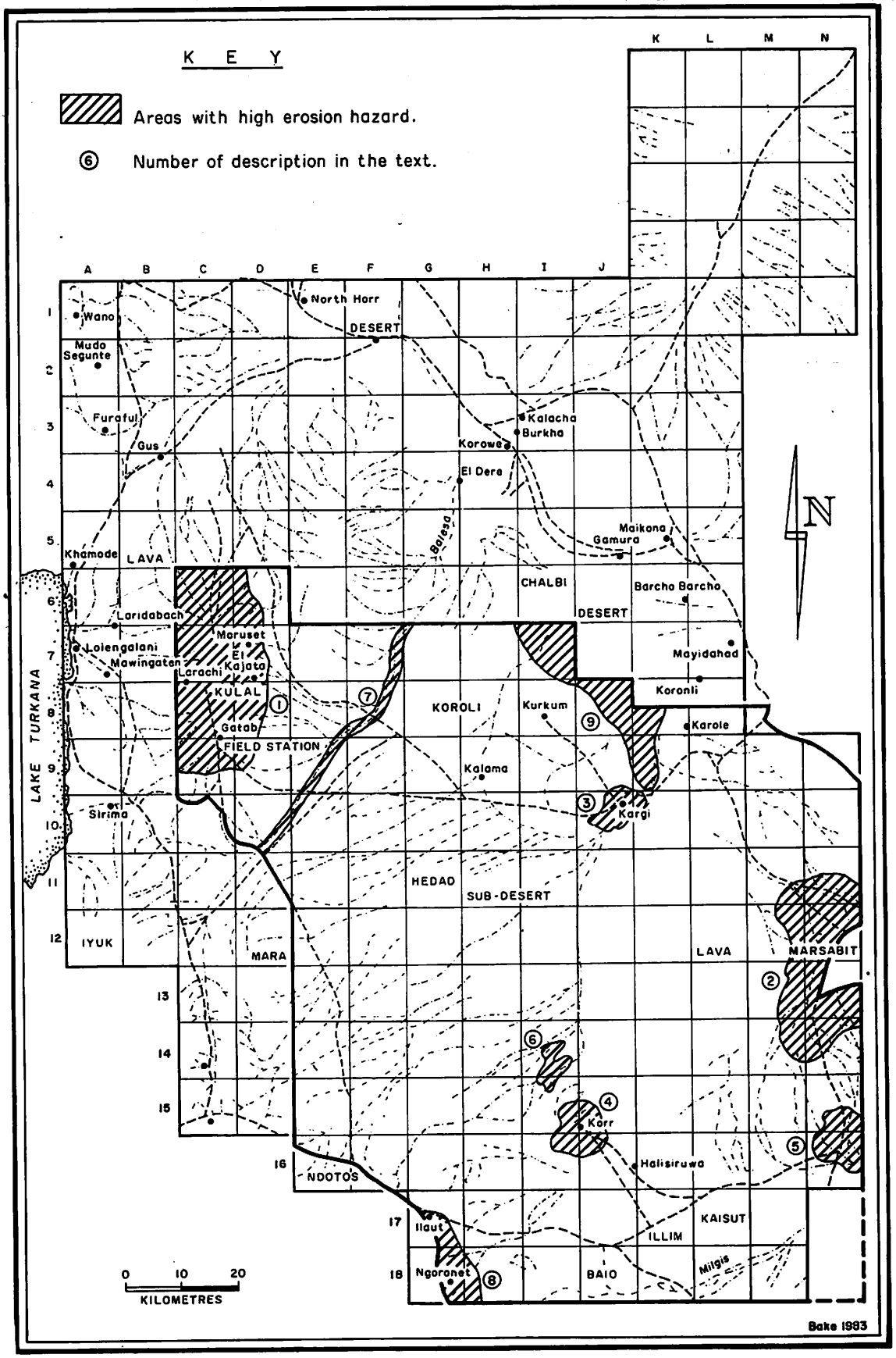
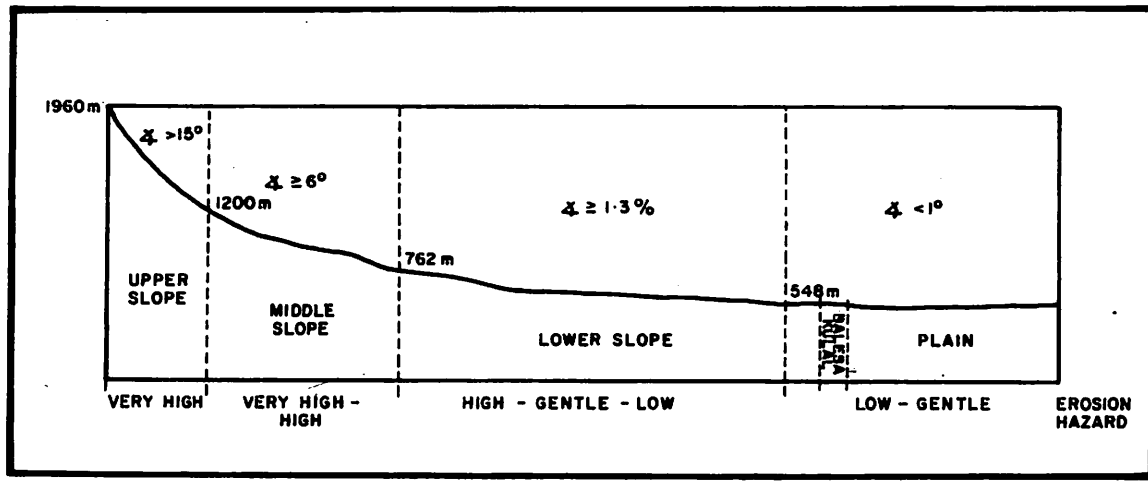


Figure 7. Profile of the eastern slopes of Mt. Kulal (Olturot area)



The middle slopes are only 6° and are much drier. On the other hand due to the greater aridity the soils are more erodable than they would be (with the same angle) in a more humid climate. The good pasture encourages people to move their livestock onto the steeper slopes which they would normally avoid. This is why people settled at Gatab, for example. The southern slopes are not as steep as the eastern ones. However there is already severe damage around Gatab which can be directly correlated with the increasing population. The deep gullies in this area were not present in 1972 when the aerial photographs were taken.

3.2 Area 2 (upper slopes and parts of Mt. Marsabit) (range unit 19)

Another dominating volcano in the Rendille grazing scheme is Mt. Marsabit which is of Quaternary origin. As distinct from Mt. Kulal we have to deal here with a volcano which is a mixture between the shield and plateau types.* This means that from the upper parts of the volcano the slopes are very gentle. Only at the steps between one plateau and another do we find steeper slopes. Rising up to 1,700 m the summit region is covered by a forest which extends down the eastern side due to exposure to the moist prevailing easterly winds.

* Note: Due to the lack of accurate maps with contours it is not possible to show a profile.

The reason why people move into such areas is that, at the step in the plateau, water is available in the wet season and sometimes all the year round. The traditional transhumance system has been changed because the people became used to this water supply. Instead of going up the mountain only in the dry seasons they are now there during the wet seasons. The sprouting grass is eaten by animals so that it cannot mature. The new shoots of the trees and shrubs are also consumed. This leads to a decrease in available forage and produces higher demands. It also means that there is less protection from erosion. The lack of former geomorphological studies in this area makes it impossible to decide whether and up to which level the area is degraded by erosion. Comparison with other areas makes it highly probable that there was formerly a thicker soil cover. Today it appears that the erosion has already reached a state at which it is decreasing due to the fact that there are virtually no erodable fine materials left. It is recommended therefore that grazing on slopes be restricted and permitted only at low stocking rates in flatter areas. Water supply will continue to be a problem because the volcanic materials are highly permeable and the water disappears underground very fast. The inaccessibility of the area makes the search for new permanent water sources difficult, but there should be some possibilities along known fissures or fault lines. The opening of new water sources would permit the use of these areas in the dry season so that they can achieve their full productivity.

The western slopes are covered in the upper parts by a dense bushed grassland With decreasing rainfall there is a transition towards the vegetation of the lowlands. Due to higher edaphic aridity one finds dryland vegetation even in higher areas. We have divided the western slopes of Mt. Marsabit into three major plateaus. The edge of plateau 3 (the highest) is around 1,200 m. Plateau 2 has an edge at around 700-750 m. Plateau 1 forms an escarpment approximately 10-20 m higher than the adjoining sedimentary plains but this escarpment is partly covered by sand in the south.

Plateau 3 on which Marsabit town is situated is used by a mixed agronomy of cattle and smallstock herding and agriculture. It also forms a kind of drought reserve for the lowland nomads. At the edge of this plateau there are several waterholes and springs which have facilitated the sedentarization of Rendille pastoralists. The dense grass cover prevents heavy soil erosion when it is in its natural state. Removing it by grazing, trampling and clearing for agriculture changes the natural system completely. Even on gentle slopes the light volcanic soil becomes eroded. So far this process is limited to a very few places including

Marsabit town and to the paths used by animals; but with an increase of livestock numbers, and especially in agricultural areas, soil erosion will increase. There is already evidence of aeolian activity in the agricultural area on Mt. Marsabit as well as erosion by water. It can be stated that deflation in this area is a man-made process only. Owing to the favourable climate and the flatness of some areas the upper plateau shows a good soil cover with a thickness up to 2 m and more. The fine particles are highly erodable if they are not protected by a dense vegetation cover.

3.3 Area 3 (sorrounding of Kargi) (range unit 24)

The area around Kargi shows desertification at various stages. Directly around the settlement almost no vegetation is left. It has been removed for firewood, *boma* and house building and by grazing. This process is very recent. In the late 1960s the village of Kargi did not exist. Nevertheless in some areas around the town only residual rock is left, with the soil cover removed by wind and water. In other places finer sediments have become highly mobile and form small sand dunes behind barriers like shrubs, rocks, etc. The growing population has increased the pressure on the ecosystem. In order to find grazing grounds for their livestock and to fulfil their need for building materials and firewood they have to go further out. This means the process is carried from the settlement to the surroundings. Up to a distance of 8 km or more the density of the vegetation cover has been reduced, leading to an increase in erosion. The calcareous crust to the west of Kargi, formerly buried under a thin soil, is now exposed. Owing to the low rainfall, limestone solution in this climate is very low so that this crust prevents soil formation. Reseeding, by natural or artificial means, is greatly hindered by this crust.

Aeolian activity is the commonest process in the area at present. Deflation and accumulation are widespread in the village itself. It has been observed that east of Kargi the first of the old dunes (see Area 9) has been reactivated recently. However, recommendations for rehabilitation can be made. Fortunately there is still a chance of success. Two years ago IPAL put up an exclosure near the school. After fencing, sand accumulated, giving annual grasses a base for growing: the grasses with their root systems stabilized the sand and served as a barrier to accumulate more sand. Loose materials now form the soil for new plant growth in various successional stages. In the managemant plan it is proposed that range unit 24 be completely closed to grazing.

3.4 Area 4 (sorrounding of Korr) (range unit 24)

Human settlements are the major cause of accelerated geomorphological processes at Korr as they are around Kargi. But the hills of Korr form a landscape unit which differs considerably from other areas. Lying approximately 100 m above the level of the surrounding plains, it consists mainly of basement materials (gneisses, granites, quartz, etc.). Today those rocks are almost completely bare. Very little vegetation or soil cover them. Even on slight slopes of 1° only residual rock waste remains. Most of the fine materials have been washed out by sheet wash after the removal of the plant cover. On the steeper slopes ($3-5^{o}$) rill erosion has started through the tendency of running water to canalize. No gullies are present owing to the resistance of the rocks and the absence of colluvial and alluvial materials. Almost throughout this unit one can observe the same aeolian process as that described in the above discussion on the problems of Kargi, i.e the formation of small dunes or *nebkhas*. The process will be discussed more fully elsewhere in this management plan. But it should be recognised that there is a general relationship between human impact and this dune formation. It is clear that some fossil dunes are being reactivated as well. Removal of the vegetation cover is followed by outwash and out-blowing of materials. Most of the sand is transported to the nearby lagas where it is carried by fluvial processes during floods, so that it cannot consolidate. From the lagas it will be blown out and form *nebkhas* (copice dune). During the rainy seasons they will be eroded and the materials transported to the lagas. These processes form a circle.

3.5 Area 5 (around Loglogo) (not surveyed for range)

Like Korr and Kargi this area had been degraded heavily by over-grazing and wood cutting. The process was initiated with the drilling of several boreholes which give "unlimited" water supplies throughout the year. Lying just at the border between the Marsabit lava and the lowlands plains there are several differences from the areas already discussed. The process of degradation is not as serious as it is around Korr and Kargi. One reason is the higher rainfall. With an average annual rainfall of 388 mm it receives almost double that of the other two villages and for this reason we find relatively dense vegetation even under heavy human impact. However on the lava with its high edaphic aridity there are only a few plants left, most of which not palatable for livestock. The fine materials are already washed out. The areas south of the lava still have a good soil cover. They are built up mainly from alluvial materials. Due to the lack of soil survey it is not known whether there are many

cut profiles. At least one has already been found. During heavy rainfall, areas with sparse vegetation or only grass vegetation, combined with the loose alluvial soils have a high risk of gully and rill erosion. The Marsabit-Isiolo road is very much effected by it and has been washed away several times. But one has to accept that in this climate, with an annual rainfall of approximately 400 mm, this would have happened even with a denser vegetation cover. Owing to the efforts of the missionaries Loglogo is a permanent settlement with all the functions of an administrative centre. Nomads have been settled there by giving them wooden houses to replace their traditional hut. It is a certainty that this village will not move again unless the boreholes dry up.

3.6 Area 6 (north of Korr) (range unit 2)

The problems of this area are mostly the same as those in Korr. There is no actual settlement in this region but it is influenced by Korr village and also by some manyattas north of area 6.

This is mainly the floodplain where several small laggas deposit their final loose sediments. Most of the sediments are transported by the wind and form *nebkhas* in this area, but also in others *nebkhas* form around dwarf shrubs especially *Duosperma* and *Indigofera*. The plants are buried by sand and forced to grow up through the sand surface. As they grow higher they form an increasing barrier against the wind which is loaded with sand particles. *Nebkhas* cannot grow indefinitely and in the IPAL area their maximum height seems to be around 50 cm to 80 cm. Upto 50% of the *nebkhas* materials are washed away during the rainy season into the adjacent valley floors. It is mostly the middle which is more resistant to water erosion because of the root system of the dwarf shrubs. Normally the sediment load in the laggas is transported over short distances only. After drying out, the wind transports it back to the accumulation areas. The wind carries only a very small proportion over longer distances.

3.7 Area 7 (Balesa Kulal) (range unit 12)

The Balesa Kulal can be regarded as representative of the study area. It rises in the South Horr Valleys with tributaries from the Ol Doinya Mara and Njiru Mts. This lagga "flows" along the edge of the Mt. Kulal and Asie lava fields towards the Chalbi basin. It is a typical "sandy river" cutting down into its own alluvial deposits sometimes by 2-3 m or more. Run-off is episodic. Probably only during "century floods" does the whole river bed become flooded over its entire course as it did in 1977. Like the other laggas, the Balesa

Kulal can transport an enormous load of sediments derived from the basement mountains in the south and the volcanic rocks in the west. There were times when the river flooded at a higher level forming a floodplain. These sediments are still loose and would be highly erodable if the dense riverine vegetation were to be removed. At the moment there is almost no grazing in the area due to insecurity. Also the sands in the river bed, with its branch streams, are extremely mobile as is shown by the ripple marks and smaller dunes. Balesa Kulal still represents an undisturbed ecosystem with just the natural amount of erosion but it is very sensitive even to small damage.

3.8 Area 8 (region of Ngurunit) (range unit 20)

This area lies within the basement mountain region and with its high relative altitude the erosion hazard is very high. Fortunately most of the upper slopes are so steep that they cannot be used. The valleys have a flatter relief which is adjoined by gentle to steeper slopes to the mountains and they consist mainly of alluvial materials up to 30 m in depth or mixed colluvial and slope waste. Due to the destruction of the natural vegetation which was formerly a closed forest of acacias mixed with an understorey of shrubs, the land surface on the slopes has been eroded in several stages by sheet wash, rill and gully erosion. It is not quite clear whether the dominance of *Duosperma* in some areas of the Ngurunit valley is natural or a man-induced change of vegetation but it can be seen that the *Duosperma* dwarf shrubs grow on mounds 10-15 cm higher than the main surface. This means that the main land surface in these areas has been eroded at least at this rate. Fortunately in most areas the alluvials are so thick that the bedrock is not exposed by such surface erosion. That is why this area can still be used. Nevertheless there is evidence of extreme localised erosion. Gullies more than 2 m deep are not infrequent features and occur here more often than in other parts of the IPAL area. These areas should correctly not be used at all but they are nevertheless included in the grazing rotation. Their rehabilitation would take more than 50 years. If the gullies are not filled in the technically correct manner they will ultimately turn into sand lagas.

3.9 Area 9 (the dune area north of Kargi) (range unit 14)

Around the old lake bed of the Chalbi desert there is a dune belt. The dunes still show their previous forms and therefore cannot be very old. Today they are covered mainly by annual grasses (40%) and sparse trees and shrubs. At least 30% of the ground is bare. The direction of the dunes varies just a

little (5°) from the prevailing wind direction. From their juvenile form and from this small variation it can be concluded that the formation of these dunes took place in the Holocene without any significant recent climatic change. A small fluctuation in the long term amount of rainfall of around 10-20% would be sufficient to activate bigger masses of sand which have accumulated around the Chalbi. With its recent formation and its thin vegetation cover this area is highly vulnerable to deflation and to the reactivation of the dunes. Near Kargi (close to the Marsabit road) the big dunes are moving, covering the larger shrubs and even trees.

D. WATER

1. Introduction

The role of hydrology within the framework of IPAL is to furnish information about capacities, variabilities and the location of known and unknown water resources in the study area, especially in the central Hedad, where there is an urgent need for the opening up of new water supplies after the initiation of a controlled grazing system.

Water, like vegetation, is a crucial resource for nomadic pastoralism as well as for the proposed controlled grazing system. Unlike climate, the hydrology of an area can be positively influenced by man. But also, (and this is a danger we should never forget) he can influence it in a negative way. That is why a soundly based knowledge of surface and subsurface waters is absolutely necessary before we can start to change the hydrology of a region for the purposes of man. In fact we have to consider this even when drilling a simple well; there are enough examples from all over the world of the fact that the well we dig may adversely affect the groundwater in the vicinity. Plants may die because they can no longer reach the groundwater table, and other wells may run dry.

2. Surface Water

Surface runoff in the IPAL study area must be characterized as *seasonal partly episodic* and *endorheic*. The erosion base levels are Lake Turkana, the Chalbi desert for most parts of the area, and for the region east of Korr, the flat parts of the Kaisut and/or the seasonal swamps of the Milgis river. For this area there is the possibility of a continuous runoff from Marsabit District towards the Indian Ocean following the old bed of the Proto-Habaswein river with its tributary the Proto-Milgis. Both of them must be dated to wetter periods of the Tertiary.

Almost invariably, when a runoff occurs in the laggas (river beds which are dry almost throughout the year in northern Kenya), the water does not reach the erosion bases levels. Either the amount of water is too small or the water infiltrates the highly permeable bed materials or it evaporates. Only very heavy rainfall gives enough water for a continous runoff. The question is whether most of these runoff systems were created by a wetter period in either the Pluvials of the Quaternary or in the late Tertiary (Pliocene?).

Most of the runoff systems in northern Kenya originate in the surrounding mountains, where there is much more rainfall and also more retention of water by a denser vegetation cover, such as forest or thick bush. Other laggas are fed by tributaries which also arise in mountain areas. This is the case for the Balesa Kulal and the unnamed lagga following the escarpment of the Marsabit lava from Korr past Kargi to the Chalbi desert.

The Balesa Kulal is the biggest and longest runoff system in the study area, reaching from the South Horr valley in the Njiru mountains to the western edge of the Chalbi desert and passing the slopes of Mt. Kulal. The river-bed is wide, almost sandy, meandering and extensively deviating, a typical example of a sandy river often overloaded by sediments coming from all sides and from its own bed. Since the beginning of the IPAL project there has been only one big flood (in 1977) which covered the whole river-bed. "Normally" just a small part is covered. We are consequently encountering many problems in monitoring the discharge; since the installation of the gauge it has not been touched by water. The course of the lagga is determined by Mt. Kulal and its wetter upper parts. The river quite often cuts old lava streams which form barriers. It seems that these are good places to find shallow groundwater throughout the year. The Balesa wells near Olturot show that there is a consequent stream even in the dry seasons. So far, however, neither capacity nor fluctuations are known, and we should therefore be careful in the implementation of any pumping system in the Balesa Kulal.

The other runoff systems are much smaller and their catchment basins less extended. Very important is the Ngurunit river rising in the Ndoto mountains. There are stories that this river was perennial until 1976, but there are also tales which assert the opposite. In fact there has been no significant climatic fluctuation nor any alteration in the vegetation cover of the mountains which could have caused such a change. At all events, since the beginning of intensive monitoring the river has stopped flowing after the long rainy season, at the beginning of August, and started again with the first rains of the short wet season (on 10 October in 1982). The groundwater flow in the river-bed is recorded continuously in certain wells below the IPAL station. The results still await a detailed analysis, but we can say that there is a direct correlation between well level and the flow of the river, which depends on the rainfall. In the dry months the level drops to 3 m or more below the surface of the river bed, but remains usable.

All runoff systems show the direct influence of rainfall patterns. After heavy rainfall the runoff will also be heavy, but a short time after the end of the rain the runoff will also stop if the catchment basin is not covered by dense vegetation. This is the case with the Ngurunit river, where runoff is normally spread over the wet seasons and the succeeding months. Nevertheless, the discharge shows the characteristic form of a "crue". The delay in the arrival of the flood of the IPAL station is about one hour, which is fairly high when we consider that other catchment areas react in much shorter times - sometimes in as little as 10 minutes. But there is no forest in such cases.

The flood rises within 5 minutes to a maximum, holding it for some time if the rain continues, and then falls slowly to its normal wet-season level. During high floods the discharge rises to 10 m^3/sec and more, while the "normal" is around 2 m^3/sec. The period of observation is still too short to justify a study of the occurrence of floods and their return periods.

It has already been shown by the continous flow of 2 m^3/sec or more in the last two wet seasons that the conservation of the mountain forest also means the conservation of the water supply in the foot regions where it is much drier. There are only a few rivers flowing permanently in the wet season. They rise in the southern mountains and on the eastern slopes of Mt. Marsabit. They also offer good possibilities for storing water for periods in the dry seasons. This is shown in the upper parts of the Ngurunit river by rock pools where there is water all the year round.

This water is used, by means of a pipeline, as the supply for the UNESCO station, mission houses, dispensary and Ngurunit village, and even for the watering of some smallstock at troughs near the village. When a dam is constructed (and there are sites available for several) it will be possible to store water throughout the year and distribute it by pipeline to the drier parts.

As in other places, the water should not be distributed at the dam site but brought by pipeline to the place where it is needed. These are the dry-season grazing areas in the forelands of the mountains. The pipeline would not be longer than 15 km, so that the costs should not be too high.

The lagas can be divided according to their bed materials into two groups. Originating in the mountains, most of them are covered with boulders, which are transported during heavy floods. During spates there is a heavy suspension load in the water, reaching 25%. Particle size is very fine, ranging from coarse silt to coarse sand in the Ngurunit river.

In the lowland plains the sand content increases and the river-beds are mostly covered by sandy materials. In the Balesa Kulal, the maximum has been found at 25-72 mesh, while at Ngurunit it is at 8 mesh. Other lagas follow these trends quite closely. If the river profile gradient decreases, the transport capacity decreases too. That is why most of the laggas coming from the mountains are difficult to follow when they reach the forelands: they are buried by their own sediments and the water evaporates rapidly because they are now in a much drier climatic region. The water flow beneath the surface is less, while there is runoff in the upper parts. The underground water is exploited to some extent by the digging of wells.

2.1 The distribution of surface water

Open surface water is rare all over the study area during the dry seasons and there are therefore no reliable water sources for watering animals. This does not include the springs around the Marsabit escarpment, which are excluded from Figure 8.

In the wet season the water is better distributed but still limited. We must, however, bear in mind that at least in the peak months of the wet seasons, after rainfall, there is widespread surface water, lying in pans and depressions of various sizes, which are often polluted but nevertheless used by livestock.

An example of the use of these waters is provided by the areas between Kargi and Korr. In the dry seasons camels are watered at Karole; in the wet season these water springs are unused.

Fig 8. Seasonal Distribution of Surface Water.

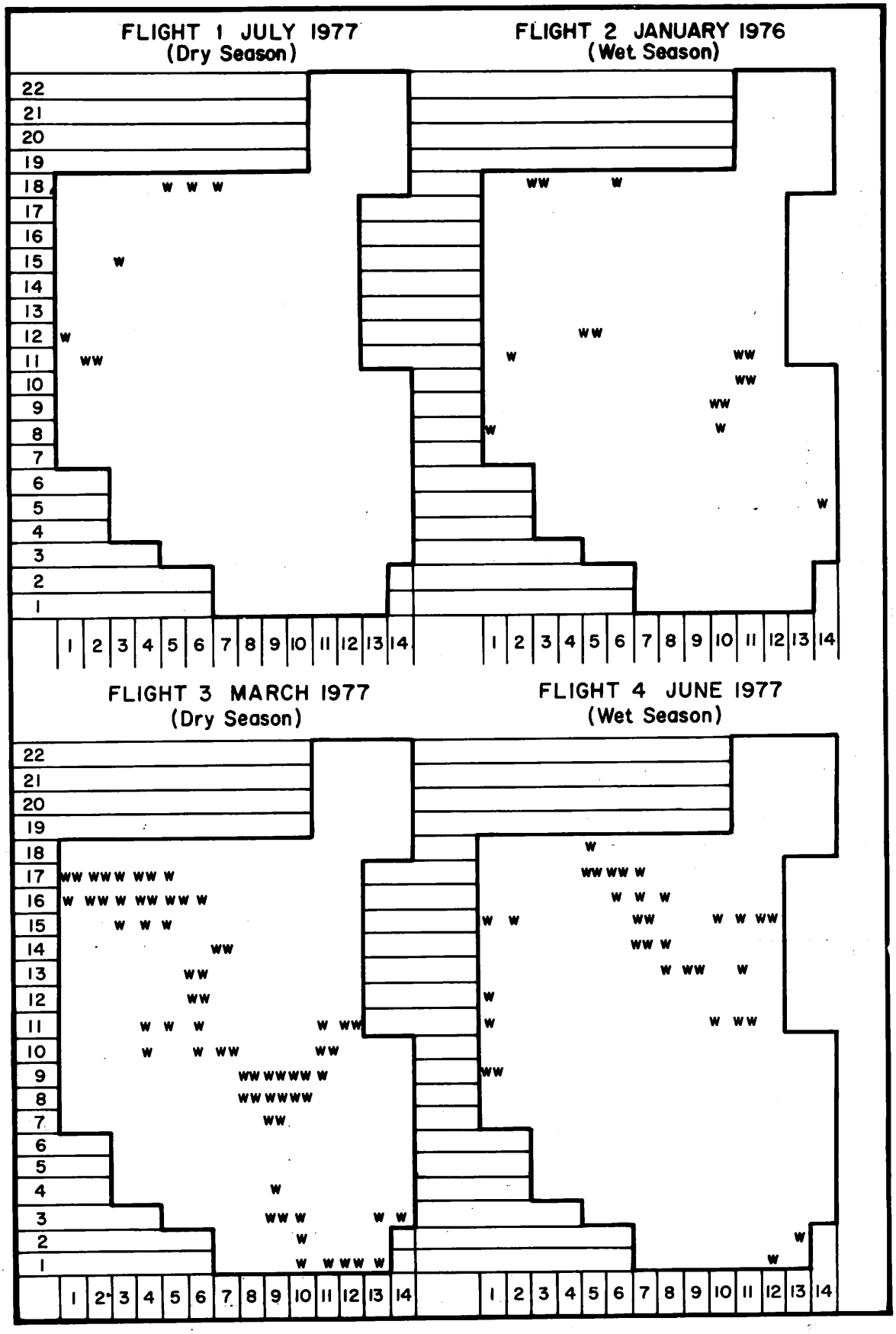
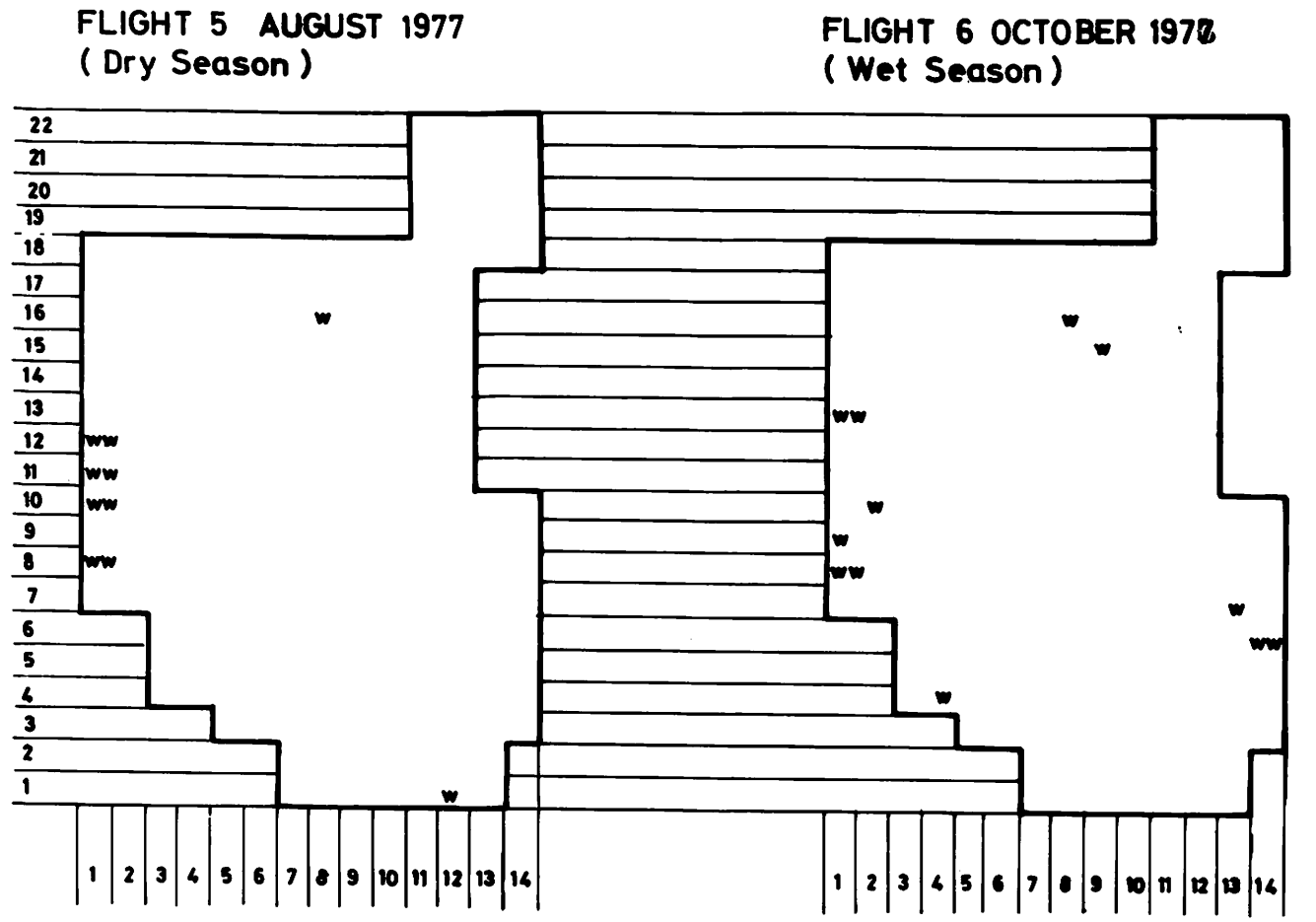
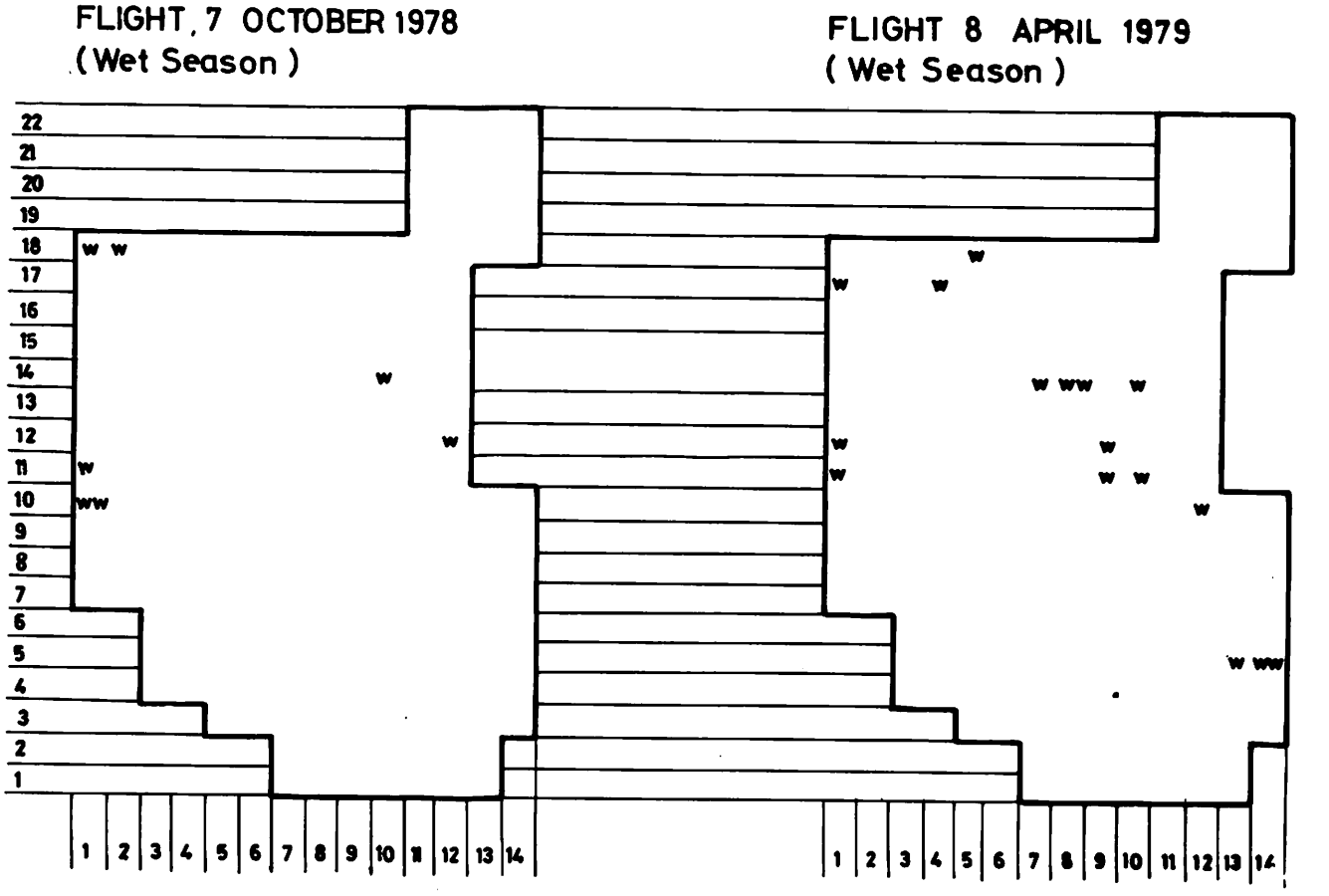


Fig 8. (contd.)


FLIGHT 5 AUGUST 1977
(Dry Season)
FLIGHT 6 OCTOBER 1978
(Wet Season)


FLIGHT 7 OCTOBER 1978
(Wet Season)
FLIGHT 8 APRIL 1979
(Wet Season)

3. Subsurface Water

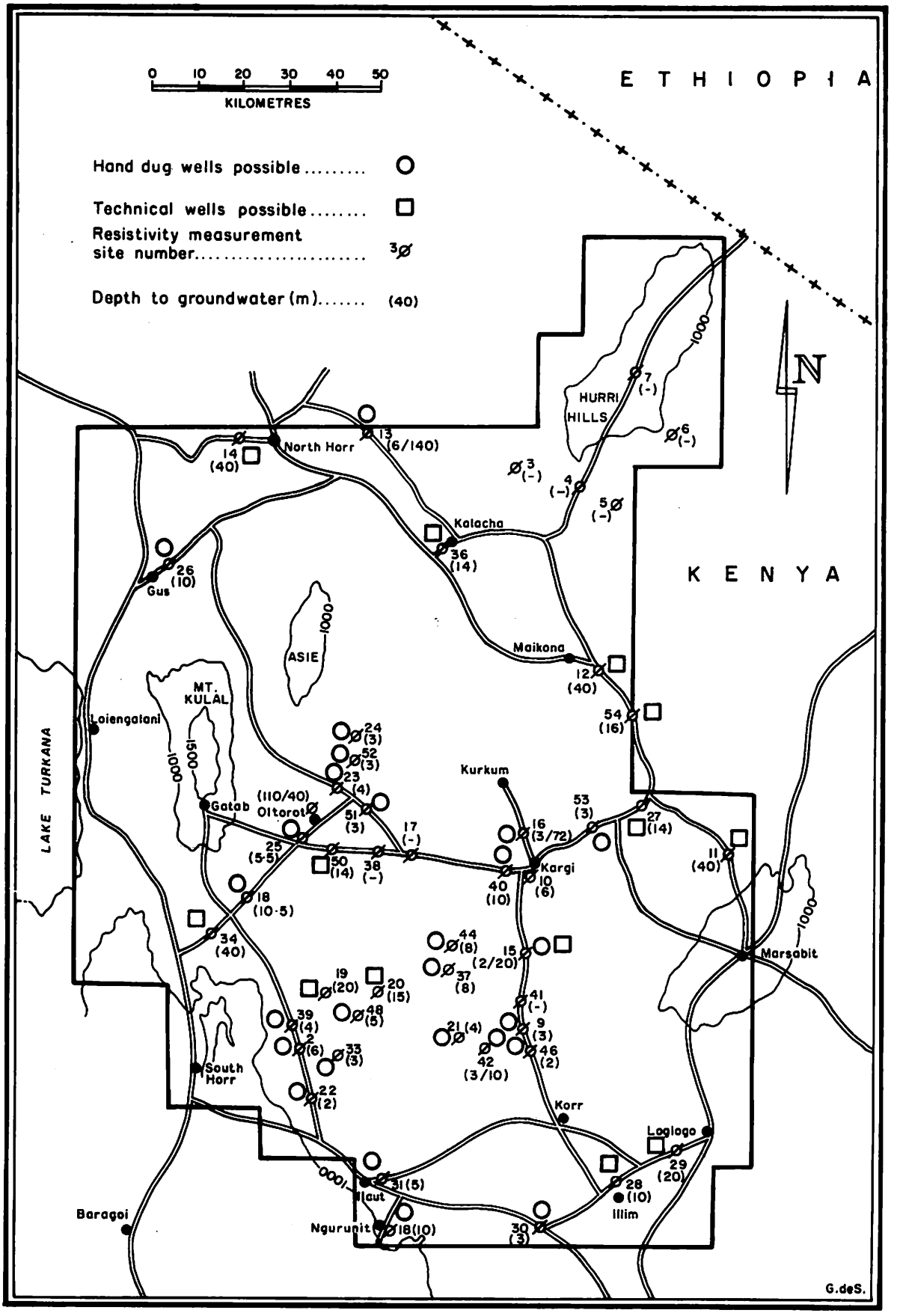
3.1 Introduction

Unlike the surface water, underground water tables are not easily detected. Normally geophysical methods have to be used. IPAL carried out several electrical resistivity surveys to get as much information as possible on the occurrence and if possible the amount of available groundwater (Map 9). There are already a number of boreholes operating in the area. Others have been drilled but did not reach any water. However, the borehole profiles give a lot of information on the hydrogeology of the area.

The IPAL area can be divided into several hydrological zones:

1. The volcanic areas of Mt. Kulal, Mt. Marsabit and Hurri Hills, with their highly permeable lavas and ashes;
2. The basement mountains and hills: the Ndotos, Baio, Illim, Nyiru, Korr;
3. The sedimentary plans of the lowlands, which cover the major part of the study area. There is a clear division into alimentation and ablation areas, due to the different distribution of rainfall.

Map 9. Electrical resistivity profiles, IPAL study area - Marsabit

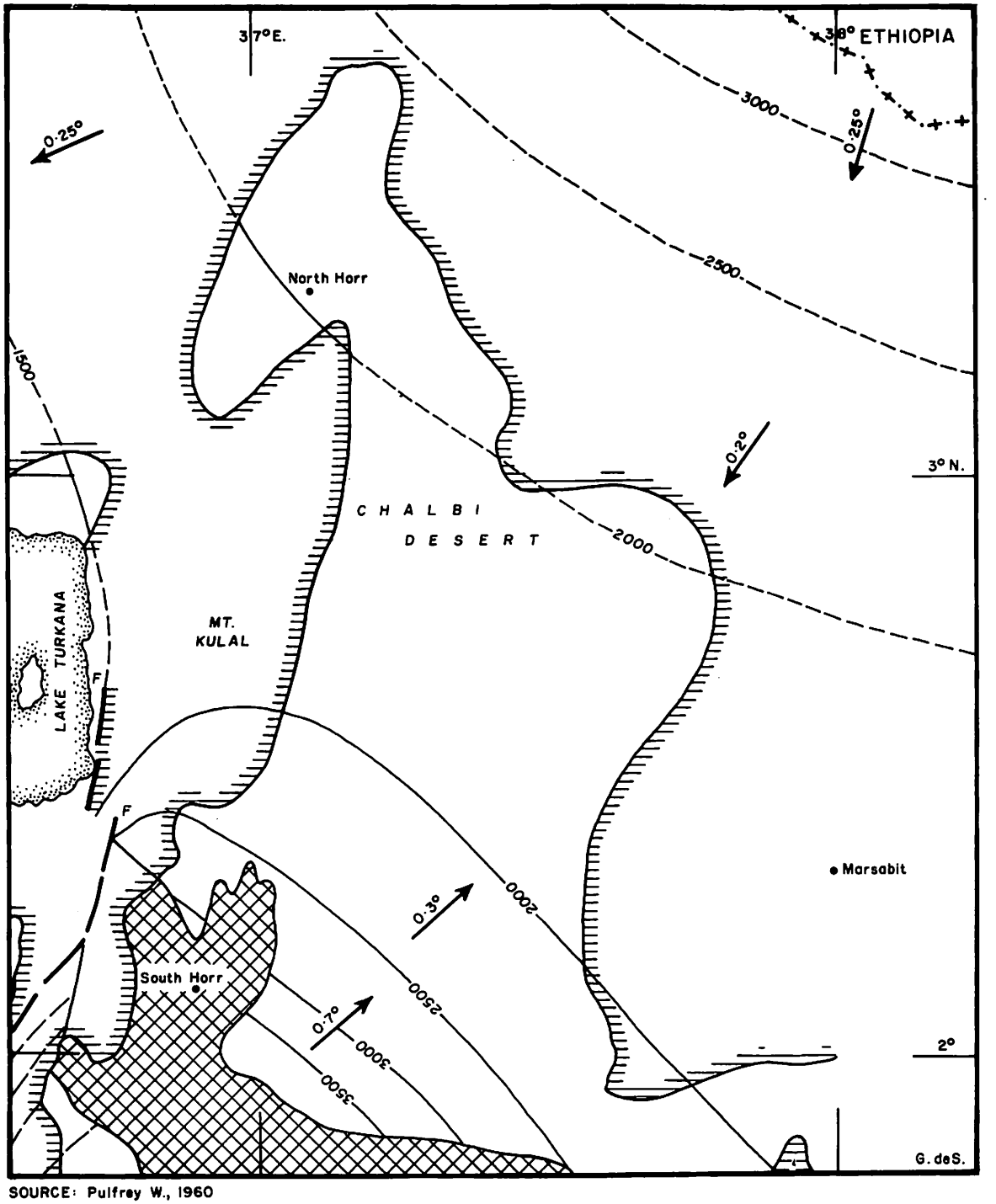


3.2 The origins of sub-surface water

The IPAL area, surrounded by volcanic and basement mountains, forms a hydrogeological basin with its deepest point in the Chalbi syncline. Pulfrey (1960) gives an approximate image of the situation with his reconstruction of a sub-Miocene erosion level, or as we would call it, the sub-Miocene peneplain (see Map 10). Tectonic movements connected with the genesis of the East African Rift system changed the situation but not in the general structures. The erosion of the surrounding volcanic and basement mountains, at least since the later Tertiary, filled the Chalbi syncline with various sediments, burying a relief which is still partly visible in the form of inselbergs, isolated mountains and inselberg chains. The thickness of these sediments varies from a few tenths to some hundred metres. The sediments consist mostly of sandy components so that they form a good aquifer. Nevertheless the old buried relief has an enormous importance for the occurrence of groundwater forming barriers or giving direction to the sub-surface flow.

Considering the present-day climate in the area it is almost certain that most water originates from the surrounding mountains which have at least four times the amount of rainfall than the lowlands. Map 11 shows the direction of water flow from the various mountains. We have to divide these into the volcanic and the basement type. On the ancient volcanoes most of the water is infiltrating very fast into the underground where it flows quite fast following the general slope. In the basement complex there is very little infiltration but a higher surface runoff.

Map 10. The sub-Miocene erosion level



SOURCE: Pulfrey W., 1960

0 10 20 40 60 80
KILOMETRES

Hills and mountains on the bevel.
Edge of main areas of volcanic rocks (shading on volcanic side).

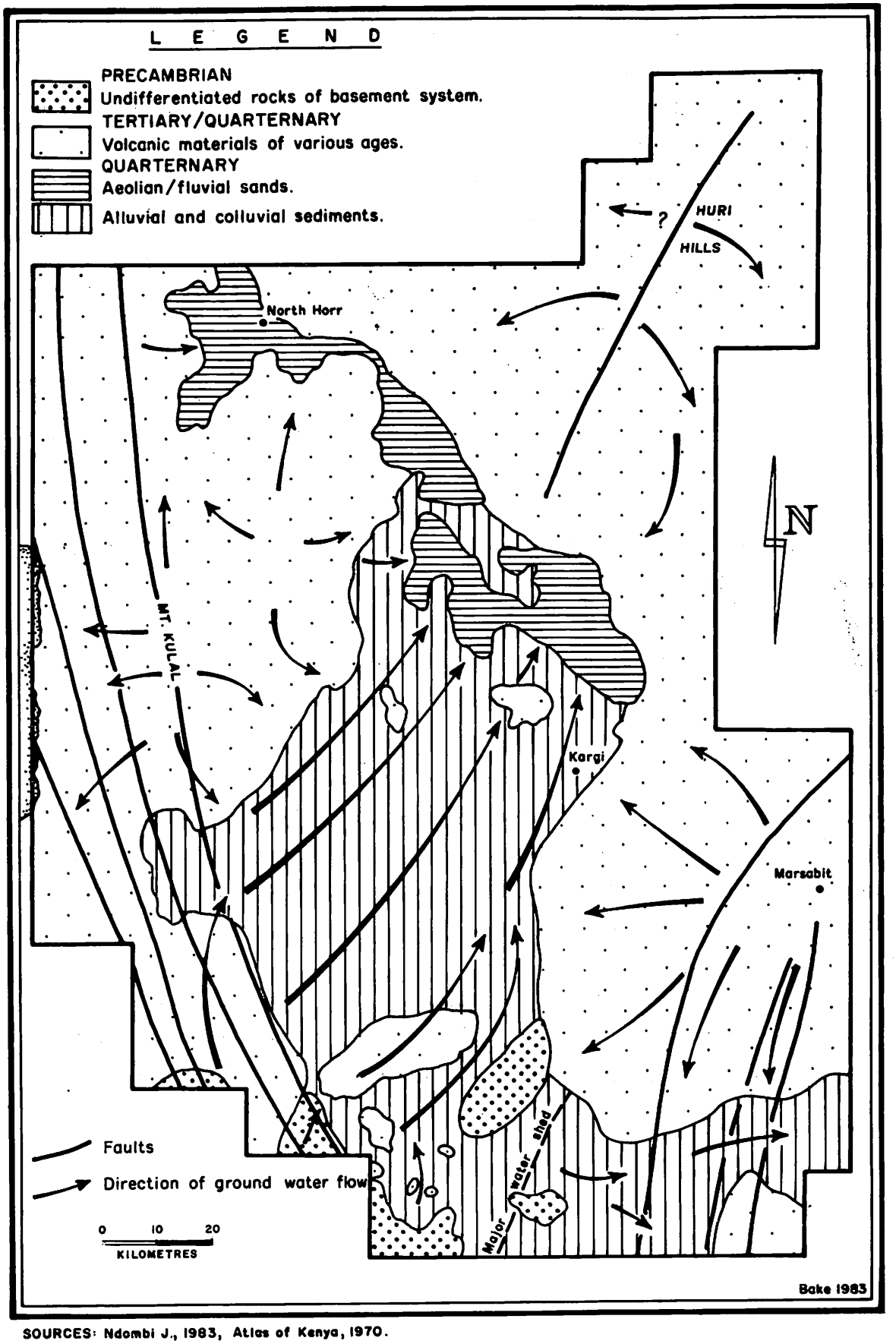
F Faults

3000 Contour lines of the bevel in feet.

1500 Conjectural contours in feet.

0·3° Calculated slope of bevel.

Map 11. Directions of the flow of sub-surface water



SOURCES: Ndombi J., 1983, Atlas of Kenya, 1970.

Only where the water reaches the lowlands with its sediments does it infiltrate and then it flows very slowly in the sediments following the general slope. In some areas, where there is much weathered material in the valleys of the basement mountains, infiltration already occurs at these places. The sub-surface water then flows channelized towards the lowlands. This occurs in places like Ngurunit basin, Arsim river and around Ilaut. These valleys then have a very high potential of shallow water, e.g. when the water is stored by natural sub-surface dams. Guaging the run-off systems provides the opportunity to determine approximately the recharge of the local aquifer.

Map 11 shows the general directions in the flows of the groundwater for the IPAL area. This is a rough sketch map where local influences have been omitted but it gives a first impression of the situation.

Modifications are necessary, mainly in the areas directly north of the basement complex where we have to deal with a buried relief which will certainly channelize the groundwater streams. To incorporate this in a map, much geophysical research, e.g. seismic soundings, would be necessary.

3.3 The speed of groundwater flows

Knowing the areas of groundwater origin raises the question of the speed of groundwater flow. Due to our poor knowledge of the underground conditions we cannot give definite figures, but we can give approximations within a certain confidence level.

From these it is possible to determine the recharge time for specific areas. In addition, an isotope analysis will be carried out soon which will determine whether the water supply touches fossil water or water which is quite old.

Table 14. Velocity of groundwater flow

Area	Min. speed	Max. speed	Mean speed
Hedad	0.015 m/d	0.3 m/d	0.16 m/d
Marsabit Mt.	*	38 m/d	-

* The minimum speed in lavas would be almost 0 if there are dykes, etc.

These speeds are equivalent to time values when the water would reach the syncline. A water particle infiltrated at the foot slopes of the basement mountain will take an average travel time of more than 1,700 years to reach the syncline of the Chalbi. Even at the "top speed" it will still take almost 1,000 years.

Compared to this the waters from Mt. Marsabit are quite fast. At the maximum velocity it would take only 2.7 years for the water to reach Loglogo. This is due to the combined effect of high conductivity of the lavas and the steep gradient. Note that this is the maximum possible speed. It is probable that the actual speed is less. If we take a mean speed of 19 m/d which is quite realistic, the travel time will be 5.3 years. This also means that the water supply in many areas is not reliable. The chances of pumping more water than is recharged should not be overlooked. Assuming that Kargi and the water holes of Koroli are supplied under the same circumstances (the altitude is actually the same as at Loglogo) the times to reach these places are 3.6 years at maximum speed and 7.2 years for the mean calculated speed.

It is not only the age of water which is determined by the speed of flow but also the recharge rate for boreholes and wells. The velocity of flow is mainly determined by the regional gradient and the hydraulic conductivity of soil and/or aquifer materials. Neither of them can be changed by human impact at present. To give a general impression of the values of conductivity(K) we list the following:

Table 15. Typical magnitudes for K for rocks in the IPAL area

Fine sand	1-5 m/d
Medium sand	5-20 m/d
Coarse sand	20-100 m/d
Gravel	100-1,000 m/d
Sand/gravel mixes	5-100 m/d
Till	0.001-0.1 m/d
Dense, solid rock	10^{-5} m/d
Fractured/weathered rock	0.001-10 m/d
Volcanic rock	almost 0-1000 m/d

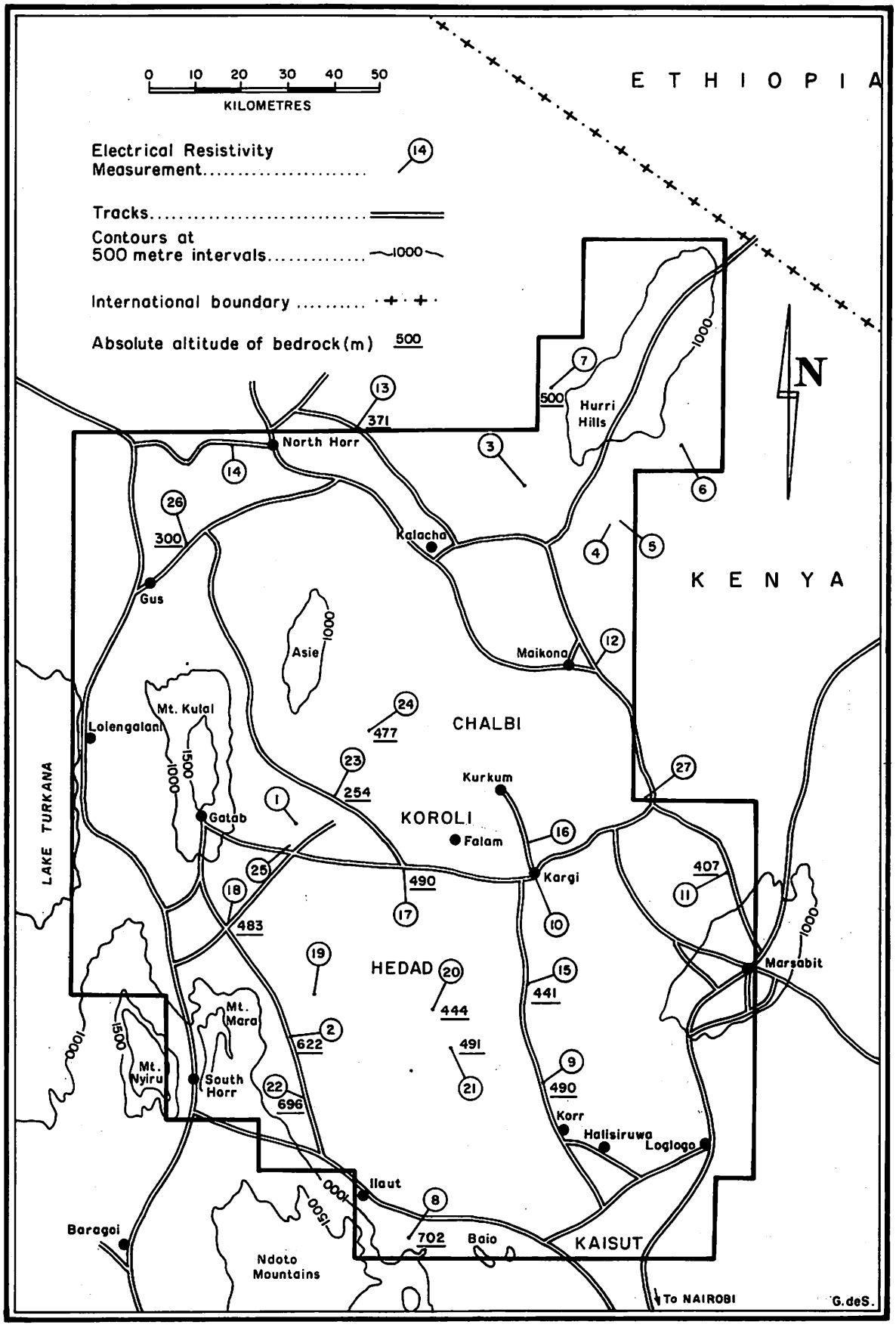
Estimates for the gradient can be obtained from well levels and electric resistivity soundings. Using the equation for the velocity of flow of groundwater given by Darcy (Darcy's law) the following speeds for groundwater flow were determined.

3.4 The different water levels

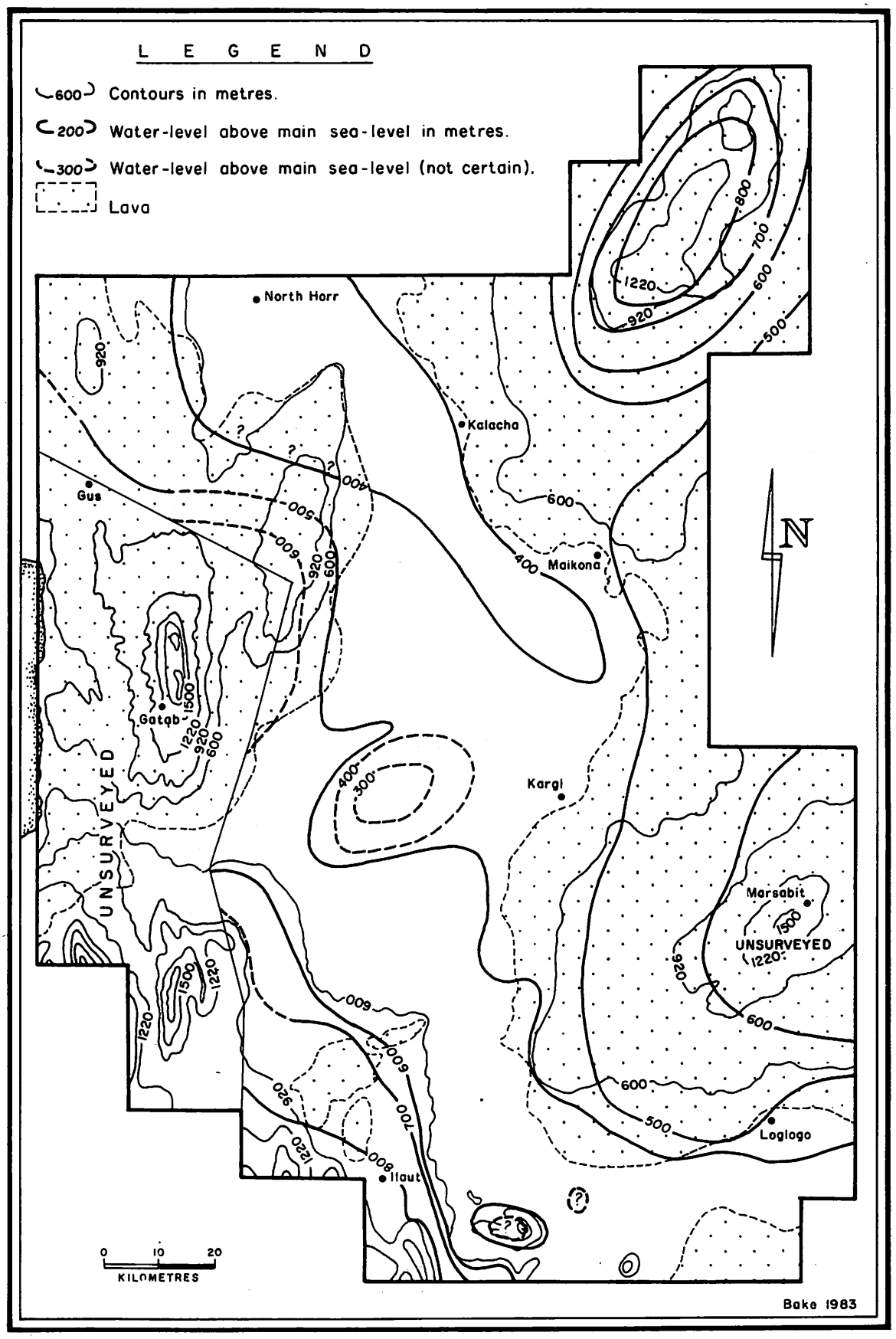
Groundwater is found at different levels in the IPAL area. Therefore we can assume with a high degree of certainty that there are several different groundwater tables. It is unlikely that these tables extend all over the study area. Local influences will cause a considerable variation (see Map 12 and 13).

In the basement mountain areas water can only be found in alluvial/colluvial or weathered materials of the valleys and depressions. Often there are only pockets which do not form a general water table.

Map 12. Altitude of bedrock above sea level



Map 13. Altitude of groundwater



In the forelands the water tables are influenced by several factors. First of all there is the porosity of the sediments, then the buried relief and the actual drainage patterns.

Locally around the lagas we find shallow water tables which are built up by the infiltration of the lagga water every wet season. These aquifers are unconfined and of limited extent.

In most cases these aquifers are not completely sealed at the bottom so that there is infiltration to deeper levels. For this reason they may be termed leaky aquifers. Their depths and their extent are not yet completely known but we assume that we have to deal with at least two of them. There is a second local aquifer at a depth of around 40-60 m which does not extend all over the study area. It is partly sealed to the bottom by clay layers, formed during the genesis of the plain by fluvial and aeolian processes. Here also we find the influence of the buried relief.

Then there is the major regional water table which is also semi-confined. The deep basement rocks form an almost impermeable material. The depth of this aquifer is shown in map 13. There are certainly leakages in the basement rock but the amount of lost water is not known and even estimates are quite difficult.

This water of the regional aquifer flows toward the syncline of the Chalbi where there is very shallow temporary water and, at a number of places, even permanent surface water. At its surface the Chalbi forms an endoreic drainage area. It is not known yet if there is a constant underground flow *out* of this syncline. It is possible that there is an underground stream from the Chalbi through the corridor between the Hurri Hills and Marsabit Mountain eastwards and then towards Wajir.

Due to the high water table it is also probable that a lot of underground water is evaporating in certain places. Direct evaporation of groundwater is possible and occurs when the water is close to the surface, e.g. 0.5 -2 m. The unsaturated hydraulic conductivities in the vadose zone may then be sufficiently large to permit upward flow from the water table in response

Table 16. Electrical resistivity results

Resistivity Station No.	Location	Depth of ground-water (m)		Depth to bedrock (m)	
		Ndombi dry season	Borgeson wet season	Ndombi	Borgeson
1	Olturot	1040	70	-	-
2	Hedad	6	4	45	45
3	Hurri hills	-	160	150	-
4	Hurri hills	-	40	150	-
5	Hurri hills	-	125	150	-
6	Hurri hills	-	30	150	-
7	Hurri hills	-	47	-	285
8	Ngurunit	10	8	20	24
9	Korr	3	5	20	35
10	Kargi	6	4	8	-
11	Segel	40	-	184	250
12	Maikona	40	33	-	-
13	Balal	614	-	-	130
14	North Horr	40	37	-	-
15	Kargi	220	12	32	32
16	Kargi	372	1040	-	-
17	Falam	-	-	-	-
18	Balesa Kulal				
19	Hedad	20	15	105	105
20	Hedad	15	11	120	120
21	Hedad	4	4	15	59
22	Karante	2	10	20	20
23	Balesa	4	4	8	245
24	Balesa	3	1	4	30
25	Balesa	55	3	-	-
26	Gus	10	20	56	150
27	Karonde	14		80	
28	Illim	10		-	
29	Loglogo	10		-	
30	Ngurunit	3		20	
31	Ilaut	5		10	
32	Elgess	-		-	
33	Hedad	3		30	
34	Hedad	40		-	
35	Hedad	-		-	
36	Kalacha	14		80	
37	Hedad	8		28	
38	Hedad	-		20	
39	Hedad	4		-	
40	Hedad	10		30	
41	Hedad	-		-	
42	Korr	310		20	
43	Hedad	-		56	
44	Hedad	8		-	
45	Hafarican	5		-	
46	Korr	2		5	
47	Balesa Kulal	3		-	
48	Kargi	4		20	
49	Balesa	828		-	
50	Balesa	14		56	
51	Balesa	3		40	
52	Balesa	3		4	
53	Kargi	3		-	
54	Maikona	16		-	
55	Kalacha	6		-	

no measurements

no measurements

- bedrock has not been recorded by this type of measuring equipment

to an evaporative demand at the soil surface (Bouwer, 1978). Salt accumulation provides evidence for this. The flow rates are significant especially when the soil surface is dry (arid climate). If the evaporation rate were only 5% of the potential in the Chalbi this would amount to an annual loss of almost 200 x 10^6 m^3 of water. In these circumstances we would not have to postulate a significant flow out of the syncline. Nevertheless we should not neglect the high probability that the basement is not completely sealed.

3.5 The different geological aquifers

There are only a few data available on the rocks of the different aquifers. More than half of them came from an area around Korr which is not representative for the study area. The others are grouped around the edges of the Marsabit lava (Kargi, Halisiruwa and Loglogo).

The Korr area is an extensive outcrop of basement rocks, where one would normally expect only a small amount of groundwater. Nevertheless several boreholes (12?) have been drilled there. Although most of them are dry there are several which produce a reasonable amount of water. There are also a number of shallow wells which have been dug by the local people.

Generally we can say that there is water in weathered basement rock which is recharged during the wet seasons. Then there is water along fault lines in the basement. Some lagas appear to follow such faults and this increases the amount of infiltrated water. For this reason most of the boreholes at Korr struck water in fractured and/or weathered basement and there is one which struck water in pyroxenite. The borehole at Halisiruwa is also influenced by the basement rocks. The water lies exactly at the boundary between the sediments and the basement. In this case the basement rocks act as impermeable material. At Loglogo the aquifer is decomposed lava lying over other lavas while the basement is almost 20 m below the water struck. The influence of the volcanoes of Mt. Marsabit extends to this area. Layers of different lavas, basalts, tuffs, etc. form the upper part of the geological profile. At Kargi the water can also be found in lava which has a thickness of 65 m. According

to the borehole description, below there is a sandstone on which there is a second water table. There is only one borehole in the sediments of the plains. It was drilled west of Ilaut and it is dry. At 200 m it is still in the sediments so that it could not have reached the regional water table. The buried relief which can be seen at the surface as inselberg chains plays an important role here.

3.6 Determination of maximum water supply from a well

Unlike boreholes with high capacities (often 10 m^3/h) a well can give only a certain limited amount of water. It taps a shallow water table which is highly dependent upon the local infiltration, that is on the rains and the runoff. Most wells which are managed in the traditional way do not have any storage tank to cater for a high water demand for a short period. Thus livestock watering has to rely on the actual water yield of the specific well, which rarely exceeds 1 m^3/h. The quantity of water that can be drawn from the well partly depends on the capability of the people managing it. The water demands of the livestock species are not evenly distributed over the year. In the wet seasons surface water is abundant and can be used easily. There is also the additional water provided by plant moisture. Camels can live in a good wet season without watering. With the beginning of the dry seasons and the drying out of the forage, animals have to walk to water more often, finally watering every second or third day (cattle), every third day (smallstock) and on every 10th to 14th day (camels). Through physiological adaptation their water needs change seasonally. Cattle watered every third day need only 15 l/d while cattle watered on a two-day routine need 20 l/d.

Unfortunately shallow wells have their minimum recharge at the peak of the dry season and may become dry. This means that when the demand is at a maximum the supply is often at a minimum.

Owing to the unpredictability of the rainfall and consequently the primary production in Northern Kenya, movements of livestock cannot be foreseen exactly. That means that the locations of water demand will vary as well.

The theoretical stocking rates do not give sufficiently reliable information for this purpose because on a yearly basis they give no figures for the possible maximum local livestock concentrations. Looking at past records is not helpful because the aerial surveys of IPAL (from 1976) show that there are potential grazing areas not used by livestock at present.

It is these areas for which the water supply now has to be planned. Stocking rates obtained from the range surveys suggest unrealistically high water needs which would be impossible to cater for without the financial input for at least three boreholes.

Managing this demand by the use of traditional wells seems almost impossible unless we build a large number of wells. Making the wells more reliable in the dry season involves increasing their depths so that they can tap deeper water tables but this would also increase the costs.

In one way it is desirable that a well is not permanent. Its drying out forces the people to move away so that the local degradation is reduced. It is preferable that a well dries up before the pasture in its vicinity is finished.

Using the stocking rates derived from the annual amount of rainfall, the following water demands are obtained. (Water demand is given in m^3/day; the figures are valid for the dry season; in the wet season they are lower. The stocking rate in this area is the same throughout the year.)

Table 17. Water demands for a well based on published carrying capacities at various radii, in m^3/d (rainfall 250 mm/a)

Radius	Le Houérou/Hoste	Pratt/Gwynne
5 km	23.6	14.7
10 km	71.3	42.1
15 km	153.4	87.2
20 km	282.8	164.6

This indicates that one well can normally serve one area with a 5 km radius. With an increase in the radius the number of wells required increases in a non-linear manner. For a radius of 10 km 3 wells will be needed; for 15 km, 6 wells and for 20 km, 12 wells. If the values given by Pratt and Gwynne are used the numbers of wells will be 1,2,4 and 7 respectively.

The IPAL range survey provided carrying capacity estimates for each range unit. The water quantities needed to achieve these levels are listed in Table 17. The quantities that would be required are unrealistically high so we have calculated an attainable mean stocking rate for the lowland areas with which we have included the Marsabit lava plateaus since they have a relatively high rainfall but also permeable soils.

Table 18*. Mean stocking rates for the Rendille grazing block per ha

Camels	3.8
Cattle	8.3
Sheep	5.8
Goats	3.5

In terms of TLU these values are:

Camels	3.0
Cattle	8.3
Sheep	0.6
Goats	0.4

This gives us a mean stocking rate of 12.3 TLU/ha which is almost the same as that given by Le Houérou and Hoste so that the data from Table 15 are also valid when calculated by this method.

3.7 Water consumption in the Rendille grazing block

(a) Water for livestock

Here we are giving figures which apply to the entire grazing scheme because the spatial distribution of the livestock is highly variable in time. Nevertheless times and areas of livestock concentration have to be well known because there will be enormous demands of water there within very short periods. Alternatively livestock may in some cases be able to move relatively long distances to watering points.

*This table gives the recommended rates.

Water demands of livestock

The livestock species have the following water demands per animal:

(a) Sheep and goats 4 l/day
(b) Cattle 20 l/day
(c) Camels 10 l/day

These figures are theoretical because livestock in arid areas are not watered every day. The watering frequencies are as follows;

(a) Sheep and goats 3 days
(b) Cattle 2 days
(c) Camels 11-14 days

This creates problems in the use of the water supplies because the water demand on certain days will be higher than estimated from the average.

The actual water demands for the grazing block

The demand for water in the grazing block as a whole is determined from the actual number of livestock and the specific needs per day. An amount of 10% is added for waste caused by the animals and the watering people.

Table 19. Water demands per day

Species	Number	Water (m^3)	10% wastage	Total (m^3)
Sheep/goats	107,547	430.2	43.0	473.2
Cattle	24,552	491.0	49.1	540.1
Camels	18,643	186.4	18.6	205.0
Totals	150,977	1,107.6	110.7	1,218.3

The total demand for water by all the livestock per day has thus been determined as 1,218.3 m^3 per day.

(b) Domestic water use

The use of water by people is directly related to the distance from the well. The further the water has to be carried the less the people will use.

Table 20. Domestic consumption of water per person

Distance to water source	Consumption /day
15 km	2 - 3 1
1 km	3 - 6 1
next to house	10-20 1

The mean consumption per person per day is assumed to be 10 1. The population of the Rendille block is estimated at 13,000 inhabitants (excluding Marsabit). This means that the water demand is 130 m^3/day + 10% waste = 143 m^3/d. Hence the water demand for the whole area is 1,361.3 m^3/day. We can say, therefore, that the entire block needs 1,500 m^3/day.

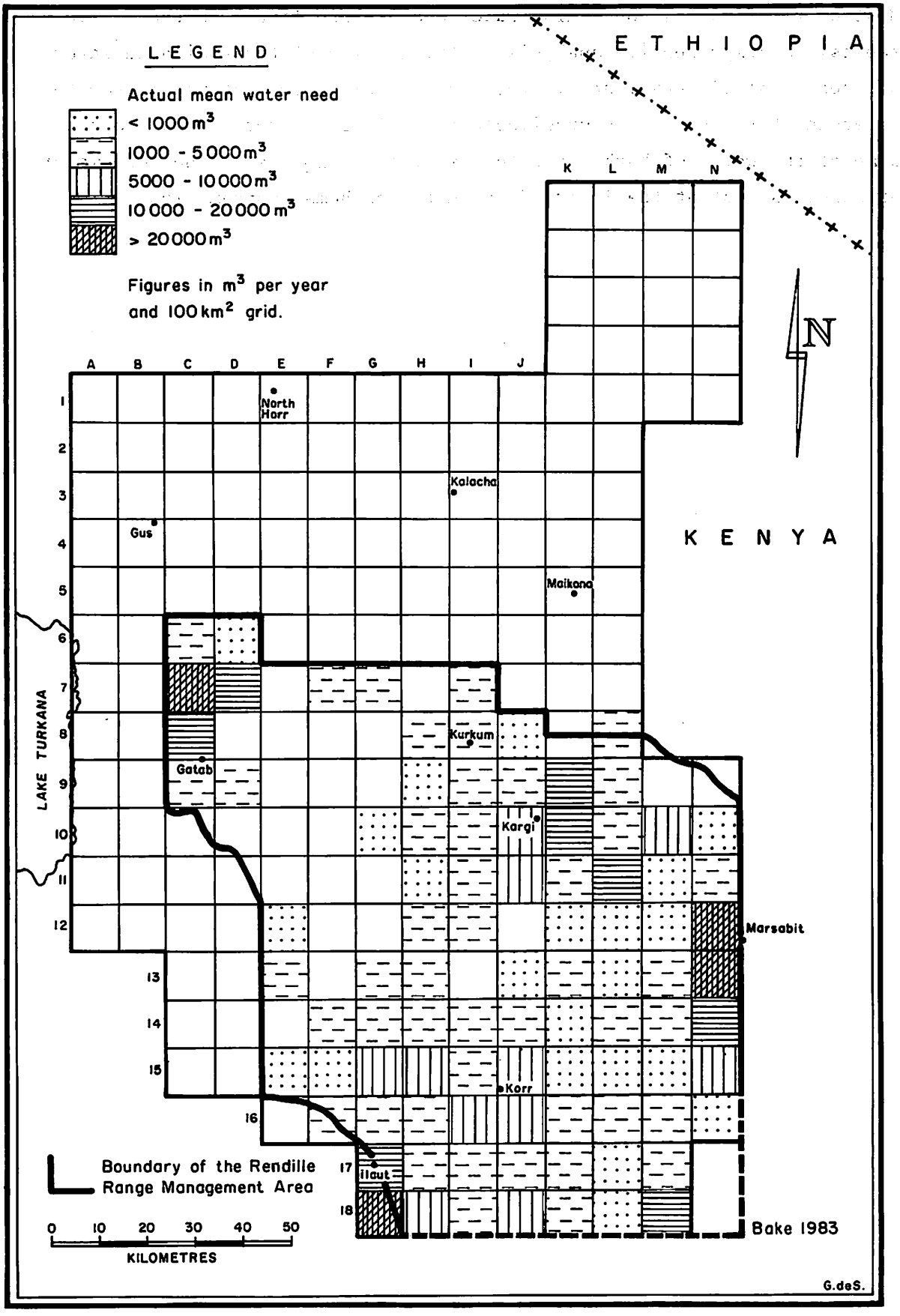
This does not include the water needs of the wild animals in the region.

3.8 The spatial distribution of water needs

(a) Livestock

Mean livestock densities per sq km have been taken from the aerial census (see page 263) and multiplied by the water needs per day of each of the livestock species. Multiplying by 100 gives the actual water need per 100 sq km per day. To show the possible variabilities the standard deviations have also been taken into account. By this method maps of the actual water needs in the area have been drawn (see Map 14). With regard to the quality of water it is understood that each species has its characteristic tolerances. These data will be analysed in one year time units.

Map 14. Water needs of livestock in the western Marsabit management area



3.9 Water quality

Most of the findings concerning water quality are listed in the following tables. A comprehensive analysis of the quality of the available water sources is still unavailable. The local people know that water from the borehole of Halisiruwa is unsuitable for calves and smallstock and that some of the wells of Kurkum are too mineralized for use. The town water of Kargi is just at the limit of salinity for human consumption.

Table 21. Water-quality analysis

Sample date	Location	E.C. umhos per cm.	meq $x 10^2$ by calcul.	Na mg/l	K mg/l	Mg mg/l	Ca mg/l	pH	Alkalinity mg/l $CaCO_3$	Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulphate mg/l Na_2SO_4	Fluoride mg/l	SAR by calcul.
	NGURUNIT													
--9--77	Water hole near old			985	16.5	96.1	127.5	8.5					1.55	
--9--77	source of piped water*			1175	71.0	151.0	140.0	8.9					1.27	
	KORR													
--12--79	village* handpump	1838						7.5						
--12--79	2 km. W. main village	1874						8.5						
--12--79	handpump near AIM Station •	1862						7.8-8.1						
28-4-81	B.H. C-1071 handpump (und. windmill)	1849	1655					8.3	222	440	301	340	1.0	3.70
--9--77	S.W. Korr, 6-7 km*		2579	277.5	26.0	81.0	128.3	8.4					1.45	4.72
	KARGI													
21-12-79	Well near exclosure	2631						8.5						
24-4-81	Hand dug well 500 m S. of town	998						9.0	32	444	216	306		0.53
22-4-81	B.H. C-3960 Town pumped water	2971	2635					8.0	862	68	233	240	1.0	30.3
--9--77	Koroli springs N.E. of Kargi*		13,841	3000	300	0.6	5.8	9.2					4.17	
--9--77	Koroli springs N.E. of Kargi*		3,502	800	9.2	-	-	9.6					2.3	
--9--77	MAIKONA *(1)	16,449	2,800	250	420.9	35.8	8.35						2.4	28.53
--9--77	" " *(2)	30,258	5,600	520	550.8	9.6	9.2							50.90
--9--77	" " *(3)	2,908	560	20	37.0	23.6	8.48						2.2	16.76
--9--77	" " *(4)	3,168	425	130	87.1	44.4	9.02							8.53
--9--77	" " *(5)	1,726	270	30	48.3	15.7	9.0							7.61
--9--77	near Palms* W. of Maikona (1)	1,409	190	20	52.3	20.4	9.02						2.4	5.05
--9--77	" "	2,158	240	25	52.3	9.2	9.5						2.6	6.76

(Table 21 contd.)

Sample date	Location	E.C. umhos per cm.	meq $x 10^2$ by calcul.	Na mg/l	K mg/l	Mg mg/l	Ca mg/l	pH	Alkalinity mg/l $CaCO_3$	Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulphate mg/l Na_2SO_4	Fluoride mg/l	SAR by calcul.
--9--77	? (4)*		4200	860	40	28.7	24.3	8.3						13.2
--9--77	? (5)*		3460	780	15	1.2	4.6	8.6						16.0
25-6-81	Easterly spring (Brown)	17,688						8.9				3,985		0.6
25-6-81	Central spring (red)	75,040						9.6						
25.6.81	S.W. Spring (grey)	5,411						8.6				1,390		
	BALESA KULAL													
2-6-81	Olturot well handpump	1,386	1568					7.5	520	128	136	136	0.8	11.60
2-6-81	Well in river near road crossing	793						8.2	290	332	23			
	OTHER AREAS													
30-4-81	Bubisa borehole	3,430						7.9	582	504	596			
19-7-78	Soriadi borehole	3,150	3272					8.4	352	130	542	1,032	0.6	26.48
17-5-78	Gudas borehole	1,000						7.9	426	124				
	KURKUM													
21-5-81	Well upstrm.house	1,325						7.6	168	-	173			
21-5-81	Well dwnstrm.house	1,608						7.2	412	443	210			
21-5-81	Old. Brit. well	3,323	2891					8.3	256	544	644	528		7.74
5-6-81	UNESCO well hand pump	11,577						8.4	174	528	1700			

*Samples taken by Dr. H.J. Schwartz in September 1977 analysed by laboratories of the University of Nairobi and the National Agricultural Laboratories (Kenya)

E.C. = electrical conductivity measured in micromhos per cm. at $25^{o}C$.

S.A.R = Sodium absorption ratio = concentrations expressed in milli-equivalents

Table 22. Tentative guides for evaluating the quality of water that can be used by livestock

Quality factor	Threshold[(a)] concentration	Limiting[(b)] concentration
Total dissolved solids (TDS) mg/l	2500	5000**
Cadmium mg/l	5	-
Calcium mg/l	500	1000
Magnesium	250	500*
Sodium mg/l	1000	2000*
Arsenic mg/l	1	-
Bicarbonate mg/l	500	500
Chloride mg/l	1500	3000
Fluoride mg/l	1	6
Nitrate mg/l	200	400
Nitrite mg/l	none	none
Sulphate mg/l	500	1000*
Range of pH	6.0-8.5	5.6-9.0

(a) Threshold values represent concentrations at which poultry or sensitive animals might show slight effects from prolonged use of such water. However, such concentrations are of little or no concern.

(b) Limiting concentrations based on interim criteria, South Africa. Animals' lactation or production might show definite adverse reactions.

*Total magnesium compounds plus sodium sulphate should not exceed 50% of the total dissolved solids.

**There are indications that the maximum concentrations of salts that can be tolerated by domestic animals without danger of injury by osmotic effect lies between 15,000 and 17,000 mg/litre.

Table 23. Chemical standards of drinking water

Quality factor	Recommended[a] maximum limits (milligrams per litre)		Maximum permissible concentrations (i.e. which constitute grounds for rejection of supply) (milligrams per litre)	
	1946	1961 Revision	1946	1961 Revision
Alkylbenzenesulfonate (detergent)		0.5	-	-
Arsenic	-	0.01	0.05	0.05
Barium	-	-	-	1.0
Cadmium	-	-	-	0.01
Carbon chloroform extract (exotic organic chemicals)	-	0.2	-	-
Chloride	250	250	-	-
Chromium	-	-	0.05	0.05
Copper	3.0	1.0	-	-
Cyanide	-	0.01	-	0.02
Fluoride	-	1.7	1.5	2.2
Iron/manganese	0.3	-	-	-
Iron	-	0.3	-	-
Lead	-	-	0.1	0.05
Manganese	-	0.05	-	-
Nitrate	-	45	-	-
Phenols	0.001	0.0001	-	-
Selenium	-	-	0.15	0.01
Silver	-	-	-	0.05
Sulphate	250	250	-	-
Zinc	15	15	-	-
Total dissolved solids (TDS)	500	500	-	-

(a) Concentrations in water should not be in excess of these limits when more suitable supplies can be made available.

Source: Borgeson, 1983

Table 24. Salt tolerance levels for desert livestock

Camels	1850 mmol/litre	(63,600 mg/l Cl-)
Fat-tailed sheep	220 mmol/litre	(7,800 mg/l Cl-)
Turkana goats	257 mmol/litre	(9,110 mg/l Cl-)

Source: Borgeson, 1983

E. RANGE RESOURCES

1. Introduction

Plants are the foundation of the range. Range livestock are a product of plant growth and livestock productivity is commensurate with the welfare of the plant. The grazing resource is therefore the most basic resource of the pastoralist and this is particularly true of the pastoralists in northern Kenya, who have never been known to practise any form of livelihood except livestock husbandry. Proper care and management of the range resource is the basis of range science.

Range management can be defined as the art and science of planning and directing range use to obtain sustained maximum animal production consistent with the perpetuation of the natural resources (Vallentine, 1971). This definition, which best fits the traditional pastoral economy of northern Kenya, gives the production of domestic livestock and wildlife a priority status in a developing and expanding discipline while recognizing other potential goods and services that can be provided by rangelands. Scientific range management takes its stand on the premise that vegetation can be used perpetually for grazing while simultaneously providing society with high quality air and water, open space, and recreation.

In its widest sense range is taken to include all vegetation present in the region in question, from the smallest herbs to the largest trees. However, in the past a large proportion of all range research and management, as they have been developed in other regions, has been concerned with the grass and dwarf shrub layers (the so-called range plants) with relatively little attention given to the trees and larger shrubs, except perhaps to regard them as undesirable elements to be eliminated from the range if possible.

Hitherto the main reason for this concentration of effort and interest upon the herb and dwarf shrub layers appears to be that rangelands have been largely managed for cattle production and consequently the emphasis has been placed upon the grasses which are the normal forage of cattle. Browsing animals have hardly figured at all as factors in range management except in areas managed for wildlife.

It can hardly be emphasised sufficiently that animal husbandry and range management in northern Kenya are as much concerned with the trees and the large shrubs as they are with the grasses, the herbs and the dwarf shrubs. The rangelands are characterised by tree and large shrub communities, which we have termed woodlands and shrublands, which make up a large proportion of the vegetation present and which provide important components in the diets of the two browsing livestock species, camels and goats, upon which the Rendille and other pastoralists are largely dependent. In assessing the capacity of the rangelands to support livestock, equal emphasis has been given here to the herb and dwarf shrub layers on the one hand and to the tree and large shrub layers on the other. In addition to the importance of the trees and large shrubs as browse plants, they are also important as sources of fuelwood and materials for livestock fencing. Range management in northern Kenya includes the active maintenance and rehabilitation of the woodlands and the large shrublands which are as essential to the pastoralists as the grasslands and the dwarf shrublands.

Proper range use calls for controlled grazing, which entails careful manipulation of grazing use to provide for the growth requirements of forage plants, to prevent soil deterioration, and to allow sustained maximum animal production. This can only be achieved through a thorough understanding of the range resources, and the main objective of the IPAL range programme is to provide the information base for such a controlled grazing system. IPAL's range ecology programme was therefore designed to answer the following questions:

1. What range types do we have and what is their plant-community composition and structure?
2. What is the contribution of each individual plant species to the forage of the major livestock species and what is their nutritional value to the livestock?
3. What is the production of these plant communities and how much of this production is available for livestock consumption? How does it vary seasonally?
4. What is the condition of each range type and what is its optimal carrying capacity in terms of livestock numbers?
5. What are the physical factors governing the vegetation on each range site - climate, soils and water?
6. What is the present use of each range type and how can it be adjusted for better production and the prevention of any further trends towards degradation?

7. What can be done to improve the range condition?

The results discussed here are based on only six months of work by the range team. They are therefore very preliminary and conclusions drawn from them for the purposes of this management plan will be modified as results are obtained from further surveys. Details of methodologies used are discussed elsewhere in available IPAL reports and will not be repeated here.

2. Range Mapping

The range mapping and classification work done in collaboration with the woodland ecology work, which included aerial photo interpretation with ground truth checks, has identified 144 range types, which have been mapped and described here. A range type is a more or less distinct vegetation unit which may be delineated on the basis of aspect, composition, or density. Based on a minimum mappable size of 25 km^2, which is the average normal daily grazing range of livestock in the study area, and also taking into account similarities of plant composition and unfertility of soils and land forms, the range types have been grouped into 24 range units. The range types have been mapped at 1:100,000 and the range units at 1:250,000. Each range unit is characterized by the three dominant species in the order of their importance.

3. Range-Type Description

For any recommendation on the use of a specific range type to be made, it is important that all factors that influence the functioning of that system be understood. This has been taken into account in the descriptions of each range unit, which includes the following:

- a description of all the physical attributes - general topography, underlying rock, soil characteristics, drainage systems, erosion status and various climatic factors such as temperature, precipitation and its reliability, and wind;
- a description of all the vegetation factors which includes species composition, cover and biomass;
- a description of past and present human influences through both livestock and settlement;
- a subjective assessment of range condition and estimated carrying capacity for that site.

Both the range analysis method (USDA, 1970) and the concentric circle method of vegetation community analysis (C.S.U., 1970) were used in determining community structures and composition, while standing biomass was determined

by clipped plots along the same paced transects through each type.

4. Primary Production

Knowledge of the primary production of a range site is essential in order to determine carrying capacity. Measuring plant production is a complex study involving the monitoring of plant materials produced by a system which is protected from most kinds of utilization, usually in protected exclosures over a period of many years, in order to reflect seasonal as well as yearly fluctuations. In the absence of such data, for purposes of this management plan, it was decided to use the above-ground standing crop biomass of the dwarf shrub and herb layer to estimate production. The data are mainly based on two wet season surveys.

5. Range Condition

Range condition is defined as the state of 'range health'. Like health, condition is relative, and when a particular piece of range is said to be in 'good condition' or 'poor condition', the description is always relative to a standard or ideal for that kind of range - its greatest potentiality in soil stability and in amount and quality of forage. A stable soil is basic to all range types. The primary objective in range management, then, it to maintain and improve those soils that are stable and to stabilize those that are now eroding.

A stable soil is a prerequisite to satisfactory condition on any area where a soil mantle has been developed. This principle is applicable to ranges anywhere and relates to any normal vegetal cover; it does not change with site or with type of vegetation. If cover is lost, soil soon follows, and with the soil gone, there will no longer be a resource. The range condition for the range sites contained here is a subjective judgement based on the following attributes: soil stability, composition of desirable and non-desirable plants, bare ground and litter cover and the state of erosion.

It is based on four categories: excellent, good, fair and poor. With the exception of one mountain range type, none of the range types had a condition better than 'fair', indicating the seriousness of the degradation of the grazing resource condition in the study area. For most of the study area, any management of the range resources will have to be preceded by effective range rehabilitation and improvement programmes. With continued investigations which are necessary in the future, a range "score card" can be developed for this area which will provide a better basis for determining

range condition.

6. Carrying Capacity

The concept of carrying capacity has arisen as a result of our recognition that plant communities have a limited tolerance to exploitation by animals. Exceeding this tolerance will cause deleterious changes in the vegetation, such as a reduction in productivity or diversity or both and may be irreversible in practical terms. There are numerous difficulties in defining, estimating and applying carrying capacity in actual land-use situations.
It is generally agreed that carrying capacity is the maximum biomass density of animal life (normally referring to livestock or wildlife) which can be maintained in the area in question, without detriment to the long term productivity of the area. The concept defines the level of exploitation which will permit the survival of the ecosystem. It does not refer to a level of use in which the productivity of the ecosystem is maximised, such as a properly managed livestock ranch. In such circumstances the maximum sustainable production in meat and milk will be achieved at a biomass density level which is substantially lower than the carrying capacity and would be termed the maximal production or optimal stocking rate.

In the definition of carrying capacity given above, the term is taken to mean the long term sustainable density of animal life. In arid environments, where climatic variability is high and is accompanied by proportional variability in plant production, the long term carrying capacity is determined by the plant production levels of the drier years and not by the average years. Thus, although it is possible to speak of the short term carrying capacity determined by the recent or current level of plant production, the results of attempting to maintain stocking rates at this level will be over-stocking when dry years occur.

While production varies from year to year with variable rainfall, it also varies spatially according to recent rainfall distribution, local drainage and soil conditions and the history of land use. Carrying capacity estimates thus have to take into account local variation and are generally applied to relatively large areas in which the variability is accounted for in the averaging process. Despite the possibilities of estimating average carrying capacity across large areas of land, the interpretation of such estimates must allow for several qualifying factors which will tend to set the actual stocking rate attainable at a lower level than the theoretical carrying capacity.

A discussion of these factors and their implication for determining final stocking rates in any particular site appears below.

Specific recommendations on proper stocking rates for the different range types of a region are an essential part of any range management plan. The recommendations can be based upon long experience in range management under similar circumstances, or upon published estimates for the eco-climatic zone in question, or finally, in the absence of adequate prior information on the region, upon actual measurements of the primary production of the area in relation to known fodder requirements of the livestock species.

In the IPAL study area the only available data to indicate levels of primary production of the range types present are measurements from the clipping of the herb and dwarf layers of the vegetation, which have been carried out in two range surveys in 1982 and 1983 and the biomass and production values for the tree and large shrub layer, obtained from the destructive sampling of the important tree species and transect observations made in each range type. These data have been used as the basis for calculating the carrying capacity values given in this management plan. In order to arrive at realistic estimates of the forage available for livestock, several adjustments to the measured standing crop biomass values have been made. Since a large proportion of the foliage standing crop biomass in the herb and dwarf shrub layers is annual production, the distinction between standing crop and annual production has not been made here. Future measurements of these layers will be made to determine the relative dry weight values of standing crop biomass and annual production in the different range plant communities.

In determining carrying capacity from herb and dwarf shrub layer clipping data the following steps have been taken. Firstly, a proper use factor of 50% has been deducted, following the standard practice in range science. From the figure thus obtained for available forage, a further deduction of 25% has been made to allow for the errors associated with the use of small clipped plots. This gives a usable forage quantity amounting to 37.5% of the total standing crop biomass of the annual grasses and herbs and is the value used in calculating the carrying capacity of these elements in the vegetation. For the dwarf shrubs, since the foliage and new growth production is low in relation to the standing crop biomass, especially in years and seasons of low rainfall, the estimated usable forage biomass was further reduced by half to 18.5% of the standing crop. In the special case of the large dwarf shrub

Duosperma eremophilum, which is largely woody, 22% of the biomass is known from previous measurements to be available forage and therefore only 11% has been taken in the calculations of carrying capacity in order to allow for low production in dry years. Of the standing dead annual grass, only 18.5% is considered to be available.

Having estimated the available herb and dwarf shrub forage using the above adjustments to the standing crop biomass, the next step is to apportion this forage among the different livestock species. In consultation with the human ecologist it has been agreed that multiple use of the range by the four major livestock species - camels, goats, cattle and sheep - would have to continue in the immediate future, until greater technical knowledge and a broader awareness should enable the traditional pastoralists to accept any advantages to be gained by separating the species for the optimal utilisation of the range. Camels overlap with goats in their use of the herb layer, while cattle overlap with sheep. This point has been resolved by accepting the existing ratio of camel to goat biomass and cattle to sheep biomass which, in both cases, is approximately 5:1. This ratio has been determined from the average livestock biomass values observed in the study area in 11 aerial census surveys carried out over four year. *Indigofera spinosa*, which is one of the most desirable plants for all the livestock species, is apportioned for use in the management plan according to the biomass proportions of the animal species.

The final carrying capacity estimates based upon the herb and dwarf shrub layers were deduced by using the average dry matter intake values obtained by the livestock ecologist: camels, 4.81 kg/day; cattle, 4.45 kg/day; sheep, 0.76 kg/day; goats, 0.84 kg/day. Carrying capacity has, in all cases, been expressed as the number of animals per km^2 per year and an estimated number of animals which can be supported by each range unit is also given based upon its area. Until more data on primary production become available, these figures should be regarded with extreme caution. They represent the best estimate based upon biomass data so far available for the area.

It should be noted that the approach to estimating carrying capacities described above is somewhat traditional with respect to the tenets of range science and is based largely on the assumption that livestock carrying capacities are dependent upon the productivity of the grass, herb and dwarf shrub layers (i.e. the so called range plants). This approach does not take into account two circumtances which are particularly characteristic of the range-livestock ecosystem of the arid zone in north-east Africa. Firstly, trees and large shrubs constitute a substantial proportion of the range vegetation and secondly camels and goats, which are browsers, obtain nearly 30% of their food from trees and large shrubs. Thus, in terms of biomass, 59% of the livestock are obtaining 30% of their diet from approximately 8% of the available forage in the region. It is therefore evident that, considering the region as a whole, tree and large shrub forage is a greater limiting factor in determining the carrying capacity for camels and goats than are the herb and dwarf shrub layers. A further essential consideration in determining the carrying capacities of woodlands and shrublands is the impact of the browsing animals, particularly the goats, upon young trees. In heavily stocked areas goats browse young trees and large shrubs so intensely that they may prevent their growth and may eventually kill them. Under these circumstances, little or no recruitment to the larger size classes takes place and an important tree or shrub species may be greatly reduced or eliminated in such an area. For this reason the age class structure of the tree and large shrub populations has been regarded as a critical criterion in determining the stocking rates of goats and, to a lesser extent, of camels. Poor structure, with few young trees present, may necessitate low stocking rates in goats and camels, and this is reflected in the recommended management proceedures in the management plan.

(a) Applying woodland parameters in range stocking estimation

The principle of estimating carrying capacity on the basis of range production levels is generally the same for woodlands and large shrublands as for the grass, herb and dwarf shrub layers. In general the foliage production of the tree and large shrub layer is similar to that of the herb and dwarf shrub layers (but may be considerably higher) when measured by the square metre of canopy.

However, since the tree foliage in most of the woodland and shrubland areas has a lower canopy coverage than that of the other foliage layers, it generally contributes less to the total biomass and production than the lower layers do. In the *Acacia* dominated woodlands and shrublands of the management area, the tree and large shrub foliage contributes approximately a quarter of the total foliage standing crop, but over large areas of grassland and dwarf shrubland may contribute considerably less than that.

In varying degrees the different livestock species select tree and large shrub foliage as part of their normal diets (see Figure 50, page 235). In both camels and goats c.29% of their dry matter consumption is normally in the form of tree and large shrub foliage and fruit; in sheep 9.3% and cattle 1.0%. If it is assumed that these proportions of the total intake of the livestock species are required for the optimum health and productivity of the livestock species concerned (although probably not essential for their survival), then it follows that the total tree and large shrub browse production which is available to the livestock is a limiting factor affecting the carrying capacity of the range as a whole, especially with respect to goats and camels. Thus, in determining the carrying capacity of each range unit the values obtained in the estimations of the available fodder in the two main vegetation canopy layers are considered and the lower of the two values is taken for this purpose. This figure may be further modified to obtain an optimum stocking rate for the area concerned by applying one or more of the factors which are discussed in section 7 below.

The following example of an estimation of camel and goat carrying capacity for an area of shrubland dominated by *Acacia reficiens* is derived from the measured foliage biomass and production of the trees and large shrubs of that area and the known tree and shrub foliage consumption of the average camel and the average goat.

Table 25. Estimates of camel and goat carrying capacity for *Acacia reficiens*-dominated scrubland

Total standing crop of tree foliage (d.w.)		110 kg ha^{-1}
Total annual production of tree foliage (d.w.)		130 kg ha^{-1}
Subtract production of *A. reficiens* (65 kg ha^{-1}) (*A. reficiens* is unpalatable).		65 kg ha^{-1}
Take half of the remaining (palatable) production		32.5 kg ha^{-1}
Annual tree fodder (d.w.) intake of average camel		553 kg
Hence camel carrying capacity is $\frac{32.5}{553}$		0.059 camels ha^{-1} y^{-1}
	or	5.9 camels $km^{-2}y^{-1}$
Annual tree fodder intake of average goat		73 kg
Goat carrying capacity is $\frac{32.5}{73 \times 2}$	or	22 goats $km^{-2}y^{-1}$

In estimating the goat carrying capacity the total annual d.w. foliage production has been divided by 4 (instead of 2 as in the camel estimate) to allow for the lower availability of tree foliage to goats.

It should be noted that the carrying capacity of this shrubland is either 6 camels or 22 goats. With both species present each species would have to be reduced proportionately. Thus the carrying capacity could be assessed at 3 camels and 11 goats or 4 camels and 7 goats. If the age structure of this shrubland is poor, but other determining factors are favourable, the goats should be further reduced in number to permit regeneration of the tree and large shrub populations and the final stocking rate recommended might be 3 camels and 3 goats.

7. The Factors Which Determine Final Recommendations on Stocking Rates

The calculated carrying capacity based upon measured biomass and production levels in the vegetation should be regarded as the potential stocking level to be recommended if all other determining factors are favourable. Several factors, which will vary in their importance from one range unit to another and from year to year, are discussed here with a view to assessing their likely effect upon sustainable stocking rates.

a) Accessibility. Certain range units contain inaccessible steep or rocky terrain which may limit or prevent access by livestock to significant areas of otherwise useful rangeland. The relative inaccessibility and the relative area which is inaccessible will determine the correction to be made in the stocking rate estimate.

In the tree and large shrub canopies all foliage above 1.2 m high is inaccessible to goats and above 3 m high it is inaccessible to camels. This aspect has been allowed for in the normal assessment of tree and large shrub available forage, as shown in the example above; the assumption is made, based upon the observed proportions of foliage at different heights in shrublands, that half of the foliage is not available to camels and three quarters not available to goats. However, with the palatable species a large proportion of the foliage becomes potential sheep food when it falls to the ground.

b) Distance from water. In the rainy seasons water distribution is not a limiting factor. In the dry seasons a large proportion of the management area cannot be used by cattle, sheep and goats owing to its distance from water sources. Camels, which drink at weekly intervals, can reach all parts of the region throughout the year and are not limited by water distribution. Areas which can only be reached by cattle and smallstock in the rains have annual stocking rates below potential carrying capacity. While it is likely that some additional water will be provided in these areas by the construction of wells and temporary dams, initially the increase in potential stocking rates in these areas will be small. Thus, in these areas the stocking rates recommended are approximately half of the estimated carrying capacity. The area mainly affected is shown in the range map (end of Volume II).
It should be noted that limited water distribution is a major management tool which ensures that certain rangeland areas are rested from grazing pressure for part of the year without the necessity to impose further grazing restrictions. This means of grazing control is well known to be effective and, if water has been available in the area concerned, causes no disruption to established grazing patterns and no resentment such as that resulting from closing down a borehole to protect grazing.

c) Varying water availability. Seasonality in water availability has been discussed in the previous section (above). The highly variable annual rainfall leads to variable water distribution from year to year. Shallow dams and wells dry up earlier in the dry season in dry years and, in a phase of dry years such as the 1968-76 drought, may remain dry for several years. Under these circumstances the pastoralists are obliged to depend on the few remaining permanent water sources and their range of movement becomes correspondingly limited. The areas affected by long term water shortage during drought periods are effectively isolated from grazing and the stocking rate will be determined by any small localised rain which falls in the wet season and the limited growth that results from it. Under such circumstances temporary and localised water and grazing must be monitored so that stocking rates can be quickly determined and implemented at short notice.

d) Provision for drought years. The effects of drought are discussed briefly above. The project's proposal for drought contingency plans is the use of at least one drought reserve area into which livestock can be moved only during drought periods. If this policy can be maintained and the drought reserve areas remain unused in normal years, the high standing crop of grasses and dwarf shrubs which exists in these areas will support a high stocking level which nevertheless must be regulated at a predetermined figure based upon the planned period of use. Since the length of future droughts is unpredictable the contingency plans should provide for a succession of fall-back areas each of which has its own planned stocking rate based upon the available forage. As it is anticipated that such drought reserves will only be used during drought periods and will be able to recover under nil grazing pressure in normal years, stocking rates during drought can be set at relatively high levels.

e) Environmental protection measures. The application of a proper use factor by deducting 50% from the total standing crop of forage has been mentioned above in the explanation of carrying capacity estimation. This first step is the means to ensure that annual grasslands are not totally denuded of their vegetative cover and that perennial plants retain a sufficient proportion of their foliage for their future survival. A further essential measure to be included in this category is the protection which should be given to tree and large shrub populations in which the age class distribution is unbalanced, with insufficient small trees available for recruitment to the mature age classes.

Thus, although a woodland or shrubland may have a high production with a proportionately high carrying capacity, if the young parts are being killed or retarded by excessive goat and camel browsing, the optimal stocking rate to ensure adequate regeneration may be considerably lower than the carrying capacity from the foliage production levels.
In general, poor age structure has been compensated for by a reduction factor of two applied to the estimated goat and camel carrying capacity.
The trampling effect of smallstock and cattle can be observed in certain heavily stocked areas, particularly on slopes, in the increased rate of soil erosion as compared with non-grazed areas. Although the erosion due to livestock is being measured at two IPAL sites, no quantitative data are yet available. It is anticipated that the optimum stocking rate of hillside grazing lands will be lower than the calculated carrying capacity and that a slope factor will be introduced into estimations of stocking levels in future.

f) Security. Inadequate protection from raiding renders approximately 40% of the regular management area inaccessible to pastoralists and, at present, is the reason why the proposed drought reserve east of Loglogo is avoided. As long as security in these areas remains poor they must be regarded as unusable. The effectiveness of future security measures will determine the extent to which these areas can be brought into the grazing patterns of the management plan and, until security is fully ensured, stocking levels will remain within limits imposed by any temporary or localised security provisions.

Camel distribution in the dry season is not limited by water availability, it is only lack of security which is excluding camel herders from large areas. Provision of security may be regarded as the crucial factor in making a large part of the management area available for use and unless security is fully ensured by the Government any additional measures such as the provision of water supplies will be wasted effort. It is evident that the potential for stocking at levels appropriate to the optimum stocking rates for nearly half of the management area cannot be realised at present due to lack of security.

g) Social and economic factors. Increasingly the Rendille are affected by lack of manpower for herding as a growing proportion of the children go to school and young men leave the district to find work. The ability to herd livestock in areas remote from the villages has been reduced and this has become a significant factor in the general trend towards the concentration

of settlement around the villages and along the main routes of access. The extent to which these trends persist despite any efforts to achieve dispersal into the less used areas will constitute an important factor in implementing planned stocking rates.

Certain social customs impose patterns of movement and distribution which significantly affect stocking rates. The *Sorio* gathering of the camels each year, and other tribal ceremonies, necessitate a return to Rendille centres by herders and their animals which may interfere with planned stocking regimes and must be taken into account.

h) The livestock ratio factor. Examination of the livestock population figures in Table 51 shows that the species exist at present at the following approximate numerical proportions:
camels 4· cattle 5: sheep 9: goats 13. Although it appears that cattle numbers fluctuate more than those of the other species in response to the climate, it seems probable that these proportions will remain substantially unchanged within the foreseeable future. The implications that these ratios have for achieving planned stocking rates are far reaching since the numbers of one species may largely influence the numbers of another. In the case of camels and cattle which are herded independently in most circumstances, it appears that any change in absolute numbers or distribution of one species need not necessarily influence another. However, in the case of sheep and goats which are always together and which have an approximate ratio of 2:3, any limitation on the numbers of one species will be likely to impose some limitation on the other. Since the recommended stocking rates for goats in many of the range units are relatively low and for sheep are relatively high, it is probable that sheep numbers will be depressed below their potential stocking rates if the sheep/goats ratio is to be maintained. On the other hand it seems possible that to conform to the recommended stocking rates, the Rendille pastoralists might in due course alter the sheep goat ratio to 3:2. As a management measure this ratio would have certain advantages particularly in facilitating the regeneration of woodlands and shrublands.

i) Stocking level adjustment: conclusions. It seems clear that the determination of a stocking rate which is both optimal and feasible for each range unit will call for the consideration of several of the factors discussed above. The stocking rates recommended in this management plan are compromises which result from the application to the calculated potential carrying capacity of the factors thought to be relevant to the unit in question.

They must be regarded as tentative and subject to change as the climate, ecological and social circumstances change over the coming years. Monitoring such changes will be an essential pre-requisite for continued management. In conclusion to this section on stocking rates, it should be recalled that, although the immediate objective of the range management is to arrest the current overstocking of critical areas and to utilise rationally the under-used areas, the ultimate objective should be to achieve optimum stocking for maximum livestock productivity. This goal will necessitate an understanding on the part of the pastoralists of the principles of efficient animal husbandry and a willingness to substitute quality (in productivity) for quantity (in animal numbers). A considerable amount of research lies ahead to determine the levels of optimum stocking in relation to carrying capacity and to the present stocking rates. Experience elsewhere suggests that optimum stocking levels may approximate to two thirds of carrying capacity levels under most circumstances. Several of the degraded range units will need many years of careful management at very low stocking rates to enable them to recover some proportion of their former productivity. If the rehabilitation of a degraded area is desired the recommended current stocking rate is likely to be nil, as in the case of Range Unit 2, the area surrounding the settlement of Korr.

j) Existing stocking rates

In preparation for the management measures necessary for the rehabilitation of degraded rangelands it is useful to examine the existing stocking rates of camels, cattle and smallstock and to compare them with the estimated carrying capacity of the range in each unit. There are two main sources of data available on estimated carrying capacities for such comparisons:

i. the standing crop biomass, and production in the case of the trees, of the available vegetation;
ii. the calculated relationship between carrying capacity and mean annual rainfall given in published literature.

From these two sources of data assessments of the existing stocking rates in the management area can be made. A summary of an assessment based upon the first source, i.e. the IPAL range surveys, is as follows:

i. Camels

A total of 17.7 per cent of the management area is overstocked with camels while the remainder is understocked or near to carrying capacity (e.g. Unit 1). The principal areas of overstocking are Unit 2 (200 km^2), Unit 5b (200 km^2),

Unit 7 (100 km^2), Unit 13 (500 km^2), Unit 19 (200 km^2), Unit 20 (200 km^2), Unit 21 (300 km^2) and Unit 24 (300 km^2).

ii. Cattle

A total of 8.8% of the management area is overstocked with cattle while the remainder is largely understocked. Areas of overstocking are Unit 12 (100 km^2 at Balesa wells), Unit 18 (100 km^2 at Ngurunit), Unit 20 (200 km^2 at Ilaut and Ngurunit), Unit 21 (200 km^2 at Marsabit), Unit 23 (100 km^2 on the Ilaut lava), Unit 24 (200 km^2 at Korr and Kargi) and 100 km^2 in the south western corner of the area near Laisamis.

iii. Smallstock

On the basis of the present sheep-goat ratio of 2:3 in the average flocks, a total of 23.8% of the management area is overstocked by goats and 12.4% is overstocked by sheep. Areas overstocked by both sheep and goats are Unit 2 (100 km^2), Unit 13 (300 km^2 along the southern boundary), Unit 18 (100 km^2 at Ngurunit), Unit 19 (100 km^2 at Loglogo and 200 km^2 east of Kargi), Unit 20 (400 km^2 around Ngurunit and Ilaut) and Unit 24 (at Korr and Kargi). In addition goats overstock a further 300 km^2 of Unit 2; 100 km^2 of Unit 11; a further 100 km^2 of Unit 13; a further 300 km^2 of Unit 19 near Kargi and Loglogo and 400 km^2 of Unit 21 on Marsabit and Kulal mountains.

Published data which provide a second method of assessing existing stocking rates are as follows:

Table 26. Range carrying capacities in tropical livestock units per km^2 per annum in relation to mean annual rainfall.

Mean annual rainfall in mm	100	200	300	400	500	600	700	800
Authors								
Le Houérou and Hoste (1977)	6	10	14	18	22	26	30	34
Pratt and Gwynne (1977)	4.2	5.6	7.5	10.3	13.9	17.9	21.3	27.0
Coe, Cummins & Phillipson 1976	0.8	2.6	5.0	7.5*	10.0	15.2*	20.4*	25.6

* By interpolation

With the exception of the areas on Mt. Kulal and Mt. Marsabit and at Ngurunit, the range lies within the mean annual rainfall zone of 250 mm. Allowing for the high groundwater table, the range between Ilaut, Ngurunit and Baio is taken to lie within the annual rainfall zone of 500 mm. The range between Loglogo and Karare is taken as lying within the 600 mm zone and Marsabit and Kulal mountains within the 800 mm zone. Taking the upper and lower estimated carrying capacity estimates of Le Houérou and Hoste (1977) and Coe, Cummins and Phillipson (1976) respectively as guidelines, then the total area overstocked varies from 8.0% to 28.3% respectively. According to the data of Le Houérou and Hoste, two 200 km^2 areas between Ilaut and Ngurunit and between Kargi and Korole and five 100 km^2 areas at Karare, Ngoruset, Firimasion, Afarei and Laisamis are overstocked. Surprisingly Korr does not qualify to be classified as overstocked using these criteria. However, according to the criteria of Coe, Cummins and Phillipson, these areas of overstocking would be substantially expanded to include 1,100 km^2 around Korr, an area of 500 km^2 between Karare and Laisamis, an additional 400 km^2 around Kargi and areas of 100 km^2 at Firimasion and Kulal. There is, in general, good agreement between the areas overstocked as judged by the range assessment (method 1) and the empirical relationships established between carrying capacity and mean annual rainfall based upon range areas outside the Marsabit area (method 2). This lends support to the validity of the range assessment in determining future stocking rates for the management area.

A further confirmation of the general validity of the stocking rates based upon the range assessment and the observed plant production levels is provided by the results of the livestock impact trials in the riverine woodlands at Balesa Kulal. At a predetermined stocking rate of 14 tropical livestock units (TLUs) per km^2 per year, the sheep and goats totally consumed the available fodder in their paddock and began to lose weight rapidly. At the same stocking rate the camels removed the whole accessible annual production of tree and large shrub foliage in their paddock. The cattle totally consumed the standing crop of grass and palatable dwarf shrubs in their paddock after reaching the equivalent of a stocking rate of 9 TLU $km^{-2}y^{-1}$. These experiments provided evidence that the carrying capacities for sheep and goats under the prevailing (average) rainfall conditio s, and also that of the camels, were approximately half of the stocking rates achieved by allowing the total consumption of the available forage, i.e. 7 TLU $km^{-2}y^{-1}$, and the carrying capacity for cattle was near to 4.5 TLU $km^{-2}y^{-1}$. These values agree

closely with those derived from the range assessment data for the riverine woodland range unit 12 in which the Balesa paddocks are situated.

k) Food availability

The availability of forage in the range has been recorded at Balesa Kulal and Ngurunit on a monthly basis in relation to the feed requirements of smallstock.

The two sets of data have been calculated differently with respect to dwarf shrubs and cannot be compared directly. Nevertheless they each illustrate certain points:

1. There are large seasonal fluctuations in food availability, with minima less than one-third of the monthly maxima.
2. These fluctuations are often but not always related to rainfall.
3. The minima are associated with the long dry season from June to August which may be prolonged to October.
4. In the Kulal area differences in available forage occurred between years as follows:

Table 27. Mean monthly forage in kg ha^{-1} availability for smallstock.

	1979	1980
Total rainfall in mm	319	215
Goats	1,249 ± 697	784 ± 420
Sheep	1,164 ± 670	714 ± 408

Available forage fell below 600 kg ha^{-1} at Kulal in only three months in 1979 but in six months in 1980. Conversely, it exceeded 1,200 kg ha^{-1} in six months in 1979 and only in three months in 1980. The total rainfall in 1979 was 319 mm, more than 100 mm higher than 1980, which was nearer the mean for the Hedad area.

At Ngurunit the forage availability is plotted for three systems of smallstock management:

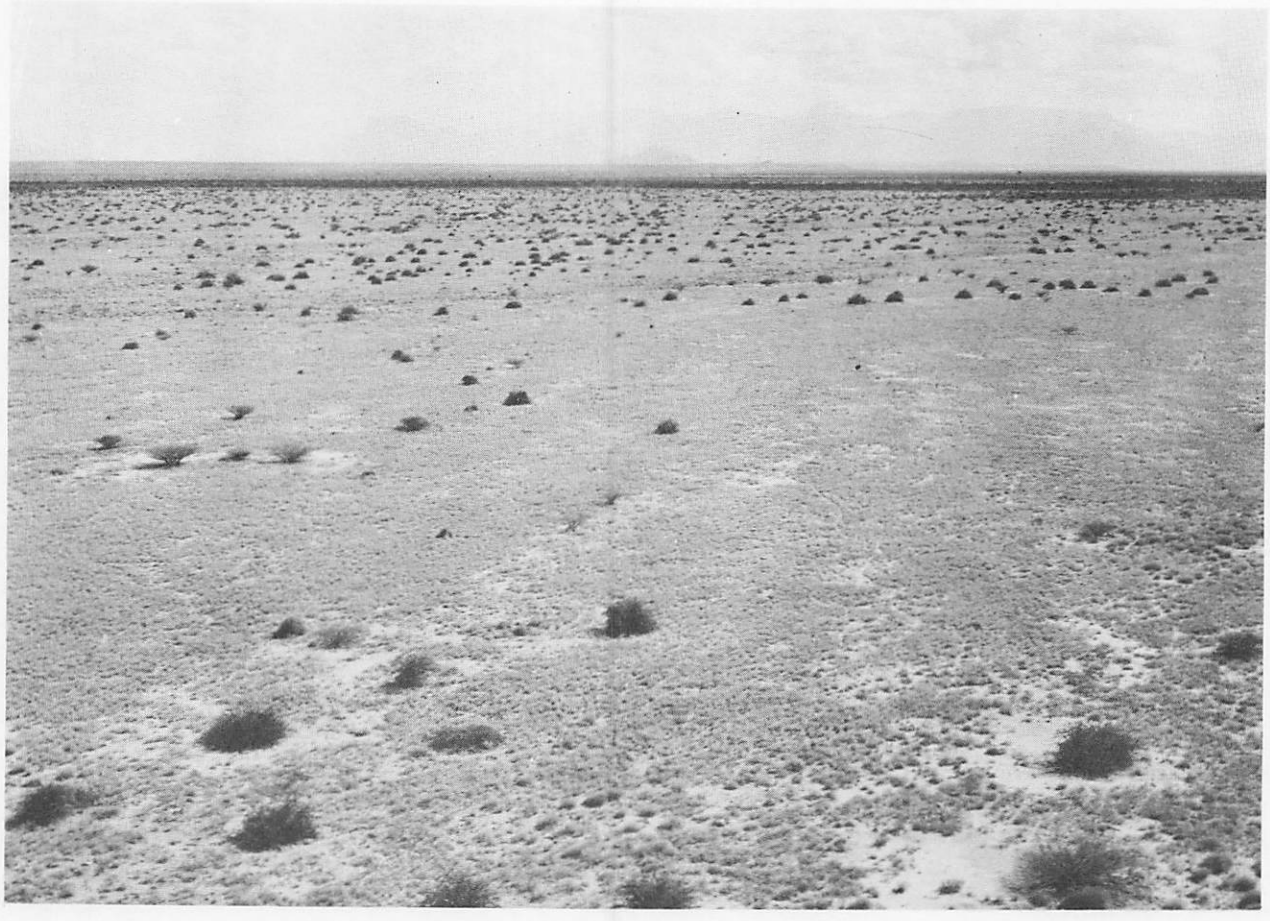
1. a sedentary system representative of the area around permanent settlement with access only to dwarf shrubland;

2. a system with a sedentary base for the household but nomadic flocks;
3. a traditional system involving transhumance to highland pastures in dry seasons.

The advantage of the traditional system in providing access to better pasture in dry seasons is clearly seen.

8. Description of Range Units (see Map 15 at end of Volume II)

8.1 Range Unit 1: *Indigofera* dwarf shrubland



a. Physical attributes

This range unit occurs on the sedimentary plains north to north-west of the lava plateau stretching from Ilaut into the Hedad. This is flat to almost flat land (0-2% slope), at an average elevation of about 600 m above sea level. This range unit has a general exposure towards the west. Within this unit there are a number of basement rock outcrops which stand out as narrow, elongated hills, with a SE-NW orientation. The unit is drained by the Hafarin lagga drainage system. It covers an approximate area of 395.2 km^2.

The average annual rainfall in this locality is around 220 mm, with the highest amounts recorded during the month of April. As in the entire study area, this rainfall is highly variable, and the estimated mean annual (actual) variability (based on five years of records) calculated for the locality is 80%. The prevailing winds are south-easterlies. These are gentle winds, with average recorded speeds of 6.5 km/hr. The occurrence of storm winds is generally low.

The major soils occurring within this range unit are developed on sediments derived from the undifferentiated basement system rocks. These are mainly well drained (except in the west of the group of rock hills, where well to imperfectly drained soils occur), generally very deep, friable, sandy loam to sandy clay loam soils, with a topsoil of sands to loamy sands. These soils are slightly sodic, and in places slightly saline, and/or calcareous (strongly calcareous in the west), below a depth of 50 cm. The fertility status of these soils can be said to be moderate. They are generally moderately well to well supplied with available nutrients (phosphorus, calcium, magnesium and potassium). The organic carbon content is about 0.2%, and thus these soils have a low organic-matter content. Small areas of alluvial soils also occur in this unit, usually as narrow "bands" along the major rivers. In the northern part of the unit (about 5% of the total area), the soils are more silty, and have well developed platy structures; this particular section is more liable to floods. Rooting depth on these soils is greater than 100 cm.

Evidence of current erosion is limited to numerous rill marks. An assessment of these shows that current erosion status is low, since the entire area is more of an accumulation plain. Sediments are deposited by the laggas, and large accumulations of unconsolidated material are seen along the banks of the major lagga. Evidence of rill and sheet erosion is, however, more prominent on the footslopes of the inselbergs mentioned earlier, but these form less than 2% of the entire unit, and their significance is therefore negligible.

b. Vegetation attributes

This range unit consists of ten range types dominated by *Indigofera cliffordiana* dwarf shrubland, which covers nearly 75% of the whole unit. The other range types are *Cenchrus ciliaris/Tetrapogon spathaceus* annual grassland (8.2%), a woodland with mixed trees on rocky outcrops (3.9%), and *Aristida mutabilis/Aristida adscensionis* annual grassland with *Indigofera spinosa* (3.7%), an *Indigofera*

spinosa dwarf shrubland with *Blepharis linariifolia* and *Duosperma eremophilum* dwarf shrubland with scattered trees (2.2%), a *Cenchrus ciliaris/Blepharis linariifolia* annual grassland with *Indigofera spinosa* (1.7%), *Heliotropium albohispidum/Duosperma eremophilum* dwarf shrubland with miscellaneous trees (1.7%), an *Acacia nubica/Acacia tortilis* woodland with *Sericocomopsis hildebrantii/Duosperma eremophilum* and *Aristida mutabilis* (1.5%), a *Cenchrus ciliaris/Tetrapogon spathaceus* annual grassland (1.3%) and an *Aristida mutabilis* with *Indigofera spinosa* and *Acacia tortilis* wooded annual grassland with dwarf shrubs (1.0%).

Within the main range type, *Indigofera cliffordiana* is the dominant dwarf shrub and *I. spinosa* with *Heliotropium albohispidum* are the other important dwarf shrubs. These major dwarf shrubs had a total cover of 21.7%. The other dwarf shrub recorded was *Ipomoea bituensis*. The annual grasses and herbs have a cover of 9.7% and 11.1% respectively and they consist of *Aristida adscensionis*, *A. mutabilis*, *Brachiaris peersiodes*, *Barleria argentea*, *Blepharis linariifolia*, *Leptothrium senegalense*, *Heliotropium steudneri*, *Dactyloctenium aegyptium*, *Oropetium minimum*, *Crotalaria deserticolor*, *Cenchrus ciliaris*, *Phyllanthus sp.* and *Enneapogon desvauxii*. Other contributions to the ground cover are summarized in Table 28.

Desirable dwarf shrubs had a contribution to the standing crop biomass of 649.3 kg/ha air-dry weight (ADW) and annual grasses and herbs 134.7. Standing dead grasses and herbs contributed 110.1 kg/ha ADW, grass and herb litter 256.7 kg/ha standing dead woody plants 86.7 and woody litter was 82.1 kg/ha.

The herbaceous annual layer, which showed a flush of growth about one week following rains, was observed to be dead less than four weeks after the last rains, except along laggas were greenness of annuals persisted to six weeks or more. The leaves of dwarf shrubs generally remained alive, sometimes up to eight weeks before drying up, except, again, along drainage-ways where they remained green much longer. The tree species also followed a similar phenological trend.

Trees and large shrubs

Over the greater part of this range unit trees and large shrubs are sparsely distributed, the dominant range type having a tree density of 4 ha^{-1}, canopy cover of 0.3% and annual dry matter foliage production of 2 kg ha^{-1}. In this type the widely dispersed tree populations, including *Acacia reficiens*, *Cadaba*

farinosa, Acacia tortilis, Commiphora flaviflora and *Salvadora persica*, have moderate to poor age-class structures which, in combination with their very low densities, provides an almost negligible fodder value and indicates that the type will remain open dwarf shrubland with no immediate successional trend towards shrubland. The same applies to the second most extensive range type (No. 4/5a; 72 km^2) in this unit, with a tree canopy of 0.3%, density of 8 trees ha^{-1}, and a foliage D.M. production of 2 kg ha^{-1}, in which the trees include *Cordia sinensis, Cadaba farinosa* and *Acacia tortilis* - all important browse plants.

Of the six other range types represented in this unit by small areas of shrubland (2-19 km^2), the *Acacia tortilis* riverine woodland of range type 9 (4 km^2) should be specially noted as a range area of great importance to livestock. With a canopy cover of 16%, foliage production (available as litter) will exceed 180 kg ha^{-1} D.M. and fruit production 240 kg ha^{-1} D.M.

c. Human influence

On the whole this range unit is currently very little used or not used at all for livestock grazing. It appears however that it was utilized in the past. This can be deduced from the number of old *manyatta* and *fora* sites that occur within the unit. There is also a well (seasonal) within this unit, which means that for part of the year (at least) there will be water available for human and livestock consumption. It can therefore be concluded that perhaps this area is at present practically unused because of problems of insecurity from cattle rustlers. Additional information shows that this unit is used as dry-season grazing - mainly for camel *fora*. Small-stock also use it and are watered in Korr.

d. Range condition

This area had previous light use with desirable plant cover of 66.4% and little evidence of erosion, but a poor standing biomass of 904.1 kg / ha. With moderate use, however, this site could be unstable. Hence, a rating of fair range condition. This site has a fair percentage of riverine cover that could increase its use.

e. Carrying capacity

The carrying capacity of this unit, based on the available (corrected) standing crop biomass and expressed in numbers of animals per km^2 per year, has been calculated at 4.4 camels, 3.1 cattle, 6.3 sheep and 9.7 goats. Since this unit is 395.2 km^2, it can carry 1,726 camels, 1,213 cattle, 2,479 sheep and 3,851 goats. Despite the value of this unit as livestock range, the tree age-class structure is poor and will necessitate the reduction of goat stocking rates in the next five years. The greatest value of this unit and other riverine belts like it in many parts of the region, lies in its capacity to provide green fodder throughout the dry season and a steady supply of firewood and building material from dead trees.

Table 28. Summary of cover, composition and biomass (Range unit 1)

Attribute	% cover	Total standing crop biomass kg/ha		Desirability by livestock (kg/ha)							
				Camels		Cattle		Sheep		Goats	
				1	2	1	2	1	2	1	2
Perennial grasses	-	-		-	-	-	-	-	-	-	-
Annual grasses	9.7	89.9		-	-	72.6	27.2	17.3	6.5	-	-
Annual herbs	11.1	44.8		-	-	36.2	13.6	8.6	3.2	-	-
Dwarf shrubs:											
1. *Indigofera spinosa*	4.0	112.7		40.6	7.5	48.8	9.0	11.6	2.1	11.6	2.1
2. *Duosperma eremophilum*	-	-		-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	17.7	536.6		417.4	-	-	-	-	-	119.2	22.1
4. Other undesirable dwarf shrubs	0.3	-		-	-	-	-	-	-	-	-
Litter:											
1. Grasses and herbs	5.9	256.7		-	-	-	-	-	-	-	-
2. Wood	2.2	82.1		-	-	-	-	-	-	-	-
Standing dead:											
1. Grasses and herbs	23.7	110.1		-	-	88.9	16.5	21.2	3.9	-	-
2. Wood	5.7	88.7		-	-	-	-	-	-	-	-
Trees and large shrubs:			(Production)								
1. Desirable foliage	0.2	10.0	(18.5)	13.6	3.3	-	-	0.1	0.07	2.75	0.67
2. Undesirable foliage	0.1	5.5	(9.5)	-	-	-	-	-	-	-	-
3. Wood	-	1500.0		-	-	-	-	-	-	-	-
Bare areas	19.4	-		-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-		-	-	-	-	-	-	-	-
Total desirable	66.4	904.1	(28.0)	471.6	88.0	246.5	66.3	58.8	15.8	133.5	24.9
Total undesirable	14.2	1931.0									

1 - desirable biomass before corrections

2 - available biomass

8.2 Range unit 2: *Duosperma/Indigofera* shrubland



a. Physical attributes

This range unit occurs on the sedimentary plains. It is located on the SE part of the lava plateau at Ilaut, and stretches north-eastwards to the escarpment of the 'Marsabit lava', and again northwards along the Korr - Kargi road for about 30 km from the vicinity of Korr. It is at an average elevation of 500 m above sea level, with an exposure to the east. This unit is flat to almost flat land (0-2% slope), and covers an approximate area of 494 km^2.

The average annual rainfall is about 190 mm, with an estimated mean variability of 80%. April is the wettest month. Mean wind speeds are much higher than for most parts of the plains (approximately 16 km/hr). These are moderate winds. The prevailing wind direction is south-westerly.

Two major soils occur within this unit. Both soil types are developed on the sedimentary deposits. Between 8 and 10% of the soils, however, are developed on alluvial deposits. To the north of Korr, the soils are well to imperfectly drained, very deep, friable, strongly calcareous, slightly to strongly saline, strongly sodic, sandy clay loam to sandy clay. In this area too there are several slight depressions that are truncated or buried under sand. In these depressions the topsoil is completely eroded, exposing a hard subsoil covered by sands, where regeneration of vegetation is difficult and sodium toxicity may also occur. To the west and south-west of Korr, however, the soils are well drained, very deep, friable, sandy loam to sandy clay loam, with a topsoil of sand to loamy sand. These soils are slightly to moderately sodic, and are in places slightly saline and/or strongly calcareous. The fertility status of these two major soils described is moderate; organic carbon content is 0.2%, indicating a low organic-matter content. Rooting depth on these soils is greater than 100 cm.

Current erosion is quite high. Both water and wind erosion occur. Water erosion is mainly in the form of rill erosion, but a certain amount of sheet wash also occurs, especially in the northern part of the unit. Evidence of wind erosion is seen to the immediate north and west of Korr, where numerous small dunes are in active formation.

b. Vegetation attributes

This unit consists of three range types dominated by a *Duosperma eremophilum/ Indigofera cliffordiana* dwarf shrubland which occupies nearly 93% of the total area. The other two range types, which occupy 5.5% and 1.8% respectively, are a *Duosperma eremophilum* dwarf shrubland and an annual grassland with scattered trees. All the three types comprising this unit are highly degraded rangelands. The dominant range type has up to 40.6% bare areas. The total cover of perennial plant species is 15.2% with *Duosperma eremophilum* covering 0.6%. The other dwarf shrubs recorded were *Indigofera cliffordiana, Heliotropium albohispidum, Indigofera spinosa, Sericocomopsis hildebrandtii, Seddera hirsuta*

and *Barleria proxima*. The few grasses identified in this range type were *Cenchrus ciliaris, Chloris virgata, Sporobolus fimbriatus, Tetrapogon spatheceus, Oropetium minimum, Dactyloctenium oegyptium* and *Aristida mutabilis*. Herbs are *Euphorbia inaequilatera, Cleome allamanii, Solanum dubium, Heliotropium steudneri* and *Barleria argentea*. There were indications that the other annuals had died out very quickly after the last rains. The trees included *Acacia reficiens, Commiphora flaviflora* and *Cordia sinensis*, all in insignificant numbers. The litter cover ranged from 14-19%; the remaining 4% is made up of grass and woody plants in the standing dead form. The two major range types had bare areas of 30 and 21% respectively, with 23-36% cover of all litter and up to 7% annual grass cover. One of these dwarf-shrub range types had as much as 11% cover of *Duosperma eremophilum*.

The productivity of this range unit was moderate with *Duosperma eremophilum* producing a standing crop biomass of only 54.9 kg/ha in the major range type and *Indigofera cliffordiana* having a standing crop biomass of 172.3 kg/ha. The total air dry weight of all kinds of litter, standing dead grass and wood was 856.8 kg/ha. The phenology of the plants in this area was similar to that of unit 1.

Across the whole of this range unit trees are scattered at low to moderate density, having *Acacia reficiens, A. nubica, Commiphora candidula, Maerua oblongifolia, Cadaba minimifolia, C. farinosa, Cordia sinensis, Euphorbia cuneata* and *Salvadora persica* with a combined density of 103 trees ha^{-1}, canopy cover of 5%. The commoner trees, *Acacia* spp. and the *Commiphora*, are of low palatability and the age-class structure is poor, indicating heavy livestock pressure in the recent past. The potential for the recovery of the tree populations is good and limitation of goat and camel numbers would be beneficial to the regeneration of the younger age classes.

c. Human influence

This rangeland is intensively used for grazing of livestock of all kinds (smallstock, cattle and camels) without any control. This has led to a highly degraded landscape completely devoid of plant cover (bare areas: 40.6% of total). Should the present trend of use continue, future erosion hazard can be extremely high, and the area may perhaps even develop into barren lands. It is therefore very necessary to provide a good and even vegetation cover. One way of doing this is to re-seed with appropriate desirable species which are fast growing to arrest the dune formation. When

the vegetation cover is established it will become necessary to exercise strict control over grazing within this range unit.

d. Range condition

This site has been subjected to heavy use, leading to a high percentage of bare soil with evidence of both water and wind erosion. Most of the cover is made up of annual vegetation. Because of the high degradation this site is given a poor condition rating.

e. Carrying capacity

The carrying capacity of this range unit, based on the available forage, has been computed as 2.2 camels, 7.1 cattle, 14.4 sheep and 4.9 goats per km^2 per year. Since the area is 494 km^2, it can carry 1,087 camels, 3,507 cattle, 7,114 sheep and 2,421 goats.

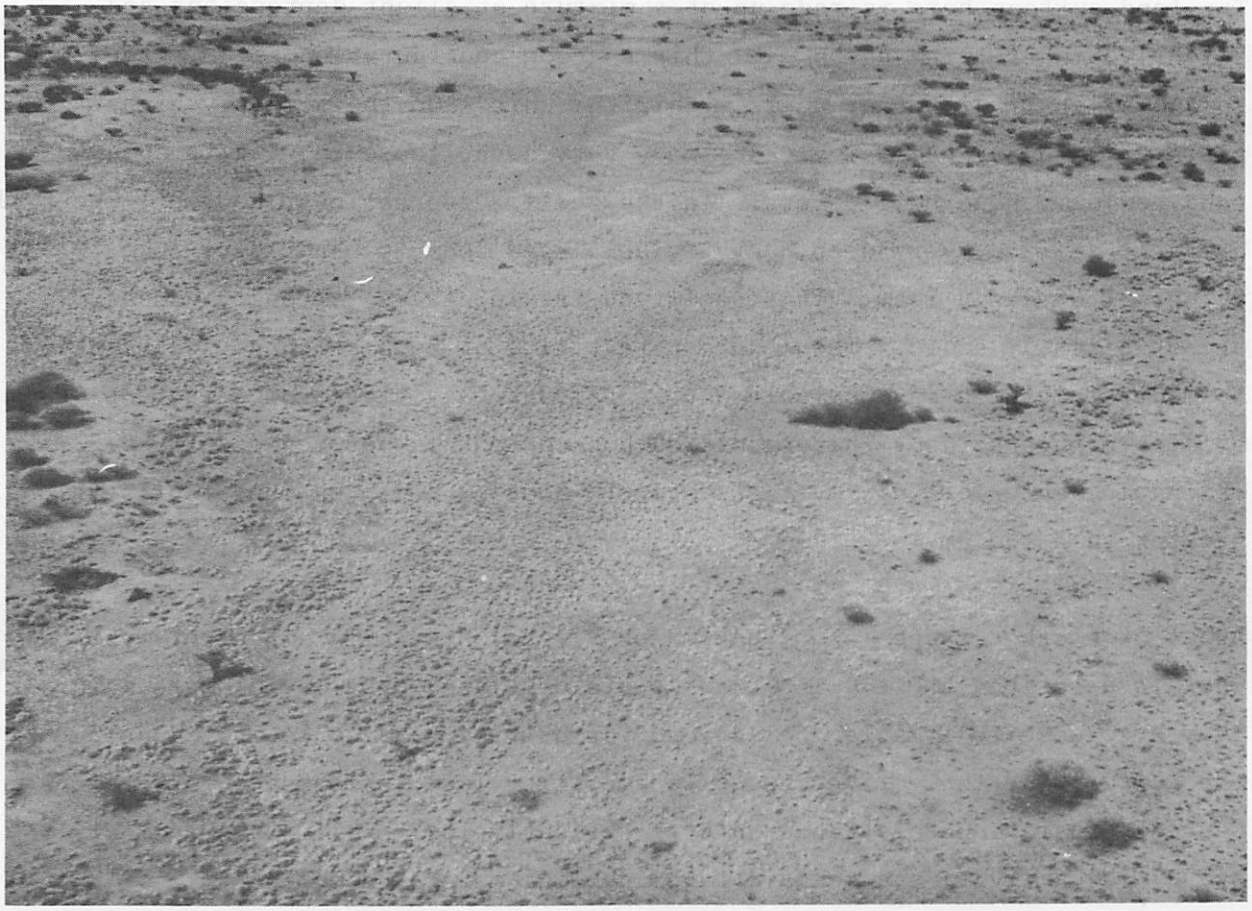
Table 29. Summary of cover, composition and biomass (Range unit 2)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	-	21.6	-	-	17.4	6.5	4.2	1.6	-	-
Annual grasses	11.4	231.7	-	-	187.1	70.2	44.6	16.7	-	-
Annual herbs	3.0	59.6	-	-	48.1	18.1	11.5	4.3	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	4.1	101.2	36.4	6.7	43.8	8.1	10.4	1.9	10.4	1.9
2. *Duosperma eremophilum*	0.6	54.9	42.7	4.7	-	-	-	-	12.2	1.3
3. Other desirable dwarf shrubs	7.3	172.3	134.0	24.8	-	-	-	-	38.3	7.1
4. Other undesirable dwarf shrubs	1.2	29.3	-	-	-	-	-	-	-	-
5. Climbers and creepers	-	46.2	35.9	6.6	-	-	-	-	10.3	1.9
Litter:										
1. Grasses and herbs	6.2	204.1	-	-	-	-	-	-	-	-
2. Wood	6.6	158.2	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	12.0	333.5	-	-	269.4	49.8	64.1	11.9	-	-
2. Wood	5.0	161.0	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	0.5	3.8	2.42	1.23	-	-	-	-	1.1	0.25
2. Undesirable foliage	1.5	13.8	-	-	-	-	-	-	-	-
3. Wood	-	800.0	-	-	-	-	-	-	-	-
Bare areas	40.6	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	38.9	1024.8	251.4	44.3	565.8	152.7	135.8	36.4	72.3	12.45
Total undesirable	20.5	1336.6								

1 - desirable biomass before corrections

2 - available biomass

8.3 Range unit 3: *Blepharis* annual herb grassland



a. Physical attributes

This range unit occurs on the sedimentary plain east of the Ol'Donyo Mara mountains and stretches into the Hedad. It occupies approximately 178.8 km^2 of a flat to almost flat area (0-2% slope), at an average elevation of about 700 m above sea level. It is drained by the Argi and Moran rivers, and has an exposure to the north west.

Average annual rainfall recorded in this locality is about 220 mm, with an estimated annual variability of 180%. The highest amount of this rainfall is recorded for the month of April. The prevailing winds are south-easterly, and an estimate of the wind speeds indicates that they are gentle.

Soils occurring within this range unit are developed on sedimentary rocks. The land surface here is made up of a mixture of slight depressions and slightly higher-lying parts, and this surface configuration gives rise to two slightly different soils within the unit. On the slightly higher parts, a somewhat excessively drained, very deep, loose to very friable, sand to loamy sand soil occurs. In the shallow depressions, however, the soils are well drained, very deep, very friable sand loam to sandy clay loam, with a topsoil of sandy loam. This soil type is, in places, strongly calcareous and/or slightly sodic. The inherent fertility of both of these soils is low to moderately high in available nutrients, but they have a high content of available phosphorus. The organic carbon content is between 0.2 and 0.3%, indicating a low organic-matter content. Rooting depth in these soils is greater than 100 cm.

About 5% of this range (along the major rivers) has soils different from what is described above. These soils are developed on alluvial materials. They are loose to friable, calcareous, stratified sand to loams. Usually the topsoils of these riverine soils are silty loam to loams.
Current erosion on this range unit is evidently low. Rill marks are few, and aeolian activity can be said to be negligible at the moment.

b. Vegetation attributes

This unit is an annual herb grassland whose grass and herb layer is dominated in all cases by *Blepharis linariifolia*. It consists of seven range types dominated by a *Blepharis linariifolia* grassland, which occupies nearly 79% of the total area. The next important range type is a *Cenchrus ciliaris* annual grassland (9.8%), followed by an *Aristida mutabilis* with *Duosperma eremophilum/Heliotropium albohispidum* annual grassland with dwarf shrubs (5%), three small *Blepharis linariifolia* annual herb grasslands (2.5%, 15% and 1.2%, respectively), and the riverine woodland consisting of *Aristida mutabilis* with *Indigofera spinosa* and *Acacia tortilis* in an annual grassland with dwarf shrub (1.5%) described elsewhere. The main feature of the dominant range type is that it is itself dominated by annual grasses and herbs, with a total cover of 26.4%, of which *Blepharis linariifolia* contributes 8.7%. Annual grasses cover 17.7% and the dwarf shrub *Duosperma eremophilum* covers 1%. Bare areas cover 38.9% and all standing dead 16%. Litter and tree cover are 12.7% and 3% respectively. Other annuals observed in this unit were

Cenchrus ciliaris, Tragus berteronianus, Brachiaria ovalis, Chloris virgata, Enneapogon desvauxii, Aristida adscensionis and *Mollugo cerviana*. The other dwarf shrubs were *Indigofera cliffordiana* and *Sericocomopsis hildebrandtii*.

The highest standing crop biomass in the major range type was contributed by annual grasses (451.8 kg/ha, ADW). *Blepharis linariifolia* contributed 154.3 kg/ha and all litter, standing dead grass and woody plants 1450.6 kg/ha. The growth pattern of the major annuals in the unit as a whole was typical of the annuals which flourished about a week after the first rains, attained maturity in 3-4 weeks and died off about 2-3 weeks after rains stopped.

The trees occur at densities of between 14 and 62 ha^{-1}, with canopy cover of 0.3 - 3.0% and foliage dry weight annual production of between 20 and 30 kg ha^{-1}. In the main range type of this unit (no. 11; 80 km^2) *Acacia senegal* and *Euphorbia cuneata* are the dominant tree or shrub species and a further nine species occur at very low densities. Six other range types are represented in this unit by small areas of between 1 and 20 km^2 in which fifteen tree and large shrub species are recorded.

c. Human influence

This range unit is very little used or not used at all for most of the year. This is due to insecurity problems.

d. Range condition

This site has a weak sandy topsoil cover which, despite non-use, is relatively unstable. The majority of the plant cover consists of annual herbs, largely from previous seasons due to little use. As most cover over the study area is composed of annuals which are usable during rain, range condition for this area was rated as fair.

e. Carrying capacity

The carrying capacity of this unit is based mainly on the annual herb *Blepharis linariifolia* for camels and goats, and annual grasses for cattle and sheep. It can carry 0.5 camels, 9 cattle, 18.4 sheep and 0.9 goats, all in animals/km^2/year.

This unit can, however, only be utilized after rains when there is a flush of the annuals. The number of animals which may be put on this range is 89 camels, 1,609 cattle, 3,290 sheep and 161 goats.

Table 30. Summary of cover, composition and biomass (Range unit 3)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	-	-	-	-	-	-	-	-	-	-
Annual grasses	17.7	451.8	-	-	364.9	136.8	86.9	32.6	-	-
Annual herbs	8.7	154.3	-	-	124.6	46.7	29.7	11.1	6.2	1.1
Dwarf shrubs:										
1. *Indigofera spinosa*	1.0	59.9	21.7	4.0	25.9	4.8	6.2	1.1	6.2	1.1
2. *Duosperma eremophilum*	1.0	-	-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	-	-	-	-	-	-	-	-	-	-
4. Other undesirable dwarf shrubs	1.0	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	12.0	24.3	-	-	-	-	-	-	-	-
2. Wood	0.7	-	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	-	33.3	-	-	29.9	5.0	6.4	1.2	-	-
2. Wood	16.0	1393.0	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	1.5	18.6	12.2	6.0	-	-	1.5	0.3	5.1	1.3
2. Undesirable foliage	1.5	9.3	-	-	-	-	1.5	0.3	5.1	1.3
3. Wood	1.5	1800.0	-	-	-	-	-	-	-	-
Bare areas	38.9	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	29.9	717.9	33.8	10.0	542.3	194.3	130.7	46.3	11.3	2.4
Total undesirable	31.2	3226.9								

1 - desirable biomass before corrections

2 - available biomass

8.4 Range unit 4: *Acacia tortilis* and *Indigofera/Duosperma*



a. Physical attributes

Range unit 4 occurs on the western part of the sedimentary plains of the Hedad. It is at an elevation of about 740 m above sea level. It is gently sloping (0-2%) with a north-east exposure. The unit has an area of approximately 112.9 km^2.

Average annual rainfall over this locality is about 230 mm, with the peak rains occurring during the month of April. The estimated annual variability of rainfall is about 80%. The prevailing wind direction is south-east and wind speeds are generally gentle (6.6 km/hr).

Soils occurring within this unit are developed on sediments originating from the undifferentiated basement complex rocks. These soils are well drained, deep to very deep, friable sandy clay loam to clay loams. They have rooting depths greater than 100 cm. In localized areas alluvial soils occur, but this occupies only about 6% of the entire area.

Current erosion status is gentle. Rill erosion is the predominant type.

b. Vegetation attributes

Practically the whole of this unit is made up of one range type, which occupies 92.1% of the unit. This dominant range type has a dwarf shrub cover of 13.8% of which 3.2% is *Indigofera spinosa*. *Duosperma eremophilum*, *Indigofera cliffordiana*, *Barleria proxima*, *Sericocompsis hildebrandtii*, *Dacysphaera prostrata* and *Seddera hirsuta* are also common. Annual grasses and herbs cover 7.7% with no particular dominant grass or herb, though more than twenty annuals were actually identified. Litter covers 5.5%, standing dead plants 4.2%, bare areas 52.6% and rocks 1.2%.

The standing crop biomass of the desirable live plants was 1,597.8 kg/ha, of which 18.1 kg/ha were *Indigofera spinosa*. *Duosperma eremophilum* contributed 694.7 kg/ha. Most of the annuals were dead shortly after the rains but contributed 174.3 kg/ha.

The main range type in this unit (17b: area 112.9 km^2) is an extensive *Acacia tortilis* shrubland with a canopy cover of 15%, density of 459 trees ha^{-1}; wood dry weight biomass of 4.8 t ha^{-1} (annual wood production of 380 kg ha^{-1}), foliage dry weight 88 kg ha^{-1} and foliage production of 160 kg $ha^{-1}y^{-1}$. *Acacia nubica*, an unpalatable species, is the co-dominant tree species in this unit with a density of 95.9 ha^{-1}. Nine other tree species are present in low numbers of which the following are important browse species: *Cadaba farinosa*, *Cordia sinensis*, *Acacia mellifera*, *Salvadora persica* and *Grewia tenax*.

c. Human influence

This rangeland is very little utilized or not used at all as a result of problems of insecurity or lack of water. This range unit is the most important woodland in the management area and merits careful management to ensure its survival and optimum production over the next hundred years. However, it is now coming into intensive use by the Samburu people and is being felled and

lopped rapidly for livestock boma construction in certain localities. It can become a major source of firewood, building poles, livestock fodder (especially fruit) if not destroyed by the Samburu cattle keepers who largely occupy the area at present.

d. Range condition

This site has a poor herb layer and large areas of bare soil which are not eroded, due to gentle slope and non-use. It is to be considered for grazing use as in poor condition.

e. Carrying capacity

The carrying capacity of this unit in animals/km^2/year, is 7.8 camels, 2.6 cattle, 5.6 sheep and 17.1 goats. The actual numbers of animals that can be kept on the unit are 881 camels, 293 cattle, 632 sheep and 1,931 goats.

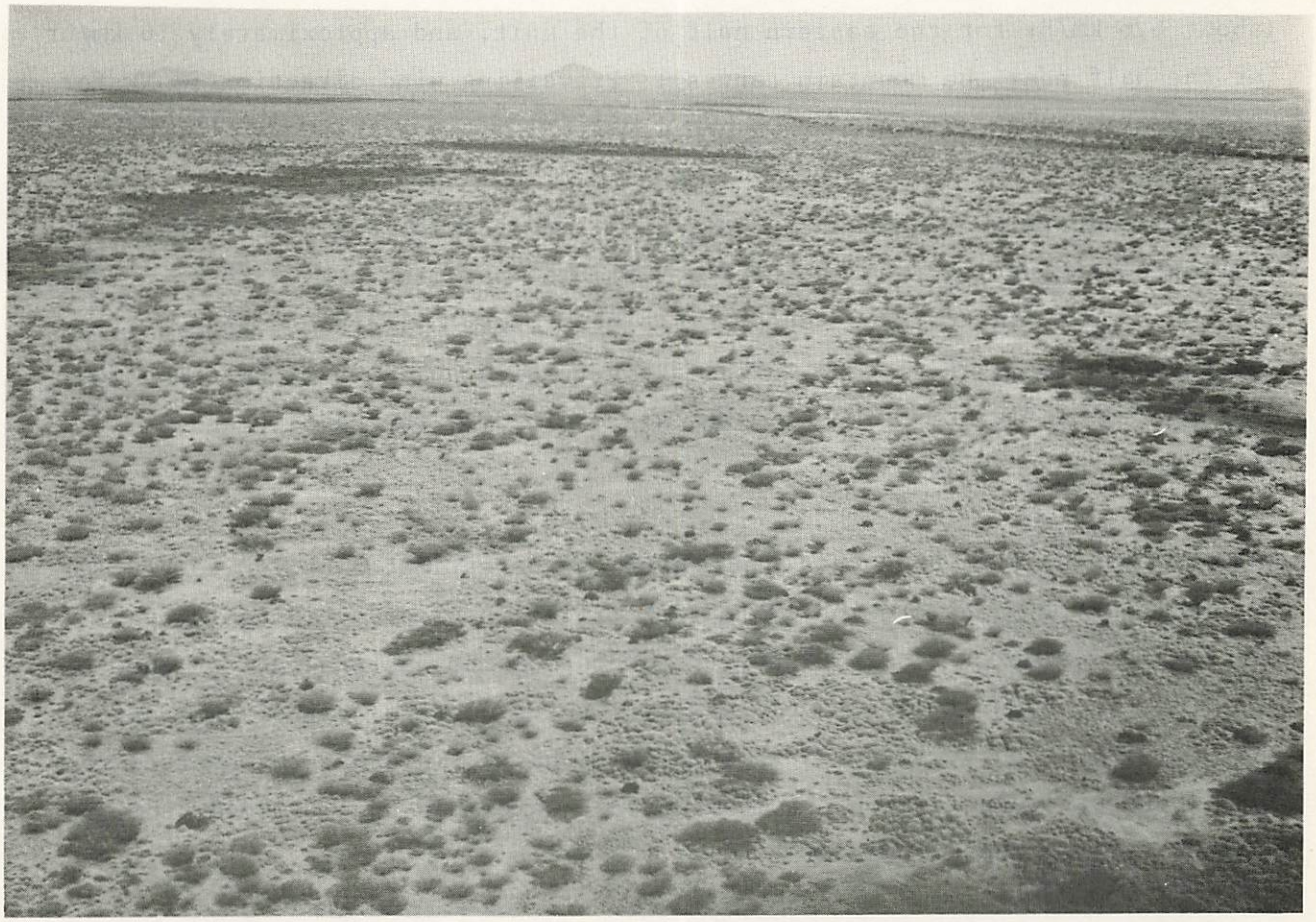
Table 31. Summary of cover, composition and biomass (Range unit 4)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	-	-	-	-	-	-	-	-	-	-
Annual grasses	3.7	106.1	-	-	85.7	32.1	20.4	7.7	-	-
Annual herbs	4.0	86.2	-	-	55.1	20.7	13.1	4.9	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	3.2	18.1	6.7	1.2	7.8	1.4	1.9	0.3	1.9	0.3
2. *Duosperma eremophilum*	3.2	694.7	540.3	59.4	-	-	-	-	154.4	17.1
3. Other desirable dwarf shrubs	6.4	560.7	436.1	80.7	-	-	-	-	124.6	23.1
4. Other undesirable dwarf shrubs	-	20.2	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	2.7	59.3	-	-	-	-	-	-	-	-
2. Wood	2.8	230.9	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	1.2	6.0	-	-	5.7	1.1	1.3	0.3	-	-
2. Wood	3.0	191.7	-	-	-	-	-	-	-	-
Trees and largeshrubs:										
1. Desirable foliage	9.0	45.0	32.4	16.2	-	-	3.9	1.0	13.6	3.4
2. Undesirable foliage	6.0	35.0	-	-	-	-	-	-	-	-
3. Wood	-	5000.0	-	-	-	-	-	-	-	-
Bare areas	52.6	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	1.2	-	-	-	-	-	-	-	-	-
Total desirable	30.7	1597.8	1015.5	157.5	154.3	55.30	40.6	14.2	294.5	43.8
Total undesirable	14.5	5537.1								

1 - desirable biomass before corrections

2 - available biomass

8.5 Range unit 5: Annual grassland with dwarf shrubs



a. Physical attributes

Range unit 5, covering a total area of approximately 355 km^2, occurs in two separate areas on the sedimentary plains found on basement system rocks. One half of this unit (approximately 272.9 km^2) occurs west of the Korr-Kargi road, immediately north of the lava plateau (extending from Ilaut into the Hedad). The remaining one half (approximately 178.8 km^2) occurs to the immediate east of the Ndoto-Ol'Donyo Mara mountain ranges. They are at an elevation of between 500 and 700 m above sea level, and are almost level ground (0-2% slopes).

The average rainfall on these units is approximately 220 mm per year, with an annual variability of about 80%. The highest amount of rainfall is recorded during the month of April. Wind speeds are gentle to moderate (about 6.6 km/hr for the eastern half of the unit, and approximately 16 km/hr for the half near the mountain ranges). Prevailing wind direction is NW for both types.

The soils occurring within this range unit are derived mainly from the sediments originating from the undifferentiated basement system rocks. These soils are well drained, very deep, friable strongly calcareous, sandy clay loams (sandy loams in places). They are generally saline, and have rooting depths of about 100 cm or more. They are drained by the Hafarin and Argi rivers and their tributaries.

Current erosion status on this range type can be estimated as low to gentle. The commonest type of erosion is that of rills. Aeolian activity is negligible, except for a few dunes that occur on the eastern half of the unit. These, however, are stable dunes. On the western half of this unit, the activity of burrowing organisms is quite high. This can be observed from the amount of loose soil on the land surface which has been removed from the 'holes' made by these organisms.

b. Vegetation attributes

(i) Range unit 5A

This range unit consists of three range types and several less important ones, dominated by *Cenchrus ciliaris/Blepharis linariifolia* with *Indigofera cliffordiana/ Duosperma eremophilum* annual grassland with dwarf shrubs, which occupies 58.4% of the whole unit. The other two range types are a *Blepharis linariifolia* annual grassland covering 26.1% of the unit and a *Duosperma eremophilum/ Heliotropium albohispidum* with *Aristida mutabilis* dwarf shrubland with annual grass understorey (3.8%). There are many minor types which together form 11.7% but are scattered in small areas and are not considered individually. The dominant range type is itself dominated by annual grasses, herbs and creepers, which form 26.6% of the total ground cover. The dwarf shrubs cover nearly 20%. Standing dead grass and woody plants cover 26.9% and grasses and woody litter 5.6%. Bare areas in this range type occupy 18%. Other annual grasses and herbs encountered in this range type are *Aristida adscensionis, Aristida mutabilis, Brachiaria ovalis, Enneapogon desvauxii, Stipagrostis uniplumis, Tetrapogon spatheceus, Sporobolus fimbriatus, Tetrapogon tenellus, Barleria argentea,*

Cleome allamanii, Heliotropium steudneri and *Portulaca oleracea. Kendrostis gijef,* a cucurbit climber, is also present. In the dwarf shrub layer is also found *Barleria proxima, Indigofera cliffordiana* and *Sericocomopsis hildebrandtii.* The few trees present are *Acacia reficiens, Cadaba ruspolii, Commiphora flaviflora* and *Euphorbia cuneata.* The composition and productivity of the second range type is similar to that described under Range unit 3.

The productivity of the major type in this unit, as estimated by the standing crop biomass, was moderate. The desirable dwarf shrubs, mainly *Indigofera cliffordiana* contributed 176.1 kg/ha, while *Duosperma* contributed 146.8 kg/ha. All annual herbs had a standing crop biomass of 57.5 kg/ha. The annual grasses contributed 275.6 kg/ha. All forms of litter had about 110.1 kg/ha, while standing dead grass and woody plants contributed 379 kg/ha. The growth pattern of plants in this type follows that of the rainfall, as has been observed for other range types in the Hedad area.

(ii) Range unit 5B

This unit is made up of five range types dominated by *Indigofera spinosa* with *Dactyloctenium aegyptium* dwarf shrubland with annual grasses. This dwarf shrubland with annual grasses occupies 58.4% of the total unit. The other range types and their respective extents are, an *Indigofera spinosa/Duosperma eremophilum* dwarf shrubland (17.5%), a *Cenchrus ciliaris/Sorphum versicolor* annual grassland (15.7%), an *Indigofera spinosa* with *Dactyloctenium aegyptium* dwarf shrubland with annual grasses (5.8%), and an annual grassland with scattered trees (2.6%). The dominant range type in this unit was found to have a dwarf shrub cover of 18.3% of which *Indigofera spinosa* contributed 13.3%. The other dwarf shrubs were *Duosperma eremophilum, Sericocomposis hildebrandtii, Heliotropium albohispidum* and *Seddera hirsuta.* Annual grasses and herbs had a cover of 38.7%, standing dead grass and herbs covered 7.8%, and litter covered 5.4%. Bare areas were only 20%. Other grasses which were identified were *Aristida adscensionis, Aristida mutabilis, Cenchrus ciliaris, Leptothrium senegalense,* and *Dactyloctenium aegyptium.*

The standing crop biomass contributed by desirable plants in the major range type of this unit was 2,171.2 kg/ha ADW of which annual grasses were 1,322.4 kg/ha. The air dry weight of the standing dead grass and woody plants was 335 kg/ha, of which 197.4 kg/ha was grass material. This range unit occurs in one of the driest parts of the study area. The quick flush of growth soon after the rains is followed by an equally rapid maturation of the

annuals, and within less than four weeks after the rains most annuals will have died out. There has been a recent invasion of *Dactyloctenium aegyptium* which accounted for the high grass biomass. Throughout this range unit the trees are scattered at low densities of between 8 and 36 ha^{-1}, canopy cover of 0.6 to 3.3% and a foliage dry weight annual production of c. 13 kg ha^{-1}. The tree species present include *Acacia reficiens, Cadaba ruspoli, Commiphora flaviflora* and *Euphorbia cuneata* all of which are relatively unpalatable to livestock.

c. Human influence

(i) Unit 5A

This area is lightly used by cattle (up to 1.4 km^{-2} in one part) and by smallstock. They obtain water at small springs on the east side of Ol'Donyo Mara.

(ii) Unit 5B

This unit is heavily used by camels (mean density 10 km^{-2} in the central 100 km^2). It is lightly used by cattle along its southern margin as they are at the limit of their watering distance from Korr (mean density 2.8 km^{-2}). Smallstock densities are moderate.

d. Range condition

(i) Unit 5A

This unit had slight use. The soils are stable with signs of slight erosion. The cover of desirables was fair, although the standing biomass was low due to loss of leaves and dying of vegetation. This site has potential for light use and is therefore rated here as fair.

(ii) Unit 5B

This site has good surface cover with a stable soil showing little erosion. The amount of desirable plant cover was good, with a high standing biomass despite moderate use. It is therefore here rated as fair to good.

e. Carrying capacity

(i) Unit 5A

The carrying capacity of this unit in animals/km^2/year is 2.1 camels, 6.9 cattle, 14 sheep and 4.5 goats. The unit can therefore carry 573 camels,

1,856 cattle, 3,815 sheep and 1,226 goats.

(ii) Unit 5B

This unit has a carrying capacity of 3.2 camels, 20.9 cattle, 42.8 sheep and 14.7 goats all in animals/km^2/year. The total number of animals which may be carried on the unit as a whole is 572 camels, 3,737 cattle, 7,653 sheep, and 1,359 goats.

Table 32. Summary of cover, composition and biomass (Range unit 5A)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perrenial grasses	0.4	-	-	-	-	-	-	-	-	-
Annual grasses	19.7	275.6	-	-	222.6	83.5	53.0	19.9	-	-
Annual herbs	6.5	57.5	-	-	46.4	17.4	11.1	4.1	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	2.8	44.2	16.1	3.0	19.1	3.5	4.6	0.8	4.6	0.8
2. *Duosperma eremophilum*	7.5	146.8	114.2	12.6	-	-	-	-	32.6	3.6
3. Other desirable dwarf shrubs	9.6	131.9	102.6	19.0	-	-	-	-	29.3	5.4
4. Other undesirable dwarf shrubs	-	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	5.0	100.6	-	-	-	-	-	-	-	-
2. Wood	0.6	9.5	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	12.1	296.4	-	-	239.4	44.3	57.0	0.5	-	-
2. Wood	14.8	82.6	-	-	-	-	-	-	-	-
Trees and largeshrubs:										
1. Desirable foliage	3.0	25.5	17.0	8.5	-	-	-	-	6.5	1.6
2. Undesirable foliage	-	-	-	-	-	-	-	-	-	-
3. Wood	-	170.5	-	-	-	-	-	-	-	-
Bare areas	18.0	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	61.6	977.9	249.9	43.0	527.5	148.7	125.7	35.3	73.0	11.5
Total undesirable	20.4	1897.7								

1 - desirable biomass before corrections

2 - available biomass

Table 33. Summary of cover, composition and biomass (Range unit 5B)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	-	-	-	-	-	-	-	-	-	-
Annual grasses	38.5	1322.4	-	-	1068.1	400.5	254.3	95.4	-	-
Annual herbs	4.3	39.3	-	-	31.7	11.9	7.6	2.8	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	13.3	136.2	49.0	9.1	59.0	10.9	14.0	2.6	14.0	2.6
2. *Duosperma eremophilum*	4.8	328.6	185.6	20.4	-	-	-	-	53.0	5.8
3. Other desirable dwarf shrubs	-	221.3	172.1	31.8	-	-	-	-	49.2	9.1
4. Other undesirable dwarf shrubs	0.2	2.6	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	5.2	350.6	-	-	-	-	-	-	-	-
2. Wood	0.2	135.3	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	7.5	197.4	-	-	159.4	29.5	38.0	7.0	-	-
2. Wood	4.8	137.6	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	2.0	16.0	8.0	4.0	-	-	-	-	8.0	2.0
2. Undesirable foliage	4.0	30.0	-	-	-	-	-	-	-	-
3. Wood	-	3040.0	-	-	-	-	-	-	-	-
Bare areas	20.0	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks										
Total desirable	65.6	2171.2	414.7	65.3	1318.2	452.8	313.9	107.8	124.2	19.5
Total undesirable	14.4	3696.1								

1 - desirable biomass before corrections

2 - available biomass

8.6 Range unit 6: *Heliotropium/Indigofera* with *Portulaca/Aristida* dwarf shrub grassland



a. Physical attributes

This range unit occurs on the flood plains of the Hedad, and covers an approximate area of 160 km^2. It is a flat to almost flat land (0.2% slope), at an average elevation of 450 m above sea level. The exposure of this unit is to the N.E.

Average annual rainfall in this locality is about 190 mm with a mean annual variability of 180%. April is the wettest month. SE winds prevail; these are gentle winds.

The soils found here are developed on alluvial material brought down by the flooded rivers and runoff which dry up in the Hedad. These floods originate mostly from the hills and mountains of the basement system rock complex. In the northern half of this unit, the soils are well drained to moderately well drained, very deep, friable, sandy clay loam to sandy clay, often with a topsoil of loam to clay, or loamy sand to sandy loam. These soils are slightly to moderately saline, and strongly sodic. In the southern half of this range unit, however, a complex of somewhat excessively drained to well drained, very deep, strongly calcareous soils of varying texture, salinity, and sodicity occurs. They have rooting depths greater than 100 cm. The soil surface is generally sealed with a thin crust, which cracks (thinly and shallowly). Runoff is very slow on this, and during heavy rains large parts of it flood. Inherent fertility of the soils in this unit is low to moderate. The available nutrients are in low to moderate supply except for phosphorus, which is in high supply. Organic carbon content is between 0.1% and 0.3%, indicating a low organic matter content.

This range unit occurs on an accumulation plain. If heavily used, however, this unit can be subjected to heavy wind erosion, since the soils are rather loose and of the fine-particle-size class.

b. Vegetation attributes

This range unit is composed of four range types dominated by the *Heliotropium albohispidum/Indigofera cliffordiana* and *Portulaca oleracea/Aristida mutabilis* mixture of dwarf shrubs and annual grasses. These occupy about 87% of the total area. The other range types are an *Indigofera spinosa/Indigofera cliffordiana* dwarf shrubland (5%), a *Blepharis linariifolia* annual grassland occupying about 4% and a *Cenchrus ciliaris* open annual grassland, also with 4% contribution to the total unit. The dominant range type is characterized by a mixture of the main dwarf shrubs and annual grasses with a combined cover of 62.3%. Apart from the dwarf shrubs already mentioned, there are also *Indigofera spinosa, Duosperma eremophilum, Sericocomopsis hildebrandtii* and *Seddera hirsuta*. Annual grasses and herbs, which cover 44.1% of the main range type, include *Brachiaria leersioides, Aristida adscensionis, Cenchrus ciliaris, Oropetium minimum, Dactyloctenium aegyptium, Eragrostis cilianensis, Aerva persica, Crotalaria deserticola, Crotalaria massaiensis, Euphorbia inaequilatera, Heliotropium steudneri* and *Mollugo cerviana*.

Bare areas in this range type occupy 28.4% whilst all forms of litter and standing dead plants cover 9.3%. The second range type, though covering only 5% of the total area, is important in that it has a cover of more than 39% of desirable to intermediate dwarf shrubs, comprising *Indigofera spinosa, Heliotropium albohispidum, Indigofera cliffordiana, Duosperma eremophilum* and *Grewia tenax*.

The productivity of this range unit as estimated from the standing crop biomass was high, desirable dwarf shrubs in the dominant range type contributing 497.1 kg/ha ADW. Grasses and herbs contributed 818 kg/ha. Litter air dry weight was about 414 kg/ha and the standing dead plants 164.1 kg/ha in the dominant range type. The perennial dwarf shrubs showed a flush of renewed growth of leaves after the rains and the annual grasses and herbs appeared shortly after the rains, matured in 3-4 weeks, and died off soon after that. The greater portion of this unit has recently (1983) been invaded by *Dactyloctenium aegyptium* which has greatly modified the physiognomy.

The trees, which cover less than 3% of the range unit include *Acacia tortilis* and *Cadaba farinosa,* both important fodder species. Tree density is c.55 ha^{-1}, foliage dry weight annual production c. 46 kg ha^{-1} and the age structure moderate. As both the dominant species are semi-deciduous they provide green fodder during the dry season but the low production of the trees will support relatively few camels and goats.

c. Human influence

Present use on this range unit is of very low intensity and limited to livestock grazing during the rainy season when vegetation and water are at their peak. The loose nature of the soils, and also their fineness in some places, will lead to severe erosion, should it be heavily used and depleted of most of the vegetal cover.

d. Range condition

This area is currently lightly utilized, though it has an effective cover of 62.3% of dwarf shrubs, grasses and herbs and a high standing crop biomass of 1,592.5 kg/ha. Although the soils are seasonally increased by floods, it is liable to wind erosion following heavy utilization. It is therefore rated fair to poor.

e. Carrying capacity

The carrying capacity of this unit was calculated as 3.7 camels, 13.2 cattle, 27.1 sheep, and 8.4 goats per km^2 per year. The unit is thus capable of sustaining 590 camels, 2,112 cattle, 4,336 sheep, and 1,344 goats.

Table 34. Summary of cover, composition and biomass (Range unit 6)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	-	39.4	-	-	31.9	11.9	7.6	2.9	-	-
Annual grasses	30.8	602.4	-	-	486.6	182.5	115.9	43.5	-	-
Annual herbs	13.3	176.2	-	-	142.3	53.4	33.9	12.7	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	4.7	168.7	60.9	11.3	73.1	13.5	17.4	3.3	17.4	3.3
2. *Duosperma eremophilum*	-	-	-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	13.0	437.7	340.4	63.0	-	-	-	-	97.3	18.0
4. Other undesirable dwarf shrubs	0.5	0	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	1.8	328.4	-	-	-	-	-	-	-	-
2. Wood	4.3	85.5	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	3.2	164.1	-	-	132.6	24.6	31.6	5.8	-	-
2. Wood	-	-	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	3.0	4.0	3.0	1.0	-	-	-	-	1.0	0.25
2. Undesirable foliage	-	1.0	-	-	-	-	-	-	-	-
3. Wood	-	13.0	-	-	-	-	-	-	-	-
Bare areas	25.4	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	68.0	1592.5	404.3	75.3	866.5	285.9	206.4	68.2	115.7	21.55
Total undesirable	6.6	427.9								

1 - desirable biomass before corrections

2 - available biomass

8.7 Range unit 7: *Aristida* with *Duosperma/Plectranthus*



a. Physical attributes

This range unit occurs on the sedimentary plain in the middle of the Hedad. It is at an average elevation of about 450 m above sea level, on flat to almost flat land (0.2% slope), with a NE exposure. This unit covers approximately 240 km^2.

Annual average rainfall in this locality is about 190 mm, with a mean annual variability of about 180%. The highest amount of rainfall is recorded during the month of April. SE winds prevail, and in this locality they are gentle.

Two major types of soil occur within this range unit. Both are developed on sedimentary deposits. About 65% of this unit (to the west) has well drained, very deep, friable, slightly to moderately sodic, sandy loam to sandy clay loam soils. These soils are slightly saline and/or strongly calcareous in places. The topsoil is usually sand to loamy sand. The remainder of the unit (to the east) has well drained to imperfectly drained, very deep, friable, sandy clay loam to sandy clay soil, which is truncated or buried in places. These soils are slightly to strongly saline, strongly sodic, and strongly calcareous. The rooting depth is greater than 100 cm. The surface of these soils is usually sealed, with a thin weak crust. The inherent fertility of these soils can be said to be moderate. They are generally moderately well to well supplied with available nutrients but have a low organic-matter content (organic carbon = 0.2%).

The entire unit is an accumulation plain and current erosion is low. Rill marks are common, and in places signs of sheet erosion are seen. If use should increase the erosion will increase rapidly.

b. Vegetation attributes

Eighty-three percent of this range unit consists of the range type whose description it bears. Included are four other range types: *Blepharis linariifolia* open annual herb grassland (12.5%), a *Cenchrus ciliaris* open annual grassland (3%), and negligible cover of an *Aristida adscensionis* annual grassland and an *Indigofera spinosa* dwarf shrubland. The dominant range type is covered mainly by annual grasses and herbs, occupying 32% and dominated by *Aristida mutabilis* with nearly 16% of the whole range type. Other important annual grasses and herbs are *Leptothium senegalense, Aristida adscensionis, Chloris virgata, Enneopogon desvauxii, Brachiaria, Digitaria valutina, Dactyloctenium aegyptium, Tetrapogon spatheceus, Heliotropium steudneri, Blepharis linariifolia, Tribulus terrestris, Sesamum alata,* and *Aerva persica*. Climbers and creepers include *Kendrostis gijef, Cissus rotundifolia* and *Vigna membranacea*. The dwarf shrubs, forming around 12.4% comprise *Duosperma eremophilum, Plectranthus ignarius, Indigofera spinosa,* and to a lesser extent *Barleria eranthemoides, Heliotropium albohispidum* and *Indigofera cliffordiana,* in order of importance. Portions of this unit have also been recently invaded by *Dactyloctenium aegyptium*. Bare areas in this range unit occupy 29.6%, and the rest is occupied by standing dead plants.

As may be expected, the largest contribution to the standing crop biomass was made by annual grasses with air dry weights of 291.9 kg/ha in the dominant range type. All kinds of litter produced 363 kg/ha and standing dead plants 154.6 kg/ha. *Duosperma eremophilum* and *Indigofera spinosa* contributed 211.6 kg/ha and 68.4 kg/ha respectively. The herb layer, which is dominated by annuals, follows the rain pattern in its growth.

The tree and large shrub cover of the main range type in this unit, which has a canopy of 17.5% and is dominated by *Commiphora* sp. (IPAL designation PY), includes *Acacia senegal, A. reficiens,* and *Cadaba farinosa*. In the unit as a whole, taking into account the open annual grassland and dwarf shrubland range types also included, the average canopy cover is 6.7% with 12 species present including three other *Commiphora species, Salvadora persica, Acacia tortilis* and *Cordia sinensis,* the last three being important browse species. The average wood dry weight biomass is 1.3 t ha^{-1} with an annual production of 53 kg $ha^{-1}y^{-1}$, which is too low to permit live good collection. Tree and large shrub foliage production is estimated at 85 kg $ha^{-1}y^{-1}$.

c. Human influence

Present land use in this unit is of very low intensity; livestock are grazed here only during the rainy season when vegetation cover/production is at its peak and water is available. Even though current erosion is low, heavy use might lead to severe erosion on this unit due to the fine and unstable nature of the soil.

d. Range condition

This unit, which has a well developed cover of annual grasses and herbs, has a relatively stable soil due to slight seasonal use. As annuals contribute considerably to available forage in season yet remain to stabilize the soil under present use, its condition is rated as fair. Heavy use must, however, be avoided.

e. Carrying capacity

The carrying capacity of this unit is 1.4 camels, 5.7 cattle, 8.4 sheep, and 3.2 goats. The unit can therefore carry 336 camels, 2,368 cattle, 2,016 sheep and 768 goats.

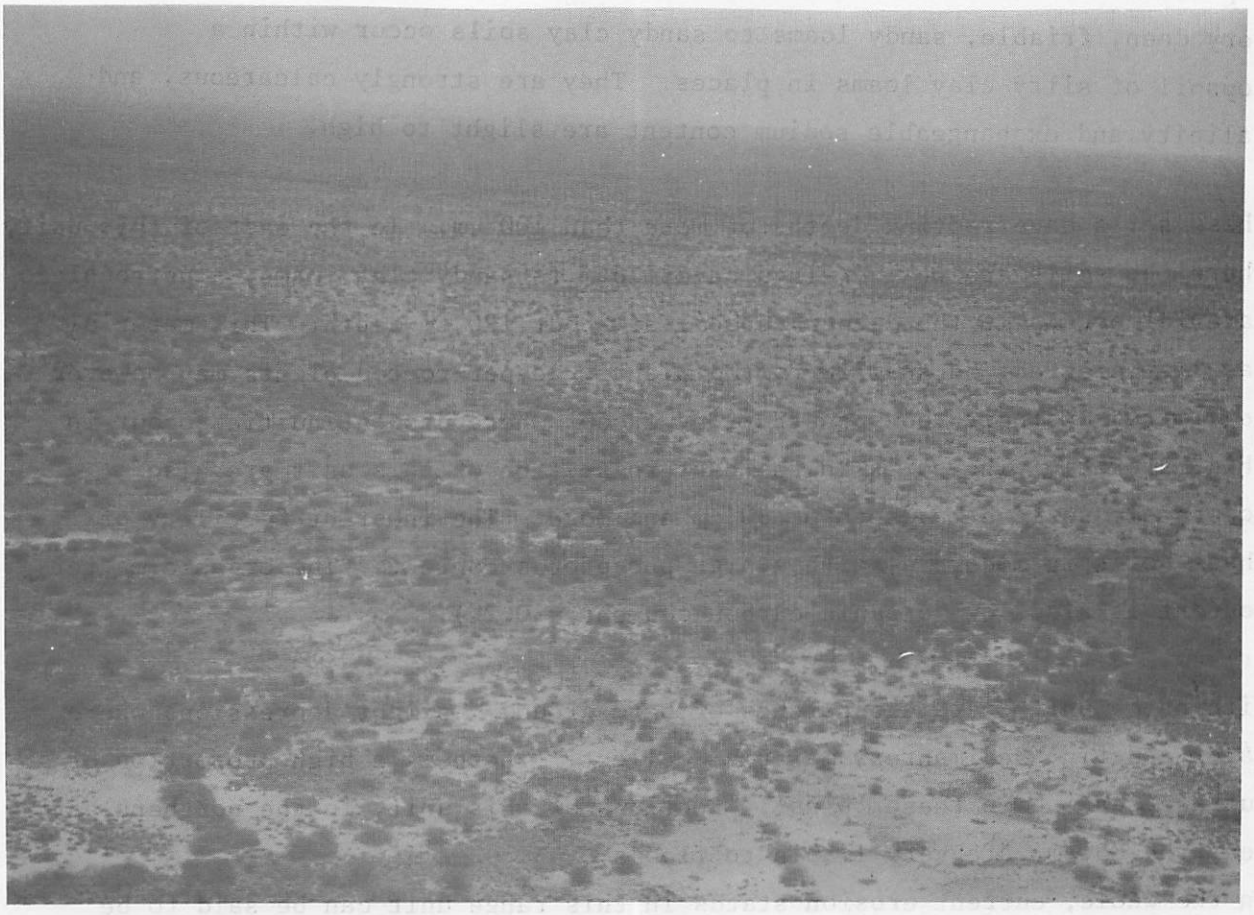
Table 35. Summary of cover, composition and biomass (Range unit 7)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	-	-	-	-	-	-	-	-	-	-
Annual grasses	30.0	291.9	-	-	285.8	88.5	56.1	12.3	-	-
Annual herbs	2.0	63.7	-	-	51.4	19.3	12.3	4.6	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	3.5	68.4	21.4	3.8	28.6	6.3	7.1	1.5	7.1	1.5
2. *Duosperma eremophilum*	5.3	211.6	164.7	18.1	-	-	-	-	47.1	5.2
3. Other desirable dwarf shrubs	3.4	18.7	14.5	2.7	-	-	-	-	4.2	0.8
4. Other undesirable dwarf shrubs	0.2	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	10.2	242.7	-	-	-	-	-	-	-	-
2. Wood	2.5	120.3	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	2.9	77.9	11.6	2.2	51.4	9.5	15.0	2.8	-	-
2. Wood	2.0	76.7	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	2.7	11.5	3.5	1.75	-	-	-	-	3.0	0.8
2. Undesirable foliage	5.0	36.0	-	-	-	-	-	-	-	-
3. Wood	-	1300.0	-	-	-	-	-	-	-	-
Bare areas	29.6	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	44.5	732.2	215.7	28.55	417.2	123.6	90.5	21.2	61.4	8.3
Total undesirable										

1 - desirable biomass before corrections

2 - available biomass

8.8 Range unit 8: *Acacia* with *Duosperma/Lippia* and *Brachiaria* shrubland



a. Physical attributes

This range unit occurs in the northern part of the sedimentary plains of the Hedad (stretching NE to the vicinity of Kargi). It is flat to almost flat land (0-2% slope), at an average of about 450 m above sea level, and covers a total area of about 244.7 km^2. It has a general exposure to the NE.

The average annual rainfall in this area is about 200 mm, with an estimated mean annual variability of about 80%. In this locality the highest amount of rainfall was recorded during the month of April. The prevailing winds are south-easterly and are gentle.

Soils occurring within this unit are developed mainly from the sedimentary deposits. To the west of this unit, well drained to imperfectly drained, very deep, friable, sandy loams to sandy clay soils occur within a topsoil of silty clay loams in places. They are strongly calcareous, and salinity and exchangeable sodium content are slight to high.

These soils have rooting depths of more than 100 cm. To the east of this unit, where the soils are well drained sandy loam to sandy clay loams, a petrocalcic material occurs in the deeper subsoil at about 120 cm depth. This material has little effect on shallow-rooted plants; deeper-rooted plants may however be limited in their root penetration, except where discontinuities occur in this material. The soils in the eastern section of this unit are also moderately sodic at a depth of 80 cm and more. The inherent fertility of these soils is moderate, with a high phosphorus content. The organic-matter content is also low (organic carbon content = 0.2%).

Within the unit there are patches of bare ground - slight depressions where water and fine sedimentary material collect. There is a high proportion of surface sealing in these 'pans'. Sections of this unit, in the northern part near the Falam, are very liable to floods.
On the whole, current erosion status in this range unit can be said to be low.

b. Vegetation attributes

This range unit is composed of thirteen range types. However, only two of these types are important and they cover 80.6% of the whole unit. The *Acacia reficiens* with *Duosperma eremophilum/Lippia* sp. and *Brachiaria leersioides* bushland is the dominant type, covering 55.8% of the unit. Dwarf shrubs cover 11.9% of this range type, with *Duosperma eremophilum* having 9.0% and 2.9% cover. Other important dwarf shrubs are *Indigofera spinosa, Heliotropium albohispidum, Indigofera cliffordiana, Sericocomopsis hildebrandtii,* and *Salsola dendroides.* The grasses and herbs cover 16.3%; the important ones being *Brachiaria leersioides, Eragrostis cilianensis, Tetrapogon cenchrisformis, Gisekia pharnaceoides, Sporobolus fimbriatus,* and *Heliotropium steudneri,* although there are many others. Litter covers only 3.4% and standing dead plants 12%. This leaves 48.6% of the range type here. It should be mentioned that 0.5% of this type is occupied by the perennial grass *Cenchrus pennisetiformis.*

The standing crop biomass of desirable forage of the dominant type was 1,689.5 kg/ha. *Duosperma* contributed 939.2 kg/ha and other dwarf shrubs 375.3 kg/ha. The annuals contributed 199.1 kg/ha.

The *Acacia reficiens* shrubland with *Duosperma eremophilum/Lippia* sp. and *Brachiaria leersioides* understorey is the dominant type, covering 55.8% of the unit. This type (5a/20: 146 km^2), with nine tree and large shrub species present, has a tree and shrub canopy cover of 7.4%, density of 115 ha^{-1}, wood biomass of 2.4 t ha^{-1} and an annual production of 195 kg ha^{-1} dry weight. The dry weight foliage production is estimated at 79 kg $ha^{-1}y^{-1}$. Numerically *A. reficiens* nearly equals the other tree and large shrub species together. Its age class structure is poor with low recruitment to the smallest classes. Other species, also poor in their age-structure, include *A. nubica, Cadaba* (3 spp.), *Cordia sinensis, Maerua* (2 spp.) and *Commiphora candidula*.

Five range types are represented by small areas (2-15 km^2) which vary from annual grassland with scattered trees to moderately dense *Acacia reficiens* shrubland (no. 20/15: 15 km^2) with 12 tree and shrub species, a density of 269 ha^{-1}, 18.2% canopy cover and a foliage dry weight of 179 kg ha^{-1}.

Two other small areas are of particular interest in this unit. Type 56/14 (5 km^2) is open *Balanites* shrubland in which young trees reach a density of 200 ha^{-1}. Type 20/C (5 km^2) is *Acacia senegal* shrubland with a canopy cover of 10.5% and a density of 259 trees ha^{-1}.

c. Human influence

This range type is also used for the grazing of livestock. However, in most parts use is very light, and it is only the section around Kargi which is heavily utilized. Camels are grazed here during the dry season, when there is little or nothing to graze on elsewhere. Local Rendille herdsmen remember that this stand of *A. senegal* grew in a previously open annual grass area after seed was brought there ten years ago by livestock. Numerous camps with large livestock concentrations were set up in the area by Rendille who settled temporarily close to Kargi village as a security measure after a series of livestock raids. The significance of this colonisation by *A. senegal* is discussed under woodland management proposals in Part II of this management plan.

d. Range condition

This unit, which is dominated by bush and only intermediately desirable shrubs, has a good standing biomass. The soils are not eroded, contributing fair stability, and since annuals, which are the most desirable species for grazing, constitute only a low percentage, a condition rating of fair is assigned largely on the basis of soil stability.

e. Carrying capacity

The carrying capacity of this unit in animals/km^2/year is 6.6 camels, 4.2 cattle, 8.5 sheep, and 14.8 goats. The unit will therefore be able to carry 1,615 camels, 1,028 cattle, 2,080 sheep and 3,622 goats.

Table 36. Summary of cover, composition and biomass (Range unit 8)

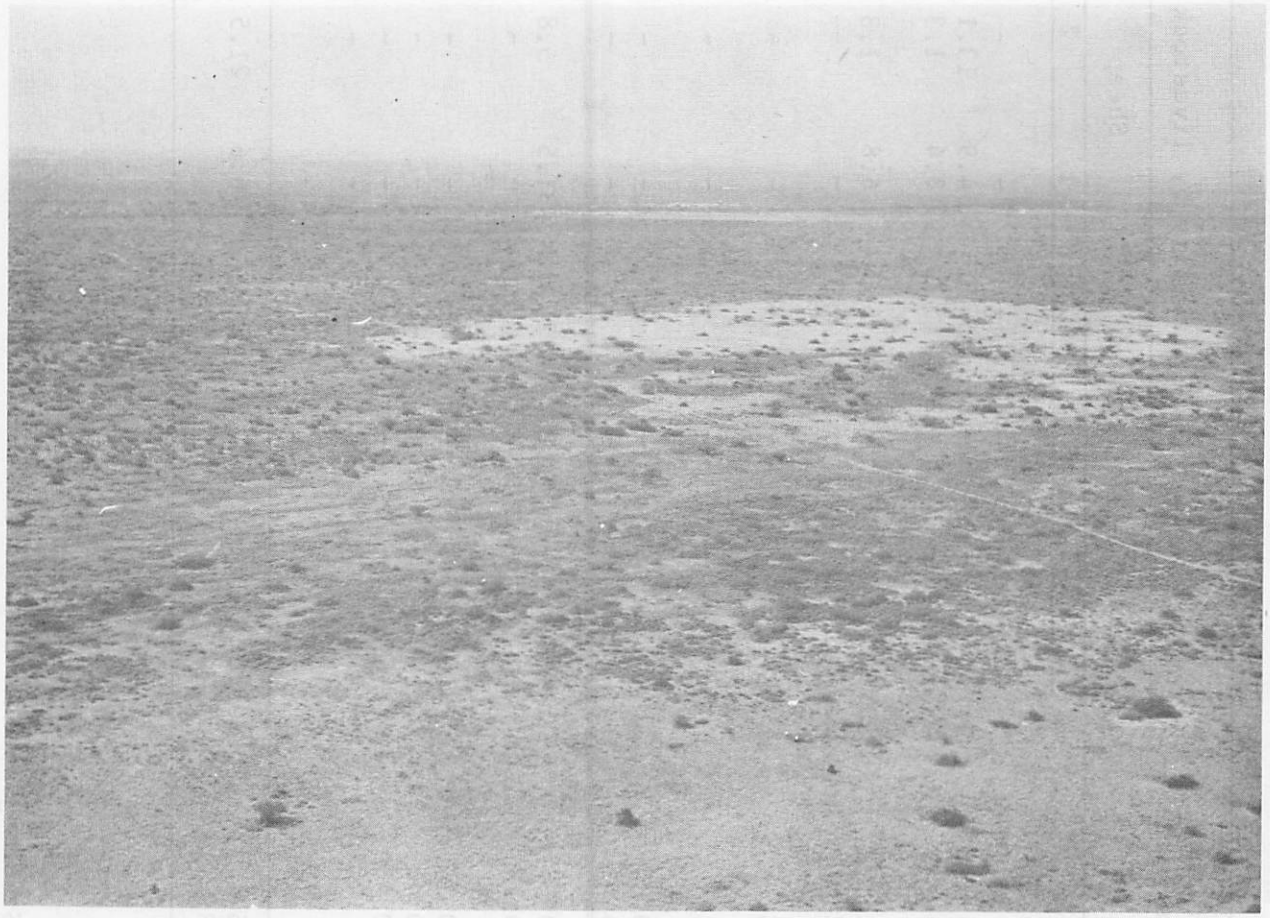
Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	0.3	-	-	-	-	-	-	-	-	-
Annual grasses	15.0	181.5	-	-	146.6	55.0	34.9	13.1	-	-
Annual herbs	1.0	17.6	-	-	14.2	5.3	3.4	1.3	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	0.3	66.1	23.8	4.4	28.6	5.3	6.8	1.3	6.8	1.3
2. *Duosperma eremophilum*	9.0	939.2	730.5	80.4	-	-	-	-	208.7	23.0
3. Other desirable dwarf shrubs	2.6	309.2	-	-	-	-	-	-	-	-
4. Other undesirable dwarf shrubs	-	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	0.7	83.0	-	-	-	-	-	-	-	-
2. Wood	2.7	33.9	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	3.3	168.9	-	-	132.4	24.5	31.5	5.8	-	-
2. Wood	8.7	993.9	-	-	-	-	-	-	-	-
Trees and largeshrubs:										
1. Desirable foliage*	3.4	12.0	9.0	4.5	-	-	-	-	3.0	0.8
2. Undesirable foliage	4.4	16.0	-	-	-	-	-	-	-	-
3. Wood		2160.0	-	-	-	-	-	-	-	-
Bare areas	48.6	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks										
Total desirable	34.9	1689.5	1003.8	133.8	321.8	90.1	76.6	21.5	287.2	37.8
Total undesirable	16.1	3286.8								

1 - desirable biomass before corrections

2 - available biomass

* Note: age structure of palatable trees is poor. Stocking rate to be reduced.

8.9 Range unit 9: *Duosperma eremophilum* with *Acacia reficiens* and *Blepharis linariifolia* shrubland



a. Physical attributes

This range unit occurs on the sedimentary plains in the north-western corner of the Hedad. It is generally flat to almost flat land (0-2%), at an average elevation of about 500 m above sea level. It has a general exposure to the west and covers approximately 672.8 km^2.

The average annual rainfall in this locality is about 220 mm, with peak rainfall in April. The estimated mean annual variability is about 80%. SE winds prevail, and in this locality they are gentle, with calculated speeds of less than 7 km/hr.

Soils occuring within this unit are developed on sedimentary deposits. They are generally well drained, very deep, friable sandy loam to sandy clay loam soils with a topsoil of sand to loamy sand. They are slightly to moderately sodic below a depth of 80 cm. In places the soils are slightly saline below a depth of 50 cm and/or strongly calcareous throughout the profile. They have rooting depths greater than 100 cm. The inherent fertility of these soils can be said to be moderate. Phosphorus content is high, but potassium is in low to moderate supply; the calcium content is low to high.

The organic-matter content is also low (organic carbon content is about 0.2%). The soils, however, exhibit good structure.

This range unit shows a typical "tiger-browse" pattern (more evident in aerial photographs), and is mostly made up of an alternation of thick *Duosperma* bushes in slightly depressed "linear" areas which act as "drainage ways", and slightly raised areas of accumulated sands which are either bare or carry trees.

Current erosion status on this range unit can be said to be low. There are signs of rill and sheet erosion.

b. Vegetation attributes

This range unit is dominated by the extensive tiger-bush *Duosperma eremophilum* with *Acacia reficiens* and herb understorey range type, which occupies 79.8% of the unit. Less extensive range types in the unit are *Acacia reficiens/ Acacia mellifera* bushland (8.5%), *Duosperma eremophilum/Indigofera cliffordiana* with *Acacia reficiens/Acacia senegal* bushed dwarf shrubland (5.7%), *Indigofera spinosa/Heliotropium albohispidum* with *Acacia reficiens* dwarf shrubland (4.9%) and a small *Acacia reficiens* with *Duosperma eremophilum* bushland (1.1%). The character of the range unit is therefore that of the dominant range type. Due to its extensive area, there are differences in grass, dwarf shrubs and tree cover in its southern and northern sections. Thus there are more bare areas, dwarf shrubs and tree cover in the north, while the south has more annual grasses and herbs and fewer bare areas. On the average, the perennial grasses and herbs 15.9%, litter 1.2%, standing dead grass 2.9%. standing deadwood 7.7% and bare areas 31%.

A large number of annual species are encountered in the herb layer, the important ones being *Blepharis linariifolia, Aristida mutabilis, Leptothium senegalense, Brachiaria leersioidea, Sporobolus fimbriatus, Tetrapogon tenellus, Oropetium minimum, Euphorbia inaequilatera, Tragus berteronianus* and others of less importance. The dwarf shrubs are *Duosperma eremophilum, Indigofera cliffordiana, Indigofera spinosa, Sericocomopsis hildebrandtii, Heliotropium albohispidum* and *Barleria eranthemoides*.

The standing crop biomass of the herb and dwarf shrub layer of the major range type was mainly contributed by *Duosperma eremophilum* with 1,022.9 kg/ha, air dry weight. *Barleria eranthemoides, Indigofera cliffordiana* and *Indigofera spinosa* yielded altogether 246.7 kg/ha. Annual herbs gave 156.4 kg/ha, annual grasses 144.9 kg/ha, herbaceous litter 280.7 kg/ha, and woody litter 135.5 kg/ha. Standing dead grass contributed 247.2 kg/ha and standing dead wood 325.2 kg/ha. In the northern section of this unit, a flush of new growth appeared about one week after rains. Maturation of some annuals was observed to be rapid, taking only two to three weeks, and drying up followed shortly afterwards.

This range unit is largely composed of *Acacia reficiens* with *Duosperma eremophilum* stands growing in the characteristics "tiger bush" pattern in which strips of *Acacia* shrubland on low ridges alternate with *Duosperma* growing densely in the depressions. The main range type, which occupies 79.8% of the unit, is an over-mature *A. reficiens* shrubland with 11 tree and large shrub species present, canopy cover of 11% and a density of 125 trees and shrubs per ha. The wood dry weight biomass is exceptionally high at 11.3 t ha^{-1} with an annual production estimated at 897 kg $ha^{-1}y^{-1}$ and foliage production of 123 kg $ha^{-1}y^{-1}$. The large number of old, dead and dying *A. reficiens* trees make this an important source of fuel wood and material for livestock fence construction. The palatable tree and shrub species are sufficiently numerous to support a moderate number of camels and goats but since their age-class structures are poor and the populations are in decline, animal stocking rates should be kept low to enable this shrubland to regenerate. The most important of the palatable species are *A. mellifera, Cadaba mirabilis, C. ruspoli, C. farinosa,* and *Maerua crassifolia*.

A further 8.5% of this unit is occupied by shrubland in which *A. mellifera* and *A. reficiens* are co-dominant, with *Duosperma* understorey, and 5.7% of the unit contains a *Duosperma/Indigofera cliffordiana* dwarf shrubland with

scattered *Acacia reficiens* and *A. senegal*. Throughout this range unit, with the exception of a small area of *Acacia* thicket, age-class structures are poor.

c. Human influence

Present use of this range unit is concentrated in the northern and eastern sections, where low-intensity grazing is carried out, shortly after or during the rainy season. The remainder of the unit, especially near the Ol'Donyo Mara mountains, is not used at all because of security problems posed by cattle rustlers.

d. Range condition

This unit, which is deteriorated former grassland, is dominated by *Acacia reficiens* and *Duosperma*, which are no longer suitable for herb-layer grazers. The soil cover is fair largely due to light use. Because of the vulnerability of the bare soil cover, this site is rated as fair.

e. Carrying capacity

This unit has a carrying capacity of 6.7 camels, 5.9 cattle, 12.1 sheep and 14.7 goats per km^2 per year. It can thus carry up to 4,508 camels, 3,969 cattle, 8,141 sheep and 9,890 goats.

Table 37. Summary of cover, composition and biomass (Range unit 9)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	0.4	-	-	-	-	-	-	-	-	-
Annual grasses	5.7	144.9	-	-	117.0	43.9	27.8	10.4	-	-
Annual herbs	10.2	156.4	-	-	126.3	47.3	30.0	11.2	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	0.2	0.9	0.4	0.1	0.4	0.05	0.1	-	0.1	-
2. *Duosperma eremophilum*	22.7	1022.9	795.6	87.5	-	-	-	-	227.3	25.0
3. Other desirable dwarf shrubs	10.0	245.8	191.2	35.4	-	-	-	-	54.6	10.1
4. Other undesirable dwarf shrubs	0.2	2.8	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	0.2	280.7	-	-	-	-	-	-	-	-
2. Wood	1.0	135.5	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	2.9	247.2	-	-	199.6	37.0	49.3	8.8	-	-
2. Wood	7.7	325.2	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	6.0	40.0	26.0	13.0	-	-	-	-	10.0	2.5
2. Undesirable foliage	1.8	6.0	-	-	-	-	-	-	-	-
3. Wood	-	1500.0	-	-	-	-	-	-	-	-
Bare areas	31.0	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	58.1	1858.1	1013.2	136.0	443.3	128.3	107.2	30.4	292.0	37.6
Total undesirable	10.9	2250.2								

1 - desirable biomass before corrections

2 - available biomass

8.10 Range unit 10: *Acacia* with *Duosperma* bushland



a. Physical attributes

This range unit occurs on the sedimentary plain in the Falam-Kobatal-Kalama-Kurkum area. It is flat to almost flat land (0-2% slope) occupying an approximate area of 1,025.7 km^2, and of this area about 26% is made up of a series of plateaus of volcanic origin. In general the plain has a north-east exposure. The average elevation is about 450 m above sea level.

The average annual rainfall is about 200 to 400 mm, with an estimated annual variability of 80%. April and November rainfall are approximately equal. The prevailing winds are south-easterlies of gentle speeds.

Soils occurring on the plains are developed on sediments originating mainly from the undifferentiated basement system rocks, while on the dissected plateaus the soils are developed on volcanic materials.

On the sedimentary plain, the soils are well to moderately well drained, very deep, friable, sandy clay loam to sandy clay with a topsoil of loamy sand to sandy loam. The first 50 cm depth of these soils is slightly to moderately saline; below this depth they become moderately to strongly saline, and strongly sodic. They have rooting depths greater than 100 cm. Surface sealing is common, especially in slightly depressed areas, but the crust formed is thin and 'soft'.

On the dissected volcanic plateaus, fine-textured soils, clay loams, occur. They are well drained, but shallow with an exceedingly stony and bouldery surface. They are moderately calcareous in places.

The inherent fertility of a large part of the soils is moderate to high. Supply of available nutrients is moderate to high, except for phosphorus which is high. Organic-matter content is low (organic carbon content = 0.1 - 0.4%). The current status of soil erosion in this unit is gentle. The main type occurring here is rill erosion. No gullies have been recorded.

b. Vegetation attributes

This unit is made up of more than eight range types with varying *Acacia mellifera* and *Acacia reficiens* compositions. Their dwarf shrub layers are mainly dominated by *Duosperma eremophilum,* with *Indigofera cliffordiana* and *I. spinosa* as common co-dominants or sub-dominants. The most extensive range type in this unit is the *Acacia mellifera* with *Duosperma eremophilum* bushland with dwarf shrub understorey, occupying about 55% of the whole area. Other notable communities are an *Acacia mellifera/A. reficiens* with *Duosperma eremophilum* bushland and an *Acacia reficiens* with *Duosperma eremophilum/Indigofera cliffordiana* bushland with dwarf shrub understorey. These three vegetation types vary in cover per cent in all layers by a small margin and are therefore represented by the dominant type whose characteristics the whole unit bears. The dwarf shrub layer of the dominant range type has a total perennial cover of 32.3%. Annual grasses cover only 7.9% and annual herbs 0.2%. Grass litter covers 1.5%, woody litter 3.9%, standing dead grass 0.5% and standing dead woody plants 4.4%. Bare areas cover 49.3%.

In the other range types, the bare areas are equally high. The dwarf shrubs, which cover 20.6%, are dominated by *Duosperma eremophilum*, which alone covered 13.2%. Other dwarf shrubs are *Barleria proxima, Heliotropium albohispidum, Indigofera cliffordiana, I. spinosa* and *Solanum* sp. *Sporobolus agrostoides* is the only perennial grass recorded. Annual grasses are *Aristida adscensionis, Brachiaris lerrsiodes, Cenchrus ciliaris, Enneapogon desvauxii, Eragrostis cilianensis, Leptothrium senegalense, Oropetium minimum, Setaria verticillata, Tetrapogon cenchroides* and *Tragus berteronianus*. Annual herbs include *Barleria argentea, Indigofera hochsteteri, Gisekia pharnaceoides, Mollugo cerviana* and *Tribulus terrestris*. *Kendrostis gijef*, a highly palatable cucurbit for all livestock species, is also found in small amounts.

The standing crop biomass of the desirable species was 1,517.2 kg/ha of which 762.1 kg/ha were attributed to *Duosperma* alone. The palatable *Indigofera spinosa* contributed only 273.7 kg/ha, while other desirable dwarf shrubs gave 235.8 kg/ha. Annual grasses gave 136.9 kg/ha, annual herbs 2.0 kg/ha, grass and herb litter 351.2 kg/ha, woody litter 327.9 kg/ha, standing dead grass 74.7 kg/ha and standing dead woody plants 188.4 kg/ha.

In this large unit the absolute and relative abundance of the two dominant trees *Acacia mellifera* and *Acacia reficiens* differ according to the rainfall and drainage conditions. The former species occurs mainly on the wetter western side of the unit but is also common in drainage lines elsewhere, where it grows in dense stands. The latter species is dominant on the drier, well drained sandy soils.

Fourteen tree and large shrub species (named in Table 50) occur at an average total density of 160 per hectare and a canopy cover of 13 per cent. The average dry weight biomass of wood is c.3,500 kg per ha with an annual production of c. 310 kg per ha. This will permit moderate harvesting for firewood and for livestock enclosures provided that the collection is distributed across the unit rather than concentrated around the settlement area of Kargi. Foliage dry weight production is c. 140 kg per ha annually.

A very distinctive feature of this unit is the gradient of grazing and browsing impact from the heavily exploited areas near Kargi, Falam and Kurkum in the east to the virtually unexploited areas near the Balesa Kulal water course in the west, which have been protected due to the lack of security.

The gradient is shown clearly in the variation in age-class structure of the tree and shrub populations. In the east of the unit, where the browsing pressure has been greatest, there is a marked shortage of young trees to provide adequate recruitment to the mature tree populations, a situation which is likely to lead to a decline in tree density within twenty years.

Although one of the dominant tree species, *Acacia reficiens*, is relatively unpalatable (its use being mainly for livestock enclosures), *Acacia mellifera*, the co-dominant species, together with several other trees and shrubs, are good browse plants and make this unit especially important for the herding of camels in the future. A further important attribute of this unit is the occurrence of scattered stands of *Acacia senegal* which can be exploited commercially for gum arabic production. Since *A. senegal* occurs as a successional stage in certain drainage situations, there is considerable possibility for propagating it from seed in order to establish it more abundantly than at present.

c. Human influence

This unit is lightly utilized, especially as a dry-season grazing reserve, and mainly by the Kargi livestock.
Use of this large unit by livestock follows a decreasing gradient from south-east where it is very high (e.g. smallstock and camel densities >50 and >20 km^{-2} near Karole) to virtually no use around Kobatal. A moderately used area occurs around Balesa Bobor in particular for smallstock (>15 km^{-2}). The western part is relatively insecure.

d. Range condition

This area has frequent but light use. Perennial and annual plant cover is moderate at 40.4% but the standing crop biomass is high at 1,5172 kg/ha. Soil fertility is moderate to high, and current erosion status is gentle. This site has a fair range condition and has possibilities for camel and goat browsers.

e. Carrying capacity

This unit has a carrying capacity of 5.7 camels, 6.8 cattle, 7.1 sheep and 12.4 goats. The total number of animals it can carry is 5,846 camels, 6,675 cattle, 7,282 sheep and 12,719 goats.

Table 38. Summary of cover, composition and biomass (Range unit 10)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	0.9	-	-	-	-	-	-	-	-	-
Annual grasses	7.9	136.9	-	-	110.6	113.6	26.3	9.85	-	-
Annual herbs	0.2	2.0	-	-	1.6	0.6	0.4	0.15	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	4.5	273.7	98.75	18.25	118.5	21.95	28.2	5.25	28.2	5.25
2. *Duosperma eremophilum*	13.2	762.1	494.3	52.15	-	-	-	-	135.5	14.9
3. Other desirable dwarf shrubs	2.0	235.8	183.35	33.9	-	-	-	-	52.4	9.7
4. Other undesirable dwarf shrubs	0.9	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	1.5	351.2	-	-	-	-	-	-	-	-
2. Wood	3.9	327.9	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	0.5	74.7	-	-	60.3	11.15	14.35	2.65	-	-
2. Wood	4.4	188.4	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	5.5	32.5	21.5	10.75	-	-	-	-	7.5	1.88
2. Undesirable foliage	5.3	25.0	-	-	-	-	-	-	-	-
3. Wood	-	3320.0	-	-	-	-	-	-	-	-
Bare areas	49.3	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	34.7	1517.2	777.9	115.0	291.0	147.6	69.2	17.9	223.6	31.7
Total undesirable	16.0	4212.4								

1 - desirable biomass before corrections

2 - available biomass

8.11 Range unit 11: *Dactyloctenium* with *Acacia*



a. Physical attributes

This range unit occurs on the flood plains of the Balesa river. It occupies approximately 23.5 km^2 of a flat to almost flat landscape at an average elevation of 400 m above sea level. The unit has a north-west exposure.

Climatic conditions prevailing in this locality are extrapolated from the records for Kalacha. The average annual rainfall is about 200 mm with a mean variability of about 80%. The prevailing winds are SE and since no records of wind speeds exist for this locality it is assumed that they are gentle.

Soils occurring within this unit are developed on alluvial deposits. These soils are somewhat excessively drained to well drained, very deep and strongly calcareous. They have varying texture, salinity and toxicity. Runoff on this unit can be low, and when the Balesa floods this whole unit is flooded and alluvial sediments are deposited. Current erosion on this unit is very low due to the frequent accumulation of materials by the Balesa Kulal.

b. Vegetation attributes

This range unit is composed of five range types dominated by the *Dactyloctenium aegyptium* with *A. reficiens* annual grassland with scattered trees. The dominant type occupies 44% of the whole unit. Also found are an *Acacia reficiens* bushland, which occupies 20%, a *Cenchrus pennisetiformis* with *Acacia nubica* perennial grassland with scattered trees, and two *Duosperma eremophilum* with *Acacia reficiens* dwarf shrublands with scattered trees, one having a rocky ground. The last three range types occupy 12% of the unit each.

The characteristics of this range unit derived from the dominant range type show total perennial cover of 24.4%. Annual grasses cover 13.4% and annual herbs 8.2%. The total amount of litter covers 9.7% of which 8.0% are grass and herb litter. Standing dead grass and woody plants cover 9.4% and 3.7% respectively, and bare areas cover 31.2%.

The dwarf shrubs encountered are *Dasysphaera prostrata, Duosperma eremophilum, Indigofera spinosa, Salsola dendroides, Seddera hirsuta, Sericocomopsis hildebrandtii* and *Suaeda monoica* all with a cover of 10.6%. The most significant contribution to the grass and herb layer is made by *Dactyloctenium aegyptium* with 9.7% cover. This species may behave as a perennial where the water table is high. *Sporobolus agrostoides* is another perennial grass with 1.7% cover. Annual grasses are *Aristida adscensionis, A. mutabilis, Brachiaria leersioides, Cenchrus ciliaris, Chloris virgata, Leptothrium senegalense, Sporobolus fimbriatus, Tetrapogon spatheceus, T. tenellus* and *Tragus berteronianus*. The herbs are *Barleria argentea, Cleome brachycarpa, Gisekia pharnaceoides, Heliotropium steudneri, Justicia exigua, Ocimum* sp. and *Oldenlandia* sp. Creepers and climbers include *Asparagus setaceus* and an unidentified cucurbit (*lengalayoy* Samburu).

The standing crop biomass of the dwarf shrub and herb layer was very low, the dwarf shrubs yielding only 151.9 kg/ha. Grasses gave 199.4 kg/ha, herbs 71.3 kg/ha, grass and herb litter 143.6 kg/ha, standing dead grass 157.5 kg/ha, woody litter 157.8 kg/ha, and standing dead woody plants 133.4 kg/ha. The total standing crop biomass of all desirable plants and plant parts was 582 kg/ha.

Dactyloctenium aegyptimum and *Sporobolus agrostoides* are capable of sprouting from their underground parts as soon as it rains and remain alive longer than annual plants, and so they form an important grazing resource, especially for cattle and sheep.

In the largest range type in this unit the trees and large shrubs have a canopy cover of 12.1% and a density of 124 per ha, with eight species represented.
Woody biomass and production are relatively high with a standing crop of over 9 tonnes dry weight per ha and annual production of 740 kg dry weight per ha. Annual dry weight foliage production is c. 130 kg per ha but, as the dominant species is *Acacia reficiens*, a large proportion of this would not be utilised due to low palatibility. Of the remaining species four are important browse plants: *Acacia mellifera, Cordia sinensis, Cadaba farinosa,* and *Salvadora persica*. Together they comprise some 15% of the available palatable browse and would contribute to the support of camels at low density.

The age-class structure of the trees and large shrubs is fair to poor in all species, indicating that goat numbers should be kept low in order to provide an opportunity for the small trees to increase.

c. Human influence

This unit is rarely used. One reason for this is fear due to insecurity.

d. Range condition

This area is rarely utilized and this partly accounts for the fairly good cover of 68.8% of mainly grasses, which include 1.7% perennial grasses. The soils are regularly increased by flood accumulations and the current erosion is very low. Since this area occasionally has high standing crop biomass, it is rated as fair to good.

e. Carrying capacity

The carrying capacity of this unit, based on the dwarf shrub and herb layer adjusted standing crop biomass, is 1.2 camels, 5.0 cattle, 10.2 sheep, and 2.6 goats per km^2 per year. The total number of animal which can be kept on this range is therefore 28 camels, 117 cattle, 240 sheep and 61 goats.

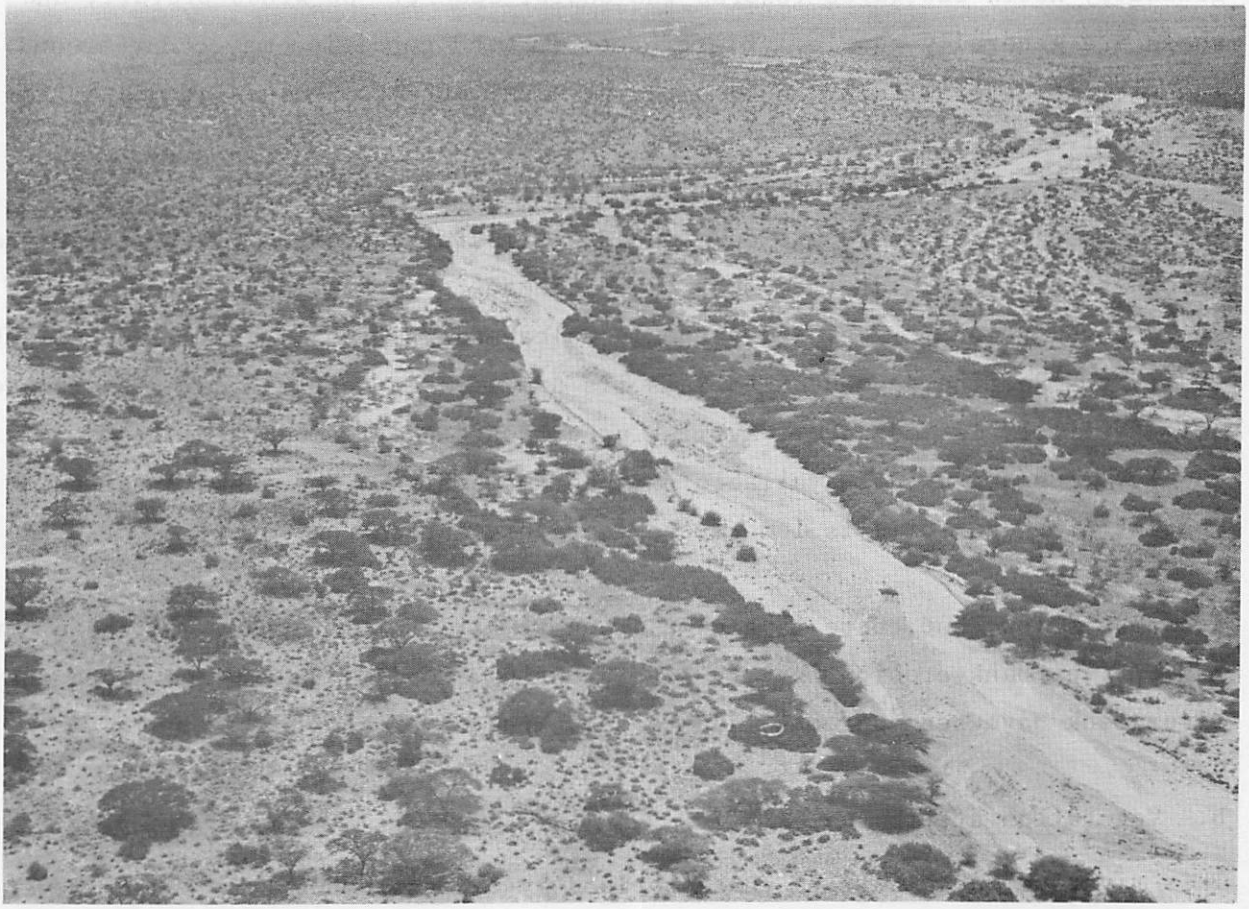
Table 39. Summary of cover, composition and biomass (Range unit 11)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	1.7	73.6	-	-	63.5	23.5	15.1	5.7	-	-
Annual grasses	13.4	125.8	-	-	101.6	38.1	29.2	9.1	-	-
Annual herbs	8.2	71.3	-	-	57.5	21.6	13.7	5.1	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	1.9	8.0	2.8	0.5	3.5	0.7	0.8	0.14	0.8	0.14
2. *Duosperma eremophilum*	0.9	3.3	2.6	0.3	-	-	-	-	0.8	0.1
3. Other desirable dwarf shrubs	7.0	120.5	93.7	17.4	-	-	-	-	-	-
4. Other undesirable dwarf shrubs	0.8	20.1	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	8.0	143.6	-	-	-	-	-	-	-	-
2. Wood	1.7	157.8	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	9.4	157.5	-	-	127.3	23.5	30.3	5.6	-	-
2. Wood	3.7	133.4	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	3.1	22.0	14.3	-	-	-	-	-	5.5	137
2. Undesirable foliage	9.0	-	-	-	-	-	-	-	-	-
3. Wood	-	9300.0	-	-	-	-	-	-	-	-
Bare areas	31.2	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	45.6	582.0	113.4	23.4	353.4	107.7	89.1	25.6	33.9	6.61
Total undesirable	23.2	9754.9								

1 - desirable biomass before corrections

2 - available biomass

8.12 Range unit 12: *Acacia* woodland



a. Physical attributes

This range unit occurs on the Balesa river floodplains. It is generally flat to almost flat (0-2% slope), narrow strip of land along the river, with a total area of about 112.7 km^2.

A number of examples of this kind of range, bearing riverine vegetation, occur in the study area. They are, however, very narrow, frequently less than 1 km broad, and are not mappable at this scale as separate units. They have therefore been mapped as inclusions in other units, and have been referred to in the respective unit descriptions.

Due to the extent of this unit, there is a variation in the amount of rainfall. Around Olturot, the mean annual rainfall is about 265 mm; this decreases gradually north-eastwards towards the Chalbi desert. SE winds prevail, and these are generally gentle. Differences in wind condition may occur around the vicinities of Olturot, due to the reversal effect of winds at night from Mt. Kulal.)

The soils occurring here are developed on alluvial deposits. They are generally somewhat excessively drained, very deep, loose to very friable, stratified sand to sandy loam. They are strongly calcareous, slightly sodic, and slightly gravelly. Rooting depths on these soils are greater than 150 cm. The inherent soil fertility is moderate. Available nutrients are in moderately good supply. The content of available phosphorus is high. The organic-matter content of these soils is low (average organic carbon content is about 0.2%).

Erosion is low, but there is accumulation of alluvial material. On the other hand, river-bank erosion is very severe during floods. Many trees along the river bank have been uprooted due to this kind of erosion.

b. Vegetation attributes

This riverine range unit is characterized by a conspicuous tree canopy cover usually dominated by *Acacia tortilis,* but also consisting of other species, especially *Acacia elatior, Cordia sinensis* and *Salvadora persica*. A more comprehensive report on the tree layer is given separately below. In the ground layer, dwarf shrubs and perennial grasses give a total cover of 10.8% of which dwarf shrubs account for 9.6%. Annual grasses cover 8.8% and annual herbs 2.9%, to give a total plant cover of 22.5%. Grass and herb litter cover 11.4%, woody litter 5.7%, standing dead grass 7.0%, and standing dead woody plants 4.8%. The range unit is, on the average, 41.3% bare, though this figure varies from area to area along the lagga. The major dwarf shrubs are *Indigofera spinosa* and *Duosperma eremophilum.* Others are *Barleria acanthoides, Indigofera cliffordiana* and *Sericocompsis hildebrandtii. Cenchrus pennisetiformis* and *Dactyloctenium aegyptium* are found to behave as perennials in this environment. Annual grasses are numerous and include *Aristida mutabilis, Brachiaria leersioides, Cenchrus ciliaris, Chloris virgata, Eragrostis* spp., *Setaria verticillata, Sporobolus fimbriatus, Tetrapogon spathaceus, T, tenellus* and *Tragus berteronianus*. The herbs are *Abutilon* sp., *Acalypha* sp., *Gisekia pharnaceoides, Indigofera hochsteteri, Mollugo cerviana* and *Solanum dubium.*

There is also a sedge, *Cyperus bulbosus*, and a leguminous climber, *Rhynchosia* sp. This unit had a relatively low standing crop biomass in the dwarf shrub and herb layer of 491.3 kg/ha for desirable dwarf shrubs, perennial grasses and annual grasses and herbs. Of this, *Duosperma eremophilum* contributed 137.7 kg/ha, and the more useful *Indigofera cliffordiana* and *I. spinosa* contributed 71.5 and 85.2 kg/ha, which was very low.

Annual grasses and herbs gave 91.9 kg/ha, grass and herb litter 215.3 kg/ha, woody litter 686.7 kg/ha, standing dead grass 87.5 kg/ha and standing dead woody plants 97.5 kg/ha. Thus the total standing crop biomass of desirables and undesirables was 1,517 kg/ha. The herb layer of this unit remains longer than those in open areas, mainly due to the protection afforded by the trees as well as to the slightly higher moisture regime in the vicinity of laggas.

This unit, although best developed along the Balesa, is to be found commonly along the major laggas. It therefore forms a significant component of most range units situated in the plains.

This riverine range unit is characterised by a conspicuous tree canopy about 10 or more metres high in which mature *Acacia tortilis* is dominant but which also includes *Acacia senegal* and along the lower reaches of the Balesa Kulal water course, *Acacia elatior*. Although this unit consists mainly of a narrow strip bordering the Balesa along the greater part of its length, in the Olturot area it widens into a block of woodland several square kilometres in size, where the groundwater from Mt. Kulal comes to within 8 metres of the surface on a perched water table. *Acacia tortilis, A. senegal* and *A. elatior* have the potential to grow into large trees under riverine conditions and elsewhere if the water is high. Where the water table is not close to the surface these species become short-lived small trees or shrubs and may occur in mixed shrublands with *A. reficiens, A. mellifera* and *A. nubica*. Mature *Acacia tortilis* woodlands are normally accompanied by a shrub layer which, in this range unit, includes *Salvadora persica, Cordia sinensis, Maerua crassifolia, Ziziphus mauritiana, Commiphora flaviflora* as well as the young trees of the larger species. This shrub layer is between 2 and 5 metres high but *Salvadora* is a climbing shrub and can frequently be found growing to the tops of the large *Acacias*. Like *Cordia* and *Maerua*, it is an important browse plant for camels and goats.

Range Unit 12 also includes approximately 100 km^2 of dwarf shrubland with scattered trees in which *Acacia reficiens* and *A. mellifera* are co-dominants, with a canopy cover of 7.3%, woody dry weight biomass of 7.4 tonnes per ha and foliage annual production of c. 75 kg ha. The age structure of the tree populations is poor and since *Acacia mellifera, Cordia* and *Cadaba,* among the trees present, are important browse species, their protection from excessive use by goats is needed in order to improve their production. A high proportion of old trees in the *A. mellifera* population would provide a useful source of firewood.

This unit also includes 11 km^2 of *Acacia paoli* thicket which is not directly useful as forage, being a strongly aromatic and unpalatable species, but is providing physical protection for eleven other tree and large shrub species in their young stages, most of which are important forage plants.

c. Human influence

Because of insecurity and the limited availability of water this area is only used near the Balesa wells, Olturot and Balesa Bobor wells. Smallstock use the latter area while all species, especially cattle, use the first two areas. Cattle and smallstock descend from Mt. Kulal in the wet seasons while camel *fora* visit the area in the dry season. Average densities are generally rather low.

d. Range condition

This riverine unit is moderately utilized. It has a relatively low desirable species cover of 31.2% and the extent of bare areas is high at 41.3%. Good soil moisture allows a bush undergrowth and the standing crop biomass is high at 1,517 kg/ha. Erosion is very low, due to accumulation of alluvial material, and hence the condition rating is good.

e. Carrying capacity

The carrying capacity of this unit in animals per km^2 per year based on the corrected standing crop biomass is 3.2 camels, 2.1 cattle, 4.6 sheep and 6.9 goats. The total number of animals which can be kept on this range is 361 camels, 237 cattle, 518 sheep and 778 goats.

Stands of young *A. tortilis*, which commonly originate from accumulations of seed deposited in the dung of livestock in temporary night enclosures, grow in the open spaces between the stands of large trees. Mature woodlands, such as those in the Olturot area, with trees of up to 25 m in crown diameter, are between 100 and 200 years old. The woodland community as a whole is a very valuable livestock range with a significance which goes far beyond its very limited area. It has a high production of palatable forage. In addition to the tree and shrub foliage which is within reach of the browsing animals, the fallen leaves and fruits of *A. tortilis* provide a large proportion of the protein in the diets of camels and goats while the shed foliage, like that of *A. mellifera*, is an important part of the diet of sheep.

A typical stand of riverine woodland in this range unit has the following characteristics: nine tree and large shrub species; 52 trees and shrubs per hectare; 16.5% canopy cover; wood dry weight biomass 13.5 tonnes per ha; annual wood production 1,075 kg per ha; foliage annual production 200 kg per ha and fruit production 350 kg per ha.

Since the maintenance of the *Acacia tortilis* woodlands is a major objective of the range management plans, it is important to note that, in all the areas where age-structure assessments were made, present recruitment to the mature tree populations is insufficient to ensure their survival, except in some small localities. Thus, in this range unit and also in the small strips of riverine woodland included within other units, it is essential to take measures to increase the recruitment rate of all the desirable tree species present. The means to achieve this increase are discussed in the management section of this document.

The *Acacia* woodlands have a high proportion of mature trees, many of which die annually and are then to be seen standing or fallen for up to twenty years. These dead trees constitute a very important source of high grade fuel wood and hard timber which should be utilized and could provide all the firewood needed in the district if its cutting and transport can be properly organised. This important potential for fuel and timber is discussed under the management section.

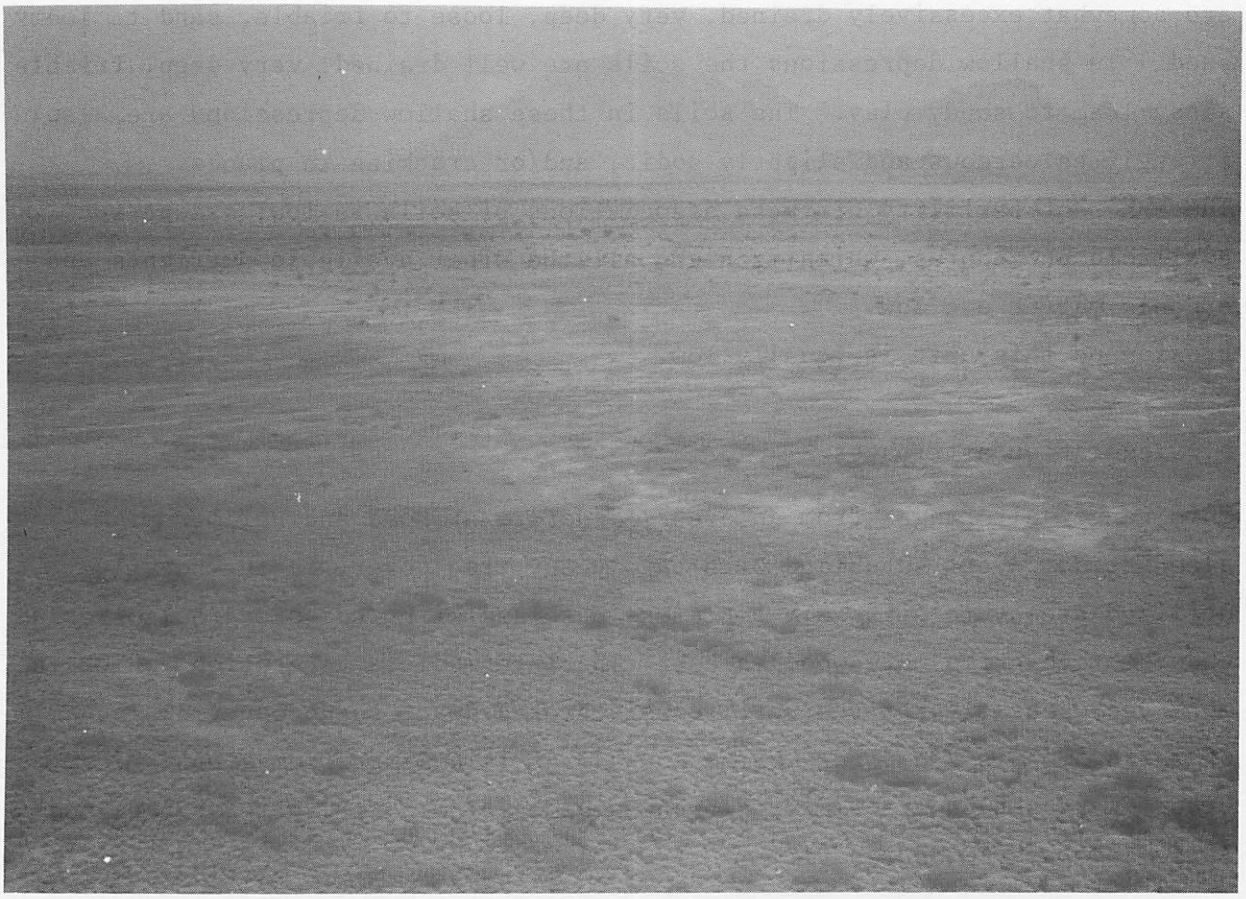
Table 40. Summary of cover, composition and biomass (Range unit 12)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	1.2	-	-	-	-	-	-	-	-	-
Annual grasses	8.8	74.8	-	-	60.4	22.6	14.4	5.8	-	-
Annual herbs	2.9	17.1	-	-	8.7	3.3	4.1	0.8	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	3.6	85.2	30.8	5.7	36.9	6.8	8.8	1.6	8.8	1.6
2. *Duosperma eremophilum*	1.4	137.7	379.2	41.7	-	-	-	-	108.4	11.9
3. Other desirable dwarf shrubs	3.0	71.5	55.6	10.3	-	-	-	-	-	-
4. Other undesirable dwarf shrubs	1.6	5.7	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	11.4	215.3	-	-	-	-	-	-	-	-
2. Wood	5.7	686.7	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	7.0	87.5	-	-	70.7	13.1	16.8	3.1	-	-
2. Wood	4.8	97.5	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	3.3	17.5	11.35	-	-	-	1.5	0.3	4.7	1.2
2. Undesirable foliage	4.0	20.5	-	-	-	-	-	-	-	-
3. Wood	-	-	-	-	-	-	-	-	-	-
Bare areas	41.3	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	31.2	491.3	476.9	63.9	179.7	45.8	45.6	11.6	137.8	17.7
Total undesirable	27.5	1025.7								

1 - desirable biomass before corrections

2 - available biomass

8.13 Range unit 13: *Indigofera/Heliotropium* with *Acacia* dwarf shrubland



a. Physical attributes

This range unit occurs on the sedimentary plains in the Korr-Ilaut-Baio area. It is at an average elevation of about 480 m above sea level, on a flat to almost flat terrain (0-2%), with exposure to the north-east. This unit covers approximately 635.2 km^2.

The average annual rainfall is about 250 mm around Ilium, but this decreases to 190 mm around Korr. Wind records do not exist for this area, but extrapolation for Korr indicates that the prevailing winds are SE with moderate speeds (= 16 km/hr for Korr).

The major parts of the soils occurring in this locality are developed on sediments derived from undifferentiated basement system rocks. They are an association of two slightly different soils. On slightly raised parts the soils are somewhat excessively drained, very deep, loose to friable, sand to loamy sand. In shallow depressions the soils are well drained, very deep, friable sandy loam to sandy clay. The soils in these shallow depressions are also strongly calcareous and slightly sodic, and/or cracking in places.
The inherent fertility of these associations of soils is low; except for available phosphorus, which is high, all the other available nutrients and organic matter are low.
Erosion on this unit is equally low.

b. Vegetation attributes

This range unit ranges from an open *Indigofera spinosa* and *Heliotropium albohispidum* dwarf shrubland with hardly any tree cover, in the heavily utilized areas, to an *Acacia reficiens* bushland with *Indigofera/Heliotropium* understorey in the more woody areas. The intermediate vegetation, which is more representative of the unit, consists of a dwarf shrub cover of 15.4%, of which 5.6% is *Indigofera spinosa* and 1.4% is *Heliotropium albohispidum*. Other dwarf shrubs are *Barleria eranthemoides, Indigofera cliffordiana* and *Sericocomopsis hildebrandtii*.

The grasses are mainly annuals with a cover of 9.1%, consisting of *Aristida mutabilis, Eragrostis cilianensis, Enneapogon desvauxii, Oropetium minimum, Leptrothrium senegalense,* and the sedge *Cyperus* sp. There is also an unidentified creeper. The litter cover is 6.5%, woody litter 8.4%, standing dead grass 11.3%, woody standing dead 8.3%, and bare areas 34.7%.

The standing crop biomass for the dwarf shrubs was 351.9 kg/ha, grass and herb litter was 124.9 kg and woody litter 274.5 kg/ha. Standing dead grass yielded 92.1 kg/ha and standing dead woody plants 192.4 kg/ha. Desirable dwarf shrubs were the main contributors to the dwarf shrub biomass with 344.4 kg/ha out of 351.9 kg/ha. The available standing crop biomass was only 559.2 kg/ha.

The tree cover of this range unit is generally low, with an average of 3%, but varies from 0.6% in the areas of open dwarf shrubland which cover half of its area, to 12% in the *Acacia reficiens/A. tortilis* shrublands along the bottom slopes of the Ndoto mountains. The unit includes two basically different

shrubland types, with *Commiphora* species dominating in the open dwarf shrublands on the plains to the east and *Acacia* species dominant on the gradual footslopes to the west. Taking the unit as a whole, fifteen tree and large shrubs are present, with a density of 55 ha^{-1}, a wood dry weight biomass of 250 kg ha^{-1} and annual production of 40 kg ha^{-1}. Tree and shrub foliage production over the whole area is low with an average of 25 kg ha^{-1} dry weight. The exception to this is the small area of *Acacia* shrublands in the west of the unit where wood biomass is 7.5 t ha^{-1} and production is 600 kg ha^{-1} y^{-1}. Only in this shrubland should live wood be collected.

c. Human influence

This unit, most of which is deteriorating, is heavily utilized, especially by camels and smallstock, whenever it rains and new growths form, which is frequent.

Camels occur throughout and densities reach > 6 km^{-2} on the west side. Due to limitations in water availability cattle do not use the central area and densities are moderate elsewhere. High densities (>40 km^{-2}) of smallstock are found near Korr and Baio and moderate densities elsewhere. The southern parts of this unit can only be used by Rendille settlements which have sufficient transport animals for carrying water.

d. Range condition

This site is occasionally heavily utilized. The effective desirable plant cover is generally low, at 25.1%, and the standing crop biomass is also low at 559.2 kg/ha. The soils are very sandy, which contributes to the low biomass. The rating given to this site is therefore poor.

e. Carrying capacity

The carrying capacity of this range unit, based on the adjusted standing crop biomass of desirable plants and expressed as number of animals/km^2/year, has been found to be 2.3 camels, 2.8 cattle, 5.9 sheep and 5.2 goats, all of which are fairly low. This unit can support only 1,461 camels, 1,778 cattle, 3,748 sheep, and 3,303 goats, despite its large extent of 635.2 km^2. This area is currently heavily grazed.

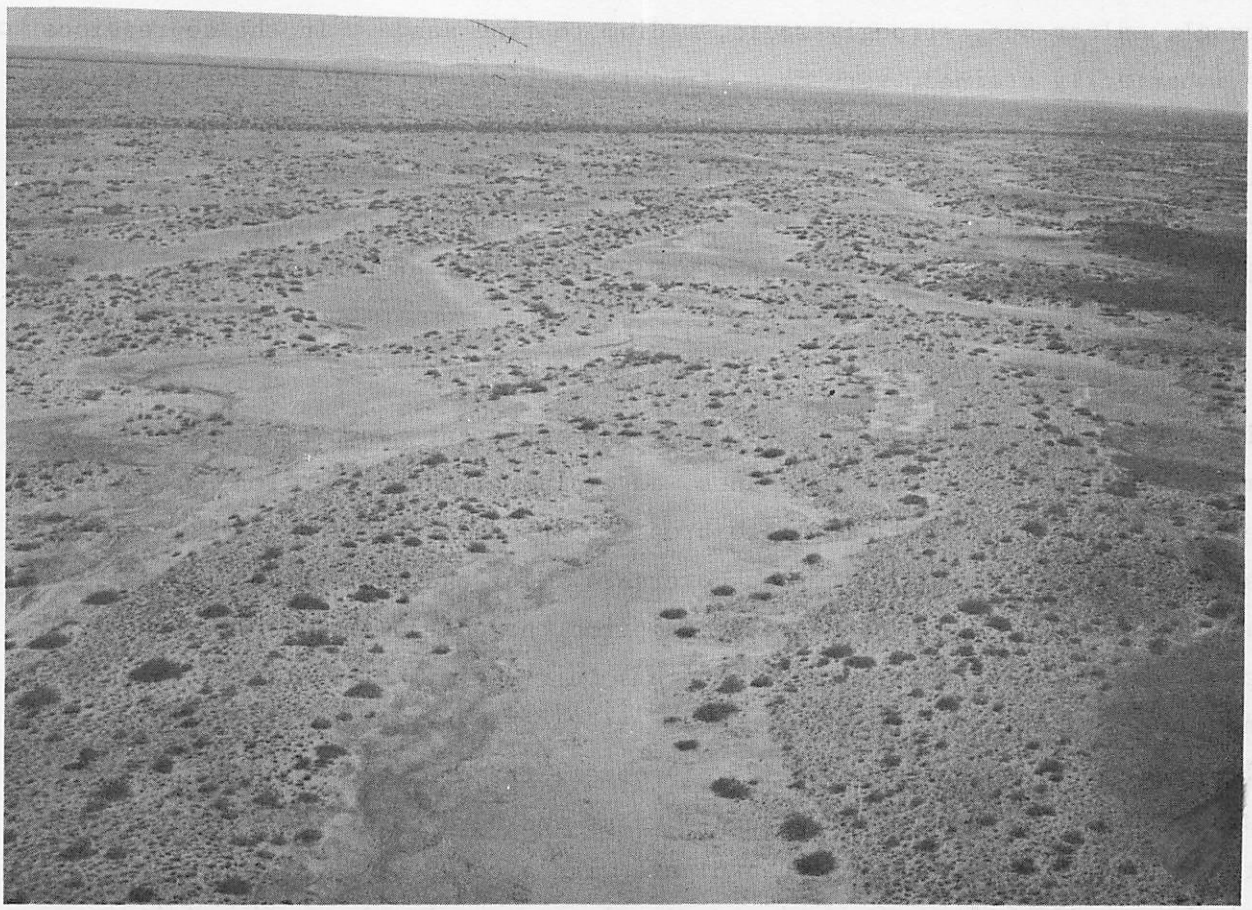
Table 41. Summary of cover, composition and biomass (Range unit 13)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	0.1	-	-	-	-	-	-	-	-	-
Annual grasses	9.0	95.1	-	-	76.8	28.8	18.3	6.9	-	-
Annual herbs	1.3	22.9	-	-	18.5	6.9	4.4	1.7	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	5.6	127.5	54.1	10.0	64.9	12.0	15.5	2.9	15.9	2.9
2. *Duosperma eremophilum*	0.9	68.2	68.2	7.5	-	-	-	-	19.5	2.2
3. Other desirable dwarf shrubs	7.8	148.7	148.7	27.5	-	-	-	-	42.3	7.9
4. Other undesirable dwarf shrubs	1.1	7.5	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	6.5	124.9	-	-	-	-	-	-	-	-
2. Wood	8.4	274.5	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	11.3	92.1	-	-	74.4	13.8	17.7	3.3	-	-
2. Wood	8.3	192.4	-	-	-	-	-	-	-	-
Tree and large shrubs:										
1. Desirable foliage	1.0	4.8	3.0	1.5	-	-	0.2	0.5	1.2	0.3
2. Undesirable foliage	4.0	19.2	-	-	-	-	-	-	-	-
3. Wood	-	616.0	-	-	-	-	-	-	-	-
Bare areas	34.7	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	37.0	559.2	274.0	46.5	234.6	61.5	56.1	14.85	78.9	13.3
Total undesirable	28.3	1234.5								

1 - desirable biomass before corrections

2 - available biomass

8.14 Range unit 14: *Aristida adscensionis/Aristida mutabilis* with *Indigofera spinosa* and *Acacia reficiens* dwarf shrubland.



a. Physical attributes

This range unit occurs on the aeolian dune landscape bordering the western and north-eastern edge of the Chalbi desert. It is at a general elevation of about 350 m above sea level. The unit has complex slopes, and the general tilt of the land is to the NE. The total area covered by the unit is 376.4 km^2.

Due to the extent of this unit, there is a gradient in the amount of rainfall. In the southern part, near Kargi, the average annual rainfall is about 200 mm, while the other part of the unit, at the eastern end of the Chalbi, has 260 mm. Mean variability is around 80%.

Soils occurring within this unit are developed on aeolian deposits of various origins. There is deep accumulation of wind blown sands, which have formed big dunes. In between these dunes are depressions or 'pans'. On the dunes are found somewhat excessively drained, very deep, loose, moderately to strongly calcareous, strongly sodic, medium to fine sands. In the depressions soils are imperfectly drained, very deep, friable to firm, strongly calcareous, strongly saline, strongly sodic, sandy clay loam to clay. During the rains, water collects in these 'pans', which form about 20% of the unit. In the northern half of this unit (nearer the Chalbi), active dune formation occurs, while in the southern half the dunes are more or less stabilized.

b. Vegetation attributes

This complex range unit is composed of eight different range types with a similar physiognomy of pans and dunes, as explained in the section above. The eight range types fall into two broad groups characterized by the types described here. The largest group covers 74.1% of the whole unit. It is dominated by the range type whose description the unit bears. This range type covers about 48% of the unit, and has fairly similar vegetation to the other 26% with which it is sub-grouped. It is characterized by a low tree (4.1%) and moderate dwarf shrub (25.3%) cover, the presence of a few perennial grasses (3.8 cover), a moderate annual grass and herb cover (16.7%), low litter cover (7.9%), standing dead plants with a cover of 10.3%, and 29.7% of it bare. Apart from the dominant annual grasses already mentioned in its characterization, this range type has many annuals, including *Mollugo cerviana, Blepharis linariifolia, Tragus berteronianus, Dactyloctenium aegyptium, Enneapogon desvauxii, Gisekia phanaceoides, Hermania boranensis, Cenchrus ciliaris, Leptothrium senegalense, Zygophyllum simplex, Oldenlandia fastigiata, Sporobolus* sp., *Chloria virgata, Oxyconum sinuatum* and *Geigeria acaulis*. The only perennial grass is *Sporobolus agrostoides*. The dwarf shrubs are *Indigofera spinosa* and *Heliotropium albohispidum, Seddera hirsuta* and *Sericocomopsis hildebrandtii*.

The productivity of the dwarf shrubs (expressed as standing crop biomass) of the range type described here was 435 kg/ha and that of the grasses and herbs 647 kg/ha, all being very low values.

The tree and large shrub vegetation in this unit has an average cover of 3.7% and is dominated over most of the area by *Commiphora flaviflora* and *Euphorbia cuneata*. In the range types which lie adjacent to unit 10, constituting nearly half of the range unit, *Acacia reficiens* is co-dominant and accompanied by *Grewia tenax, Lycium europeum, Maerua oblongifolia,* and *Salvadora persica*. In the remaining areas *A. reficiens* is absent.

Wood and foliage production throughout this unit are low and tree and large shrub age structures generally poor to fair. The dominant tree species are unpalatable to livestock and make poor fuel. Tree densities are generally too low to permit live wood cutting for livestock fencing. The small quantities of palatable shrubs present (*Grewia, Maerua* and *Salvadora*) would support a very low density of camels and goats.

c. Human influence

The southern part of this unit is very heavily used for grazing. The northern section is not in use or is little used, due to problems of insecurity and lack of water.

d. Range condition

This area, which is heavily used, has a variable cover which increases with distance away from the Chalbi desert. It has alternate ground cover of nearly 68% and 'pans', which contribute to the bare areas, of up to 32%. The standing crop biomass is good at 1,241 kg/ha, but the soils are liable to heavy wind erosion. The area is therefore rated as fair.

e. Carrying capacity

The carrying capacity of the dwarf shrub and herb layer of this unit, expressed as the number of animals/km^2/year, has been calculated as 1.5 camels, 11.7 cattle, 23.8 sheep and 3.5 goats. The total number of animals which may be kept on the entire unit is thus 565 camels, 4,404 cattle, 5,958 sheep and 1,318 goats.

Table 42. Summary of cover, composition and biomass (Range unit 14)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	3.8	167.0	-	-	135.9	50.6	32.1	12.0	-	-
Annual grasses	15.7	472.0	-	-	381.2	143.0	90.8	34.0	-	-
Annual herbs	1.0	8.0	-	-	6.5	2.4	1.5	0.6	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	23.0	390.0	140.7	26.0	168.9	31.2	40.2	7.4	40.2	7.4
2. *Duosperma eremophilum*	0.2	-	-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	1.9	37.0	28.8	5.3	-	-	-	-	8.2	1.5
4. Other undesirable dwarf shrubs	0.2	8.0	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	6.2	55.0	-	-	-	-	-	-	-	-
2. Wood	1.7	-	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	8.8	167.0	-	-	134.9	25.0	32.1	5.9	-	-
2. Wood	1.5	-	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	-	-	-	-	-	-	-	-	-	-
2. Undesirable foliage	4.1	22.0	-	-	-	-	-	-	-	-
3. Wood	-	850	-	-	-	-	-	-	-	-
Bare areas	25.4	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	6.6	-	-	-	-	-	-	-	-	-
Total desirable	53.4	1241.0	169.5	31.3	827.4	252.2	196.7	59.9	48.4	8.9
Total undesirable	14.6	935.0	-	-	-	-	-	-	-	-

1 - desirable biomass before corrections

2 - available biomass

8.15 Range unit 15: *Aristida* annual grassland



a. Physical attributes

Range unit 15 occurs on a non-dissected erosional plain. It covers an approximate area of 70.6 km^2, at an average elevation of 370 m above sea level. This is almost flat to gently sloping land (0-3% slope), with exposure to the west.

The average annual rainfall in this locality is about 260 mm, with a calculated mean annual variability of 100%. April is the wettest month. SE winds prevail.

The soils occurring within this unit are developed on quartzitic sandstone, except for a small area (about 5%) near the edge of the lava, where the soils are developed on various volcanic materials. The bulk of the soils (developed on quartzitic sandstone) are excessively drained, shallow, extremely rocky, stony and gravelly sandy clay loam.

The soils developed on volcanic material (5%), are well drained to imperfectly drained, very deep, friable silty clay with fine gravels, with a cracked surface. Runoff in this part of the unit is slow, but is very rapid in the remaining 95% of the unit.
On the whole, the current erosion status of this unit is high. Sheet erosion is the dominant type. All fine soil particles have been washed off, leaving a very rocky, stony and/or gravelly land surface.

b. Vegetation attributes

This unit is dominated by annual grasses and herbs, which cover 29% of the area. The vegetation in general is sparse, being developed between erosion pavement and rocks which cover as much as 48.3%. Bare soils add another 10.7%, woody litter 0.3%, and other litter 4.7%. Dwarf shrubs cover only 4.7%, the major ones being *Indigofera cliffordiana* and *Indigofera spinosa;* others are *Barleria* sp. and *Sericocomopsis hildebrandtii*. The dominant annual grass species are *Aristida mutabilis* (16.7%) and *Aristida adscensionis* (7.7%). Other grasses and herbs are *Oropetium minimum, Enneapogon desvauxii, Tetrapogon cenchriformis, Blepharia linariifolia, Eragrostis cilianensis, Leptothrium senegalense, Cenchrus ciliaris, Indigofera hochsteteri, Limeum* sp., *Helinus intergrifolius* and *Justicia exigua*. Two grasses which occasionally behave as perennials are *Cenchrus pennisetiformis* and *Dactyloctenium aegyptium,* with a cover of 1%.

The apportionment of the standing crop biomass in this unit is given in the accompanying table. Of the usable vegetal matter in the dwarf shrub and herb layer, the dwarf shrubs contributed most, notably *Indigofera cliffordiana* (69.5 kg/ha) and *Indigofera spinosa* (45.8 kg/ha). In general the standing crop biomass produced was very low.

The tree and large shrub cover in this unit is extremely sparse at 0.1% and the only species recorded are *Acacia tortilis, Euphorbia cuneata, Maerua crassifolia* and *Acacia senegal*. Heavy use of the area by livestock makes tree growth difficult.

c. Human influence

This unit is very heavily utilized by all kinds of livestock, resulting in the degration described in part (a).

d. Range condition

This site is currently heavily grazed. It has a low vegetation cover of 34.7% and very low standing crop biomass of 258.1 kg/ha. Its erosion status is high. The condition is therefore poor.

e. Carrying capacity

This unit has a low carrying capacity for the dwarf shrub and herb layer. Per km^2 per year, it can carry 0.8 camels, 1.9 cattle, 3.8 sheep, and 1.8 goats. Thus the whole unit can carry only 56 camels, 134 cattle, 268 sheep and 127 goats.

Table 43. Summary of cover, composition and biomass (Range unit 15)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	1.0	-	-	-	-	-	-	-	-	-
Annual grasses	28.7	117.9	-	-	95.2	35.7	22.7	8.5	-	-
Annual herbs	0.3	2.9	-	-	2.3	0.9	0.6	0.2	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	2.0	45.8	16.5	3.1	19.8	3.7	4.7	0.9	4.7	0.9
2. *Duosperma eremophilum*	-	-	-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	2.7	91.5	71.2	13.2	-	-	-	-	20.3	3.8
4. Other undesirable dwarf shrubs	-	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	4.7	20.7	-	-	-	-	-	-	-	-
2. Wood	0.3	146.8	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	-	-	-	-	-	-	-	-	-	-
2. Wood	-	5.8	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	1.3	-	-	-	-	-	-	-	-	-
2. Undesirable foliage	-	-	-	-	-	-	-	-	-	-
3. Wood	-	-	-	-	-	-	-	-	-	-
Bare areas	10.7	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	48.3	-	-	-	-	-	-	-	-	-
Total desirable	34.7	258.1	87.7	16.3	177.3	40.3	28.0	9.6	25.0	4.9
Total undesirable	5.0	173.3	-	-	-	-	-	-	-	-

1 - desirable biomass before corrections

2 - available biomass

a. Physical attributes

This range unit occurs on a dissected erosional plain along the north-eastern edge of the Chalbi desert. It covers a total area of approximately 150.6 km^2, on an almost flat to sloping landscape (0.13% slopes). It lies at an average elevation of about 370 m above sea level, and has a complex exposure (due to the heavy dissection).

Average annual rainfall in this locality is about 260 mm, with a mean annual variability of about 180%. The prevailing winds are south-easterlies (no records of speeds exist but it is believed that they are gentle winds, as in most parts of the study area).

The soils are developed on quartzitic sandstone. The bulk of these soils (about 70%) are excessively drained, shallow, exceedingly rocky, stony, and gravelly sandy clay loam. The eastern section of the unit (about 30% of the area) is covered with a thick accumulation of sands, forming longitudinal dunes that are more or less stabilized. The unit is heavily eroded, and in most places the soil is completely lost, revealing the parent rock.

b. Vegetation attributes

This unit is composed mainly of highly degraded soils which expose mother rock to the extent of 67.7% of the total area. 4% of the total cover is bare soil. Annual grasses and herbs, which dominate the vegetation, cover 20.3% and consist of *Aristida mutabilis, Chasminim* sp., *Tetrapogon* spp., *Cenchrus ciliaris, Enneapogon desvauxii, Oropetium minimum, Helinus integrifolius, Crotalaria deserticola* and *Hermania kirkii*. Dwarf shrubs cover 4.4% and are mainly *Indigofera cliffordiana,* others being *Indigofera spinosa, Cleome* sp., *Barleria proxima, Barleria* sp., and *Sericocomopsis hildebrandtii*.
Standing dead woody plants cover 0.3%, and woody litter 0.7%. The total dwarf shrub standing crop biomass was 322.6 kg/ha, most of it being *Indigofera cliffordiana*. Grasses and herbs contributed another 259.3 kg/ha. Other details are given in the table below.

Tree cover in this unit is 2% and includes the species *Ormocarpum trichocarpum, Cadaba farinosa, Maerua crassifolia* and *Commiphora flaviflora*. Tree and large shrub density is 88 ha^{-1}, wood dry weight biomass is estimated at 180 kg ha^{-1} and annual production c. 14 kg ha^{-1}. Foliage production is estimated at 15 kg ha^{-1} and is negligible for the support of livestock. The dominant shrub species, *Ormocarpum,* has a good age structure and is likely to occupy this unit for the next two decades. It is unpalatable to livestock. The *Cadaba* and *Maerua* also support a small number of goats.

c. Human influence

This unit is also very heavily utilized by livestock throughout the year. As stated above, the degree of degradation has in places reached an extreme.

d. Range condition

This area is heavily utilized and has a very low vegetation cover of only 24.7%. The unit also shows a very low standing crop biomass of 617.3 kg/ha. The soil is very heavily eroded, sometimes exposing the parent rock. Because

of the very degraded status of the soil, the rating given to this unit is very poor.

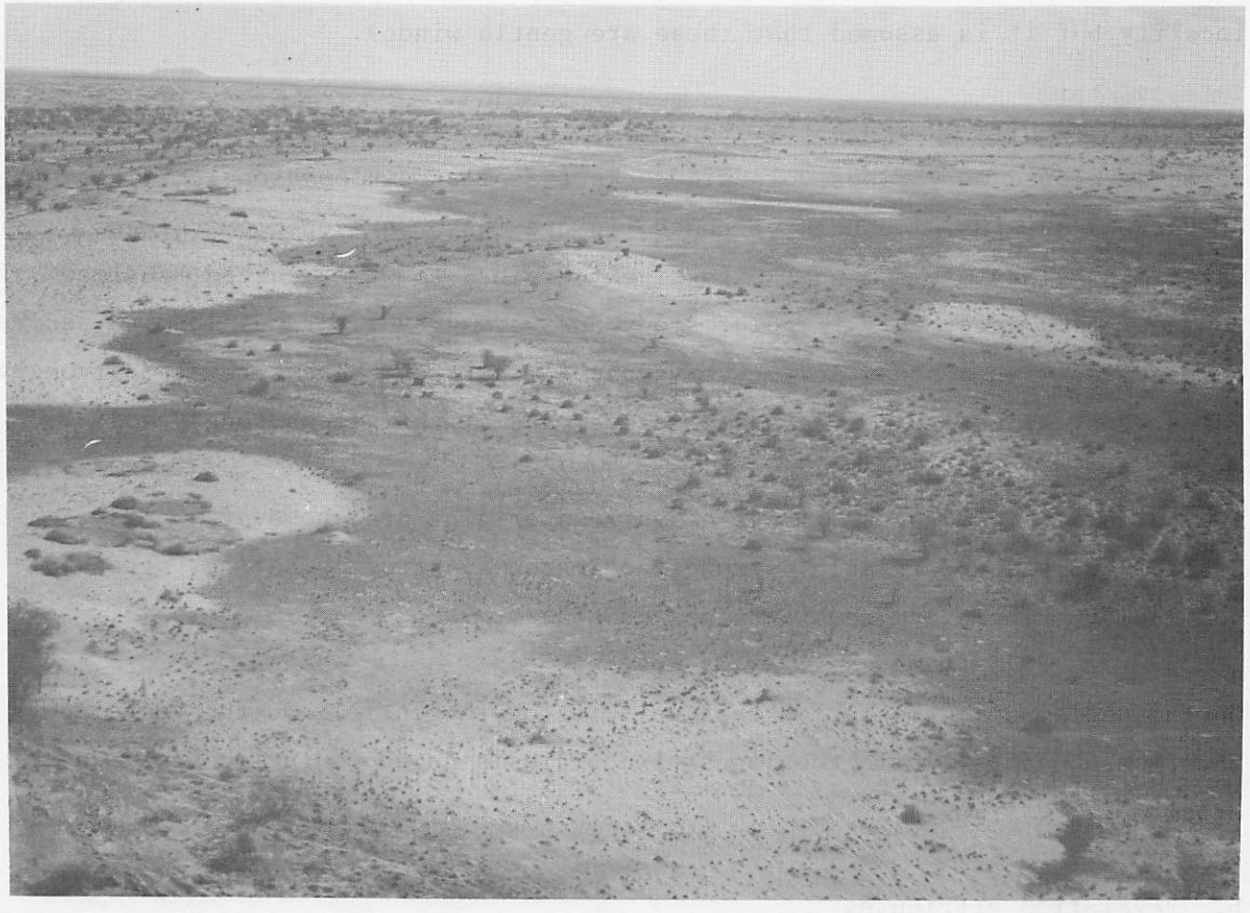
e. Carrying capacity

The present carrying capacity of this range unit is 2.3 camels, 3.8 cattle, 7.7 sheep, and 5.2 goats per km^2 per year. The total number of animals this unit can take is therefore 346 camels, 572 cattle, 1,160 sheep and 783 goats.

Table 44. Summary of cover, composition and biomass (Range unit 16)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	-	-	-	-	-	-	-	-	-	-
Annual grasses	18.3	42.9	-	-	34.6	13.0	8.3	3.1	-	-
Annual herbs	2.0	216.4	-	-	174.8	65.5	41.6	15.6	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	-	37.4	13.5	2.5	16.2	3.0	3.9	0.7	3.9	0.7
2. *Duosperma eremophilum*	-	-	-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	4.4	304.6	237.0	43.8	-	-	-	-	67.7	12.5
4. Other undesirable dwarf shrubs	-	18.0	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	-	-	-	-	-	-	-	-	-	-
2. Wood	0.7	157.6	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	-	-	-	-	-	-	-	-	-	-
2. Wood	0.3	26.3	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	-	-	-	-	-	-	-	-	-	-
2. Undesirable foliage	2.6	-	-	-	-	-	-	-	-	-
3. Wood	-	-	-	-	-	-	-	-	-	-
Bare areas	4.0	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	67.7	-	-	-	-	-	-	-	-	-
Total desirable	24.7	601.3	250.5	46.3	225.6	81.5	53.8	19.4	61.6	13.2
Total undesirable	3.6	201.9								

8.17 Range unit 17: *Indigofera* with *Euphorbia*



a. Physical attributes

This range unit occurs on the footslopes of the volcanic area around Maikona and stretches south-westwards to cover the lacustrine plains on the edges of the Chalbi desert. It covers an approximate area of 47.1 km^2 at an average elevation of 300 m above sea level. The land is almost flat to gently sloping (0-3% slope), and has a westward exposure.

The average annual rainfall in this locality is about 260 mm, with a mean annual variability of 80%. April is the wettest month. The prevailing winds are south-easterlies (no records of wind speeds are available for the locality but it is assumed that these are gentle winds).

The soils occurring within this range unit are variable. They range from soils developed on various volcanic rocks to soils developed on sediments of various origins. The bulk of the soils are those developed on volcanic materials. They are somewhat excessively drained to well drained, shallow to moderately deep, very friable, stony and very gravelly sandy loam to sandy clay soils, with a stony and/or very gravelly surface. They are also strongly calcareous, slightly to moderately saline, and slightly to strongly sodic.

The soils developed on sediments of various origins are, however, poorly drained, very deep, friable, strongly calcareous, strongly saline, strongly sodic clay. There are rock outcrops in places.

On the whole, soil erosion on this unit is low to gentle. On the footslope, sheet wash occurs, while the lacustrine plain is an accumulation plain where erosion is very low.

b. Vegetation attributes

This unit is mostly denuded of vegetation cover. The bare areas cover 70.7%. The only dwarf shrubs left consist almost entirely of *Indigofera spinosa* and cover 9.7%. Another unidentified *Indigofera* sp. has been observed. The perennial grass *Sporobolus spicatus* covers 2%. Annual grasses and herbs cover a mere 1% and consist of *Aerva persica, Aristida mutabilis, Cenchrus ciliaris, Gisekia pharnaceoides, Justicia exigua, Leptothrium senegalense, Setaria* sp., *Sporobolus* sp., and *Tragus berteronianus*. Grass and herb litter covers 0.3% woody litter 4.7%, standing dead grass 1%, and woody standing dead 1.7%.

The standing crop biomass of this unit was equally low, with dwarf shrubs having 225 kg/ha, all grasses and herbs 26.4% kg/ha, and standing dead grass 20.9 kg/ha. The actual breakdown of these figures is given in the accompanying table.

The tree and large shrub cover of this unit is estimated at 0.3% over 82% of the area, where it consists of scattered small *Acacia tortilis* and *Maerua carssifolia*. The remainder of the unit is an open shrubland with 8.3% canopy in which *Salvadora persica* and *Acacia tortilis* up to 8 meters in crown diameter are co-dominant. The other species present are *Cadaba mirabilis, Cordia sinensis* and *Grewia tenax,* all five species being excellent browse plants. Foliage production in this 21 km^2 of shrubland is estimated at 131 kg $ha^{-1}y^{-1}$ and it is clearly an important camel and goat habitat suitable for moderate stocking rates.

Wood dry weight biomass is c. 3.9 t ha^{-1} and annual production 310 kg ha^{-1}, a level which will permit the collection of small quantities of live wood.

c. Human influence

This unit is very heavily utilized by both livestock and humans settled around Maikona. It is utilized all the year round and this is reflected in the extreme loss of vegetal cover.

d. Range condition

This unit is currently under very heavy utilization. The vegetation cover is almost gone, with an effective cover at present of only 22.7%. It has a very poor standing crop biomass of 272.3 kg/ha. In places the erosion status is high, although this is gentle in the lacustrine plain. It is given a rating of very poor.

e. Carrying capacity

The carrying capacity of animals/km^2/yr of the dwarf shrub and herb layer of this unit is very low: 0.7 camels, 1.5 cattle, 2.9 sheep and 1.8 goats respectively. The whole unit can carry only 33 camels, 71 cattle, 137 sheep and 75 goats.

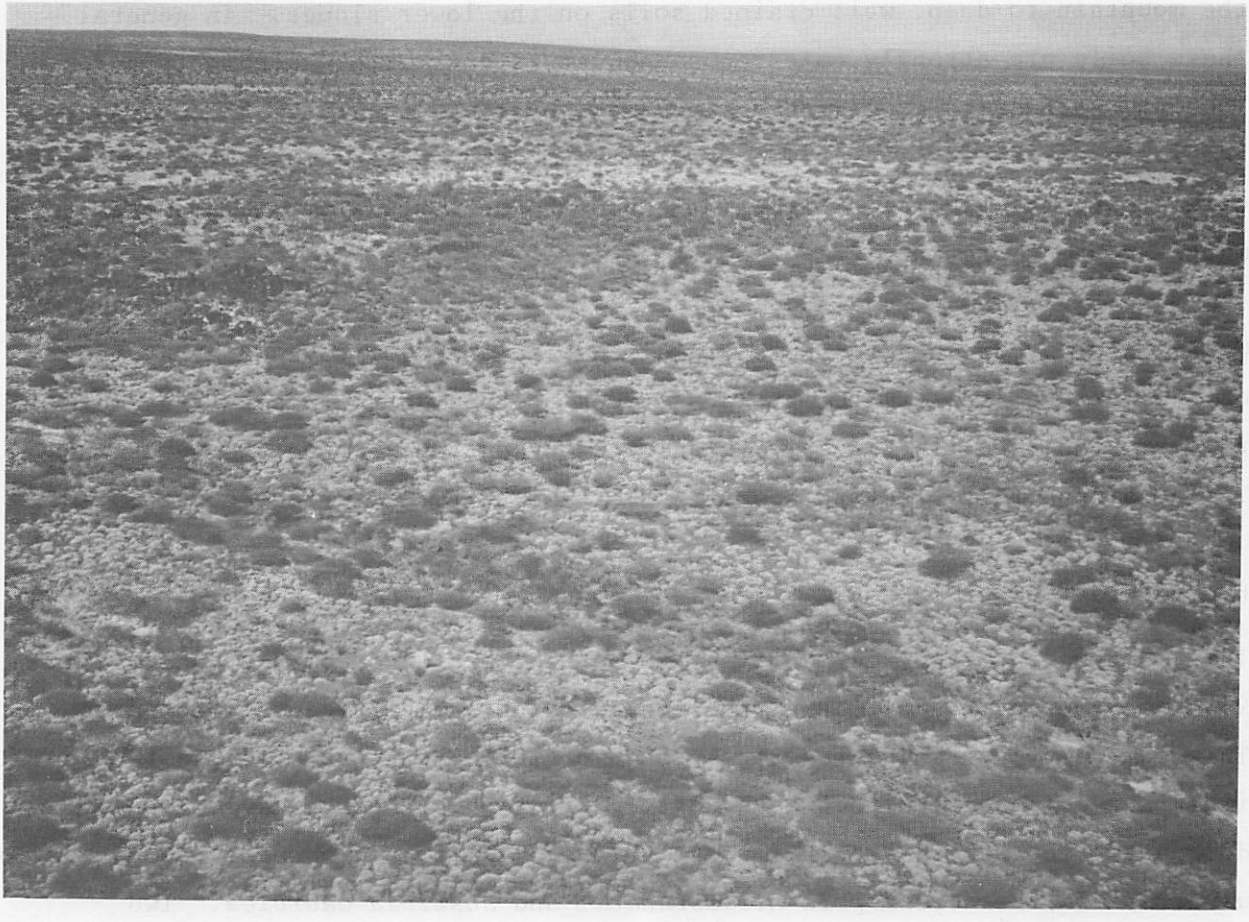
Table 45. Summary of cover, composition and biomass (Range unit 17)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	2.0	17.2	-	-	13.9	5.2	3.3	1.2	-	-
Annual grasses	0.7	8.0	-	-	6.5	2.4	1.5	0.6	-	-
Annual herbs	0.3	1.2	-	-	1.0	0.4	0.2	0.1	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	9.7	225.0	81.2	15	97.4	18.0	23.2	4.1	23.2	4.1
2. *Duosperma eremophilum*	-	-	-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	-	-	-	-	-	-	-	-	-	-
4. Other undesirable dwarf shrubs	-	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	0.3	54.5	-	-	-	-	-	-	-	-
2. Wood	4.7	357.7	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	1.0	20.9	-	-	16.9	6.3	4.0	1.5	-	-
2. Wood	1.7	-	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	9.0	-	-	-	-	-	-	-	-	-
2. Undesirable foliage	-	-	-	-	-	-	-	-	-	-
3. Wood	-	-	-	-	-	-	-	-	-	-
Bare areas	70.7	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	22.7	272.3	81.2	15.0	135.7	32.3	32.2	7.4	23.2	4.1
Total undesirable	6.6	412.2	-	-	-	-	-	-	-	-

1 - desirable biomass before corrections

2 - available biomass

8.18 Range unit 18: *Acacia* with *Duosperma*



a. Physical attributes

This range unit is a complex area occurring on the middle and lower slopes of Mt. Kulal and stretching to the Asie hills. It covers an approximate area of 668.1 km^2, but large parts of it are inacessible. Complex landforms, slopes and soils occur within this unit.

Climatic conditions are also variable. The nearest recording station is Olturot, where the recorded annual rainfall is 265 mm, with an estimated mean annual variability of about 80%. The unit, however, stretches to the Asie hills, where the climatic conditions may be different from those around Olturot.

The soils occurring within this unit are developed on various volcanic materials. They range from shallow soils on the hills and upper slopes of the mountain to deep, well drained soils on the lower slopes. In general these soils are strongly calcareous and very stony, with variable textures. The land surface is exceedingly stony, and bouldery in places. The inherent fertility of these soils can be said to be moderate. The quantities of calcium and magnesium are high, while phosphorus, potassium and the organic-matter content are low.

On the whole, current erosion on this range unit is low to gentle, as most of the surface is protected by lava stones and boulders. Sheet wash and rill erosion occur in places with a low stony surface, or on steeper slopes. The erosion potential of this unit is very high if the surface cover is lost.

b. Vegetation attributes

This unit is formed by communities, two of which are co-dominant and occupy 93.4% of the entire unit, the other three being insignificant in comparison. This community has an average tree cover of 10%. Dwarf shrubs also form an important component, with a cover of 15.3%, of which *Duosperma eremophilum* is dominant. The others are *Indigofera spinosa, Hibiscus aponeurus, Heliotropium albohispidum, Sericocomopsis hildebrandtii* and *Justicia caerulea*. Two perennial grasses, *Chrysopogon plumulosus* and *Brachiaria deflexa,* are present and together cover 0.2%. Annual grasses cover only 8.1%. Approximately twenty other annuals have been recorded. The litter covers 9.3%, standing dead plants 8.8%, bare soil 26.9%, and rocks 28.7%. The productivity of the desirable forage was low at 597.8 kg/ha standing crop biomass. Undesirables produced 972 kg/ha. This community, being on lava rocks, closely followed rainfall availability in its growth pattern. The majority of the annuals germinated, matured and died off very quickly after the rains.

This large range unit includes five communities, the two largest of which are approximately equal in area and together occupy 93.4% of the unit. The terrain is a mosaic of *Acacia* dominated shrublands and open lava gravel areas which are either bare or thinly covered with annual grass and dwarf shrubs. While the individual stands of *Acacia mellifera* and *Acacia reficiens* shrubland have canopies of at least 20%, the overall tree and large shrub cover amounts to approximately 4%. At least 15 tree and large shrub species occur in this unit, including *Cordia sinensis, Cadaba* spp., *A. tortilis, A. senegal, Maerua crassifolia, Maerua oblongata, Salvadora persica, Commiphora candidula,*

C. rostrata, and *Blepharisperma bania.*

Taking into account the large areas of bare ground and annual grassland, the overall density of trees and large shrubs is 95 ha^{-1}, with a wood dry weight biomass of c.900 kg ha^{-1} and production of 80 kg $ha^{-1}y^{-1}$. Tree and shrub foliage production is estimated at 40 kg $ha^{-1}y^{-1}$ and will thus support only a low camel and goat stocking rate, which need not be further reduced to permit regeneration since the tree and large shrub age-class structures are in fair to good condition.

This unit includes several strips of riverine woodland lining the tributary water courses which flow from Mt. Kulal into the Balesa Kulal. The woodlands are very narrow but consist of dense shrub and tree vegetation which is of great importance to livestock.

A major feature of this unit as a livestock habitat is the concentration of *Acacia mellifera* trees which is at its greatest along the western edge of the unit, on the lower slopes of Mt. Kulal. These *A. mellifera* shrublands are a major source of forage for camels, goats and sheep. The latter consume the leaves after they have fallen, and the area remains a useful foraging area well into the dry season.

c. Human influence

Quite a substantial amount of use is made of this area, especially during the rainy season, when there is a flush of annual vegetation and water. A large number of manyattas are also to be seen. Use intensity, however, can be said to be variable at different localities in this unit, due to intertribal conflicts and security problems.

d. Range condition

This unit is utilized substantially. It has a variable cover which increases with the slope. The effective cover is fair, being 44.4%, and the standing crop biomass is also good at 1,569.8 kg/ha in areas with less dwarf shrub cover. The soil is stabilized by lava stones and boulders and consequently erosion is low. The use of this unit, however, is greatly limited by slope and accessibility. The condition rating given to the unit is therefore fair.

e. Carrying capacity

The carrying capacity of this unit expressed as number of animals/km^2/year, is 2.1 camels, 2.5 cattle, 5.1 sheep, and 4.7 goats. The total number of animals which may be carried on the whole unit is thus 1,043 camels, 1,670 cattle, 3,407 sheep and 3,140 goats.

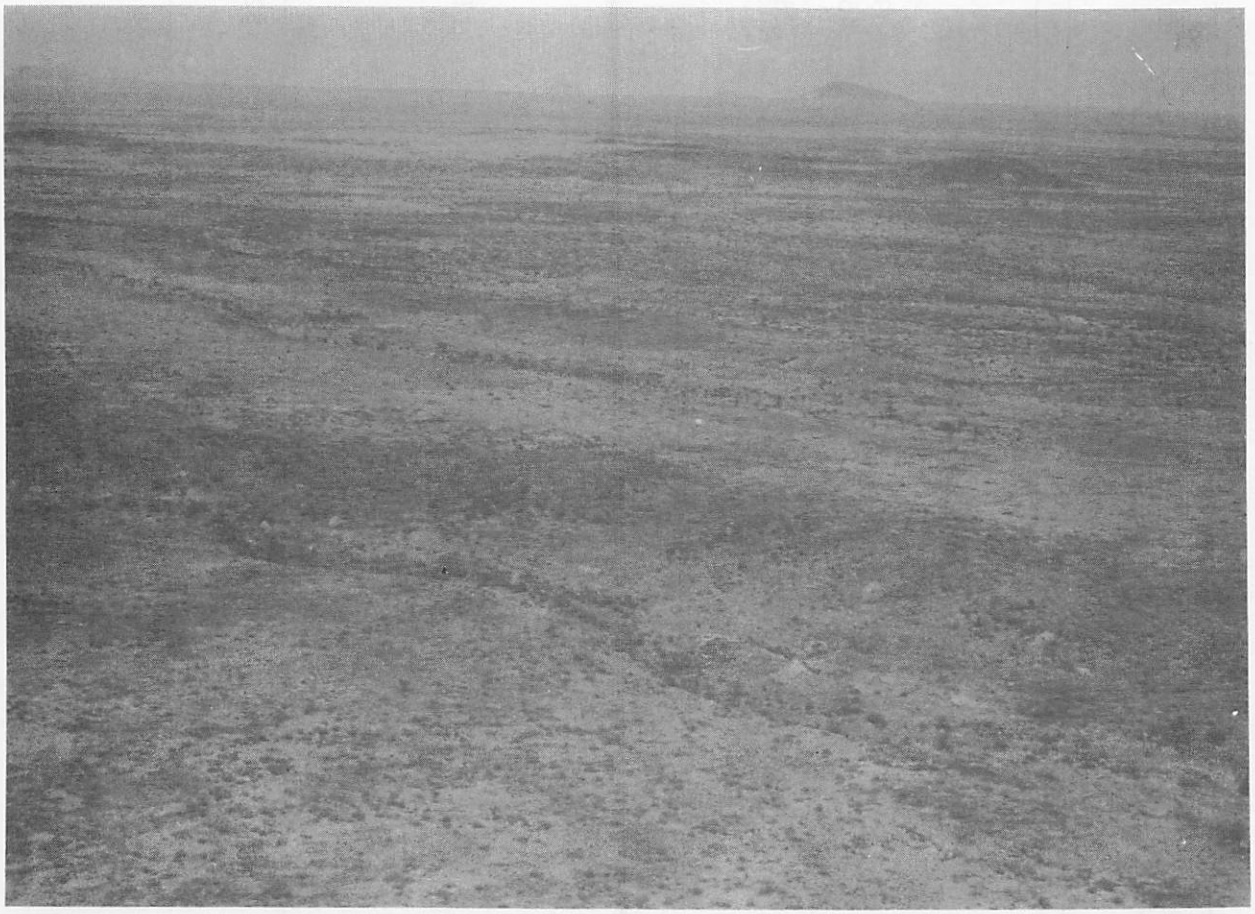
Table 46. Summary of cover, composition and biomass (Range unit 18)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	0.2	-	-	-	-	-	-	-	-	-
Annual grasses	8.1	98.5	-	-	79.6	29.8	19.0	7.1	-	-
Annual herbs:	-	30.3	-	-	24.5	9.2	5.8	2.2	-	-
1. *Indigofera spinosa*	4.0	92.2	33.3	6.1	39.9	7.4	9.5	1.8	9.5	1.8
2. *Duosperma eremophilum*	3.3	205.6	159.9	17.6	-	-	-	-	45.7	5.0
3. Other desirable dwarf shrubs	7.8	117.0	91.0	-	-	-	-	-	26.0	4.8
4. Other undesirable dwarf shrubs	0.2	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	1.8	13.1	-	-	-	-	-	-	-	-
2. Wood	0.2	-	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	7.7	48.2	-	-	38.9	7.2	9.3	1.7	-	-
2. Wood	1.1	-	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	4.5	6	3.9	1.9	1.9	-	-	-	1.6	0.4
2. Undesirable foliage	5.5	9	-	-	-	-	-	-	-	-
3. Wood	-	950	-	-	-	-	-	-	-	-
Bare areas	26.9	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	28.7	-	-	-	-	-	-	-	-	-
Total desirable	35.6	597.8	288.1	42.4	182.9	53.6	43.6	12.8	82.8	12.0
Total undesirable	8.8	972.0								

1 - desirable biomass before corrections

2 - available biomass

8.19 Range unit 19: *Acacia* with *Duosperma* and *Chrysopogon/Enneapogon*



a. Physical attributes

This range unit occurs on the lower and middle slopes of Mt. Marsabit. It is a complex unit made up of different land forms, slopes, soils and vegetation. The unit covers a total area of about 3,011.2 km^2. It stretches from an approximate elevation of about 1,300 m above sea level, near Marsabit town, and declines gently to about 500 m in the vicinity of Kargi and Korr.

Climatic conditions occurring within this unit are also variable. Average annual rainfall is highest at Marsabit (800 mm) and this again decreases to 200 mm and 188 mm around Kargi and Korr respectively. SE winds prevail. Wind speeds are equally variable. They can be very strong around Marsabit.

Soils occurring within this unit are developed on various volcanic rocks. These soils are a complex of a somewhat excessively drained to well drained, shallow to moderately deep, very stony, sandy loam to sandy clay loam, with an exceedingly stony surface, and a well drained, very deep, very friable to friable loam to clay, with an exceedingly bouldery and/or exceedingly stony surface. These soils are strongly calcareous, but moderately sodic and moderately to strongly saline in places. Basaltic outcrops also occur.

Numerous volcanic craters occur within this unit, some of them hold water for long periods after the rains and serve as watering points for livestock.

The inherent fertility of these soils is moderate. They have a low potassium and low to high phosphorus content, a high calcium and magnesium content, and a low organic-matter content.

The current erosion status of this unit varies from place to place. In some places gully and sheet erosion occur, while in a large proportion of the unit erosion is low, due to the protection of the soil by the numerous stones and boulders. These soils have a high erosion hazard.

b. Vegetation attributes

This range unit consists of a gradation of vegetation types, mainly on lava rocks, which extend from an *Acacia mellifera* bushland with thick *Duosperma eremophilum* dwarf shrub undergrowth in the higher mountain plateau, through a series of perennial and annual grasslands with varying stunted tree cover, to an *Enneapogon desvauxii* annual grassland with *Duosperma eremophilum* in the lower altitude lava plateau. On the average, the dwarf shrub layer is dominated by *Duosperma eremophilum* with a cover of 17.4%, followed by *Justicia fischeri* with 8.3%. Other dwarf shrubs are *Abutilon* sp., *Cissus rotundifolia, Crotalaria massaiensis, Euphorbia heteromorpha, Euphorbia samburuensis, Grewia villosa, Hibiscus* sp., *Heliotropium albohispidum, Justicia caerulea, Justicia odora, Barleria eranthemoides* and *Plectranthus sylrestris.*

The grasses and herbs cover 24.9% and consist mainly of *Barleria argentea, Bidens incumbens, Brachiaria leersioides, Thrysopogon plumulosus* (11.7%), *Enneapogon desvauxii, Rhynchosia minima, Sataria* sp., *Aristida* spp., *Sorghum versicolor, Sporobolus fimbriatus* and many others. Bare areas cover about 20% of this area, rocks 18.3% and the litter and standing dead cover are negligible.

The total standing crop biomass of this unit was 3,771.4 kg/ha of which 1,724.9 kg/ha was desirable for livestock. *Duosperma* alone contributed 639.6 kg/ha to the total and perennial and annual grasses and herbs contributed 764.8 kg/ha.

At the higher levels on Mt. Marsabit below the forest edge (1,200 m contour) there is a zone of dense *Acacia mellifera - Kleinia kleinioides* shrubland with *Duosperma* understorey with a 25% tree and large shrub canopy and an estimated foliage production of 250 kg $ha^{-1}y^{-1}$. This shrubland includes at least nine other tree and large shrub species: *Acacia reficiens, A.* sp. nov., *Commiphora* (4 spp.), *Cordia sinensis, Euphorbia scheffleri* and *Salvadora persica*. Following the gradients downhill to the west, the tree densities decrease rapidly and the tree and large shrub canopy over very wide areas has an average of 2.7%. At the 800 m contour the annual grassland has scattered stunted trees at an average density of between 15 and 60 ha^{-1} among which the commonest are *Acacia paoli, Cadaba farinosa, C. racemosa* and several *Commiphora* species. While this tree and shrub community might be taken as typical of large areas of unit 19, fifteen other tree communities have been identified, most of which have canopy covers of 0.5 - 3% and very low foliage production levels of from 5 to 20 kg $ha^{-1}y^{-1}$. The important exception to this is the strips of *Acacia tortilis* woodland which follow the numerous seasonal water courses and provide localized sites of high wood and foliage production, probably essential to the survival of the Rendille pastoralists and their herds through a large part of the year. An example of such a woodland is range type 58 with *Acacia tortilis* and *Cadaba farinosa* as dominant species, canopy cover of 15%, with a wood biomass dry weight of 8.6 t ha^{-1} and a foliage production of 190 kg $ha^{-1}y^{-1}$. However, this woodland is typical in another way. Its age-class structure is very poor. The *Acacia tortilis* woodlands along the water courses across the whole of unit 19 are in danger of drying out and immediate management is needed to maintain them. The management proposed is given in the woodland section of Part III.

c. Human influence

This unit is currently being heavily utilized during the wet season by large numbers of livestock from Kargi and Korr.

d. Range condition

This area is quite heavily used. It has variable cover with a mean of 61.7% and the standing crop biomass is also variable but high at an average 3,771.5 kg/ha. Erosion is heavy in places but quite low in others, where lava stones and boulders protect the soil. Use of this range is sometimes limited by accessibility and slope. On the whole this unit is rated as fair to good.

e. Carrying capacity

This unit has a calculated carrying capacity of 4.5 camels, 11.2 cattle, 22.9 sheep, and 10.4 goats per km^2 per year, based on the dwarf shrub and herb layer alone. The total number of animals that can be kept on the unit is therefore 13,550 camels, 33,725 cattle, 68,956 sheep and 31,316 goats.

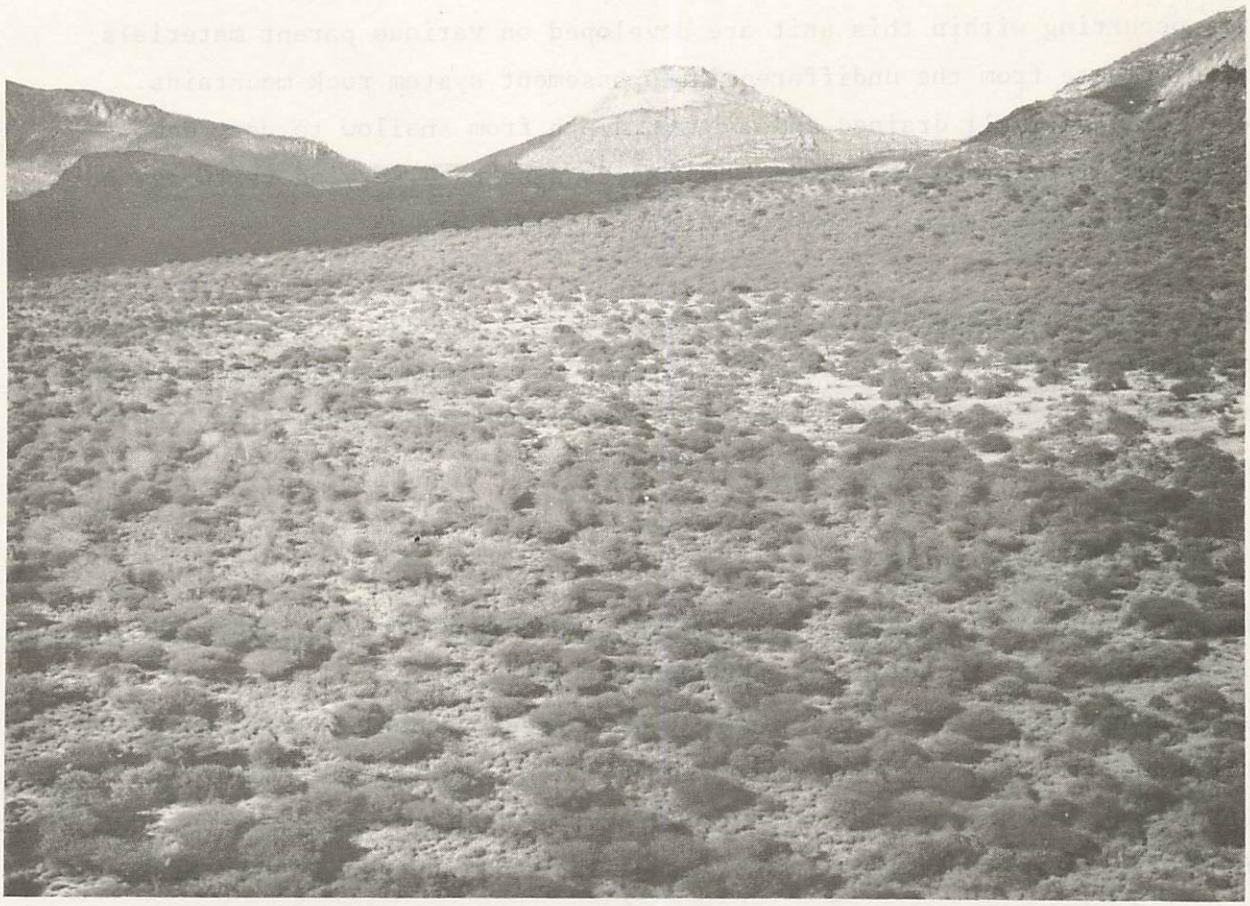
Table 47 Summary of cover, composition and biomass (Range unit 19)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	11.7	140.8	-	-	113.7	42.6	27.1	10.1	-	-
Annual grasses	8.2	338.5	-	-	273.4	102.5	65.1	24.4	-	-
Annual herbs	5.0	285.5	-	-	230.6	86.5	54.9	20.6	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	-	20.5	7.4	1.4	8.9	1.6	2.1	0.4	2.1	0.4
2. *Duosperma eremophilum*	17.4	639.6	497.5	54.7	-	-	-	-	142.1	15.6
3. Other desirable dwarf Shrubs	16.4	237.9	185.0	34.2	-	-	-	-	52.9	9.8
4. Other undesirable dwarf shrubs	negl.	7.7	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	0.5	466.0	-	-	-	-	-	-	-	-
2. Wood	-	1017.8	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	-	59.1	-	-	47.7	8.8	11.4	2.1	-	-
2. Wood	-	103.7	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	0.5	3.0	3.0	1.5	-	-	-	-	1.5	0.9
2. Undesirable foliage	2.0	9.0	-	-	-	-	-	-	-	-
3. Wood	-	450.0	-	-	-	-	-	-	-	-
Bare areas	20.0	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	18.3	-	-	-	-	-	-	-	-	-
Total desirable	59.2	1724.9	692.9	91.8	674.3	242.0	160.5	57.6	198.6	26.5
Total undesirable	2.5	2046.5	-	-	-	-	-	-	-	-

1 - desirable biomass before corrections

2 - available biomass

8.20 Range unit 20: *Acacia* with *Duosperma*



a. Physical attributes

This range unit occurs on the footslopes of the Ndoto and Ol'Donyo Mara mountains at an average elevation of about 650 m above sea level. It is a gently sloping (2-6%) dissected landscape, with a general exposure to the east. Its extent is approximately 390.5 km^2.

Average annual rainfall received on this unit is about 500 mm around Ngurunit, with an estimated annual variability of about 80%. Around the Ol'Donyo Mara mountains the rainfall is about 200 mm per year, with an estimated variability

of about 180%. The prevailing winds are south-easterlies, and speeds are gentle.

Soils occurring within this unit are developed on various parent materials that originate from the undifferentiated basement system rock mountains. These soils are well drained and vary in depth from shallow to very deep. The bedrock is exposed in places. The soils also have varying textures, but are mostly in the range of the fine textural classes.

Current erosion status can be said to be moderate to high on this range unit. Erosion is due entirely to the action of water. Sheet wash and rill erosion are the dominant types, but gullies are common phenomena especially around Ngurunit.

b. Vegetation attributes

This unit consists mainly of *Acacia tortilis* woodland with *Duosperma eremophilum* understorey in the footslopes around Ngurunit and the south-western mountains. It is dominated by trees, notably *Acacia tortilis*. Total dwarf shrub cover is 39.9%, of which 31% is *Duosperma*, the others being *Heliotropium albohispidum, Ocimum americanum, Indigofera cliffordiana, Indigofera spinosa* and *Aspilia mossambicensis*. Annual grasses and herbs cover 5.2% and consist of *Digitaria velutina, Brachiaria leersioides, Pupalia lappacea, Eragrostis cilianensis, Aristida adscensionis, Sporobolus fimbriatus, Commelina africana, Tetrapogon spathaceus, Portulaca oleracea, Setaria verticillata, Sesamum alata* and *Barleria argentea*. Litter cover is 7.4%, woody litter 5.5%, standing dead woody plants 5.7% and bare areas 22.8%.

The total standing crop biomass was found to be 7,557.8 kg/ha, of which only 906.9 kg/ha were usable. Dwarf shrubs had a standing crop biomass of 679.2 kg/ha of which 566 kg/ha were *Duosperma*. Other data are shown in the accompanying table. The low standing crop biomass was due to thick shrub growth in the area.

All the *Acacia tortilis* trees were observed to be of almost the same age group, which suggests the occurrence of particularly favourable growing conditions during a particular period in the past.

This unit consists mainly of *Acacia tortilis* woodland with *Duosperma eremophilum* understorey and occupies the footslopes of the Ndoto mountain near Ngurunit. The large tree species, *Acacia tortilis,* is dominant over the greater part of the unit and, together with at least ten other tree and large shrub species, forms a canopy of between 12 and 15%. Where the canopy is densest, in a large area of mature *A. tortilis* woodland in the Ilaut - Arsim area, the large shrub layer includes the four species *A. senegal, Salvadora persica, A. nubica* and *Boscia coriacea.* Elsewhere, in more open woodland, old *A. tortilis* trees are accompanied by *Commiphora* (3 spp.), *Cadaba* (2 spp.), *Maerua* (2 spp.), *Jatropa dichtar* and an unidentified tree. In a further dense tree community in this unit *Commiphora candidula* and the unidentified species are co-dominants with nine other large shrubs and small trees. In all, 18 tree and shrub species are recorded.

The unit is most notable for the high biomass and production of the woodlands. Wood dry weight biomass is between 5.0 and 10.8 t ha^{-1}, with the largest area at 9.5 t ha^{-1}. Wood annual production is between 400 and 860 kg ha^{-1} and foliage production between 160 and 250 kg $ha^{-1}y^{-1}$. These woodlands can support a relatively high stocking rate of camels, but owing to the poor age-class structure in most of the range types, a low goat stocking rate has been recommended so that young trees are given an opportunity to grow.

This is undoubtedly the most important woodland unit in the management area. It has arisen as a result of a small number of individual years in the past when conditions were particularly favourable for the dispersal, germination, growth and emergence from the goat-vulnerable size classes. It appears that there are three main age-classes represented in the mature woodlands of Ngurunit, each of which has resulted from such favourable conditions in the past. The oldest, at 100 years approximately, may have grown after the livestock mortality in the years of the rinderpest epidemic in 1882. The middle age class of 40 - 50 years may have followed the series of drought years in the 1940s. The last widespread emergence of young trees was possibly caused by the water-borne dispersal of seed in the flood year of 1962 after which the young trees were able to grow beyond goat reach before the goat populations had recovered from the dry years preceeding 1962.

The remarks on *Acacia tortilis* woodlands and their particular importance to human and livestock populations are entirely applicable to the woodlands of this range unit and will not be repeated here. It should be noted that the large stands of *A. tortilis* trees in the 20 years age class near Ngurunit are now being cut down by Samburu pastoralists to make livestock night enclosures. The survival of this woodland for the future benefit of the Samburus themselves will depend on protection measures which should be implemented within the next two years before it is too late. Such measures are discussed under woodland management in Part II.

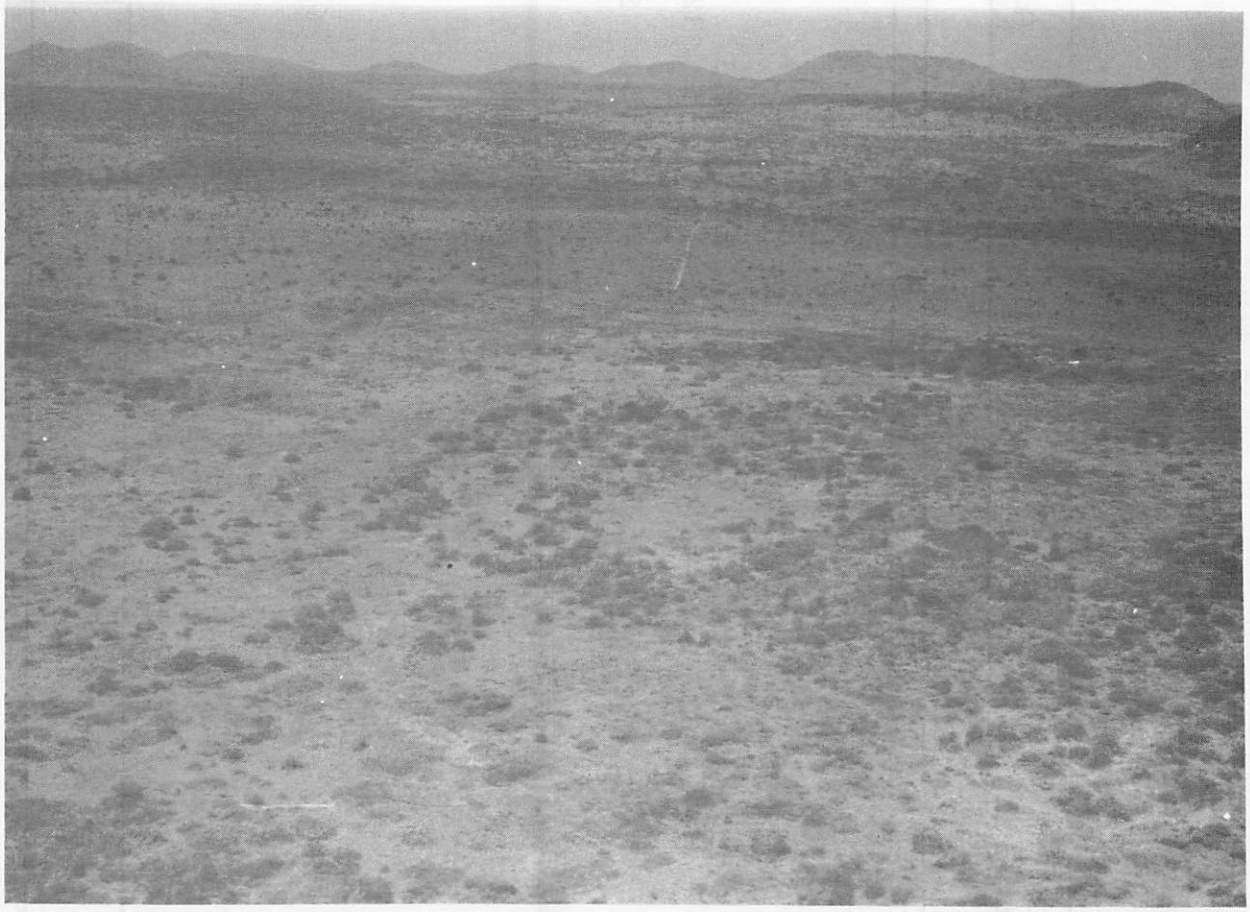
c. Human influence

This unit is heavily utilized by cattle and smallstock and quite substantially by camels as well.

Table 48. Summary of cover, composition and biomass (Range unit 20)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	0	26.5	-	-	21.4	8.5	5.1	1.9	-	-
Annual grasses	3.5	9.8	-	-	7.9	3.0	1.9	0.7	-	-
Annual herbs	1.7	113.9	-	-	92.0	79.0	21.9	8.3	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	1.0	16.3	5.9	1.1	7.0	1.3	1.7	0.3	1.7	0.3
2. *Duosperma eremophilum*	31.0	566.0	440.2	48.5	-	-	-	-	125.8	13.9
3. Other desirable dwarf shrubs	7.9	96.9	75.2	14.0	-	-	-	-	21.6	4.0
4. Other undesirable dwarf shrubs	-	-	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	7.4	209.2	-	-	-	-	-	-	-	-
2. Wood	5.5	347.5	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	-	25.0	-	-	20.2	3.8	4.8	0.9	-	-
2. Wood	5.7	27.2	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	6.0	52.5	33	16.5	-	-	4.25	1.1	14.0	3.5
2. Undesirable foliage	7.5	67.0	-	-	-	-	-	-	-	-
3. Wood	22.8	6000.0	-	-	-	-	-	-	-	-
Bare areas	-	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	51.1	906.9	554.3	80.1	155.5	95.6	39.6	13.2	163.1	21.7
Total undesirable	26.1	6650.9								

8.21 Range unit 21: *Pennisetum/Bothriochloa* with miscellaneous evergreen shrubs



a. Physical attributes

This range unit occurs on the stepped plateaus on the middle slopes of Mt. Marsabit. It is at an average elevation of about 900 m above sea level, with a side slope of about 6 - 13%, it covers approximately 329.4 km^2, has an almost flat top, and is heavily dissected.

Climatic conditions here are close to those prevailing around Marsabit (as discussed for Unit 19).

Two main types of soils occur here, both developed on various volcanic rocks. In the northern half of the unit, near Gof Bongole, the soils are well drained, deep to very deep, very friable clay, and very stony in places. The southern half of the unit has well drained, moderately deep, friable to firm, slightly calcareous, cracking clays.
This soil is very stony and very bouldery (also on the surface). Both soils are moderately well supplied with available nutrients (calcium, magnesium, potassium), but they are low in phosphorus and organic matter.

Current erosion on this unit is low, due to the very good vegetal cover that protects the soil.

b. Vegetation attributes

This unit is dominated by perennial grasses, which cover 56.9%. The grasses are themselves dominated by *Pennisetum mezianum* with a cover of 27%, followed by *Bothriochloa insculpta* with 18% and *Sehima nervosum* with 4.3%. Other perennial grasses are *Brachiaria serrata, Chrysopogon plumulosus, Cynodon dactylon, Digitaria abyssinica, Heteropogon contortus* and *Themeda triandra.* Annual grasses and herbs, which cover 19.7, include *Aristida adscensionis, Commelina* sp., *Eragrostis* spp., *Phyllanthus* sp., *Setaria* sp., *Solanum incanum* and *Sporobolus fimbriatus.* Dwarf shrubs cover only 4% and consist of *Acalypha fruticosa, Justicia caerulea, Satureia abyssinica, Crotalaria fascicularis* and *Ocimum americanum.* Trees share the remaining 19.6% with bare areas.

This unit had an overall standing crop biomass of 3,107.7 kg/ha, of which only 172.7 kg/ha were woody litter and perhaps unutilizable by livestock. Of the rest 2,063.7 kg/ha was potentially utilizable. A breakdown is given in the accompanying table.

The community of shrubs in this unit is characteristic of sub-humid bushlands which normally occur at levels below rain forest and above the dry savanna shrublands and woodlands of the lower altitudes. The unit lies on the southern side of Mt. Marsabit in the zone of influence of the south eastern rain-bearing monsoon winds and sheltered to some extent by the cloud cover of the mountain. The trees and large shrubs of this open bushland have a canopy cover of 9%

and include *Acacia brevispica, Clerodendrum myricoides, Securinega villosa, Ormocarpum trichocarpum, Euclea schimperi, Maytenus senegalensis, Vangueri linearisepala* and *Terminalia* sp.

Wood biomass and annual production are estimated at 3 t ha^{-1} and 180 kg ha^{-1} respectively and foliage production at 80 kg $ha^{-1}y^{-1}$. The large shrubs provide valuable browse for goats and, in its present condition, it appears to be maintaining itself despite heavy browsing impact. The unit is high and has a climate which does not suit camels for prolonged periods.

The main danger to the survival of this community is grass fires.

c. Human influence

This unit is heavily utilized by all kinds of livestock in all seasons, and is very liable to fires, which commonly start in the grasslands further down the mountain slopes, sweep through the dense perennial grass of this zone in the dry season and burn the young trees and shrubs back to ground level. However, since this community is resistant to fire, this usually results in retarding the tree and shrub growth rather than killing it. Nevertheless, hot fires which can occur at the end of the dry season when the grass is very dry may kill whole sections of the bushland, leaving open areas of grassland. The mosaic of grass and bush which results may be the most desirable type of range for mixed livestock populations and, on Marsabit mountain is an important habitat for the Greater Kudu, the large antelope which is of outstanding importance to the national park and tourism in the area.

d. Range condition

This site has a stable soil condition, with a perennial grass cover of 56.9% and annual grasses of 16.3%, which, despite heavy use, had a standing crop biomass of 3,107.9 kg/ha. This site was observed to be in the best condition of any in the study area and hence forms the upper limit of the best condition rating of excellent. Only the slope may limit utilization, but the use of contours may alleviate this constraint.

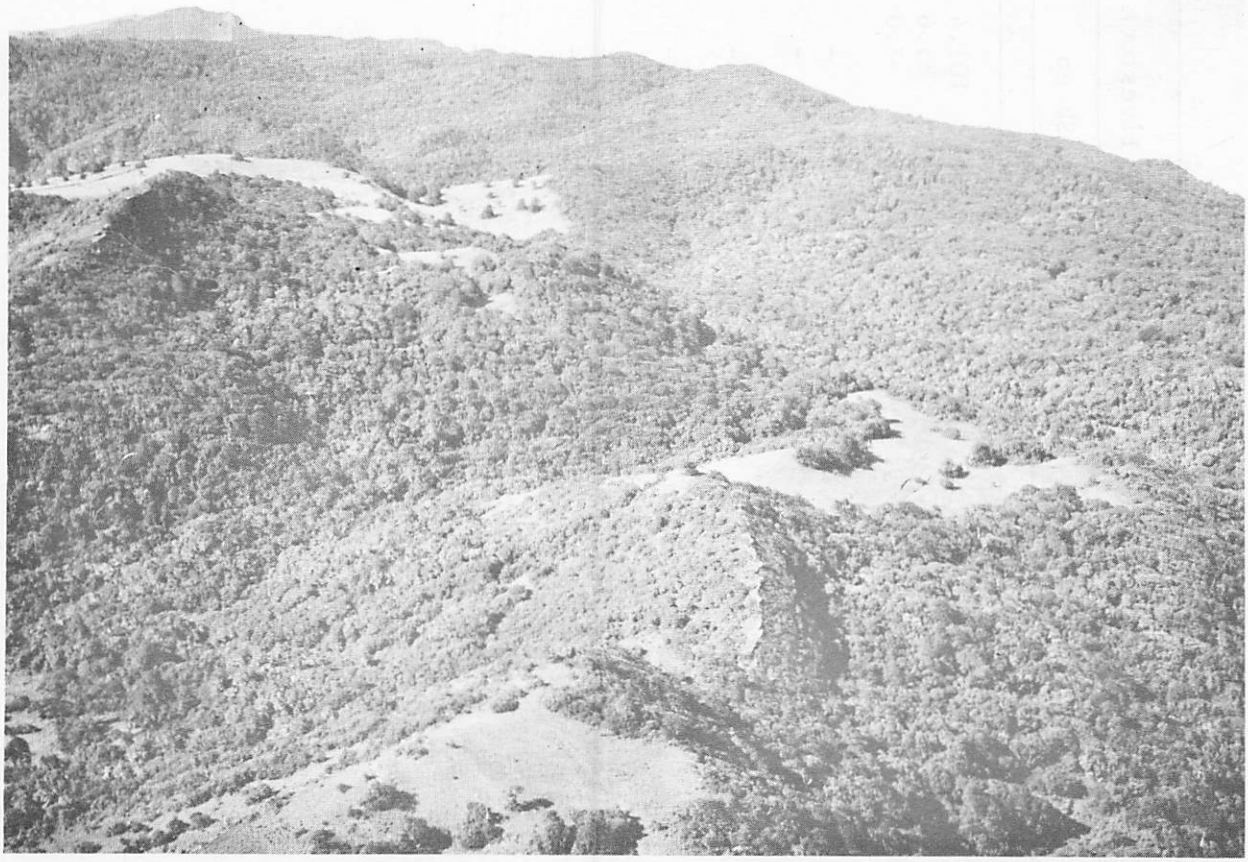
e. Carrying capacity

The carrying capacity of the dwarf shrub and herb layer of this unit, calculated in number of animals per km^2 per year, is 0.1 camels, 28.0 cattle, 57.3 sheep, and 0.2 goats. The total number of animals that can be kept on the unit is 33 camels, 9,223 cattle, 18,875 sheep and 66 goats.

Table 49. Summary of cover, composition and biomass (Range unit 21)

Attribute	% cover	Total standing crop biomass kg/ha	Desirability by livestock (kg/ha)							
			Camels		Cattle		Sheep		Goats	
			1	2	1	2	1	2	1	2
Perennial grasses	56.9	1405.7	-	-	1135.2	425.7	270.3	101.4	-	-
Annual grasses	16.3	492.7	-	-	398.0	149.3	94.8	35.6	-	-
Annual herbs	3.3	41.1	-	-	33.2	12.5	7.9	3.0	-	-
Dwarf shrubs:										
1. *Indigofera spinosa*	-	-	-	-	-	-	-	-	-	-
2. *Duosperma eremophilum*	-	-	-	-	-	-	-	-	-	-
3. Other desirable dwarf shrubs	0.3	4.6	3.6	0.7	-	-	-	-	1.0	0.2
4. Other undesirable dwarf shrubs	3.3	135.5	-	-	-	-	-	-	-	-
Litter:										
1. Grasses and herbs	-	736.0	-	-	-	-	-	-	-	-
2. Wood	-	172.7	-	-	-	-	-	-	-	-
Standing dead:										
1. Grasses and herbs	-	119.6	-	-	96.6	17.9	23.0	4.3	-	-
2. Wood	0.3	-	-	-	-	-	-	-	-	-
Trees and large shrubs:										
1. Desirable foliage	-	-	-	-	-	-	-	-	-	-
2. Undesirable foliage	-	-	-	-	-	-	-	-	-	-
3. Wood	-	-	-	-	-	-	-	-	-	-
Bare areas	-	-	-	-	-	-	-	-	-	-
Erosion pavement and rocks	-	-	-	-	-	-	-	-	-	-
Total desirable	76.8	2063.7	3.6	0.7	1663.0	605.4	396.0	144.3	1.0	0.2
Total undesirable	3.6	1044.2								

8.22 Range unit 22: Evergreen mist forest



a. Physical attributes

This unit consists of the forested summits of Mt. Marsabit and Mt. Kulal. It occupies an area of about 315.2 km^2, at an average elevation of approximately 1,400 m above sea level.

The average rainfall is about 800 mm per year with a mean variability of 40%. SE winds prevail. The soils occurring here are developed on various volcanic rocks. These soils are generally well drained, moderately deep to very deep, very friable clay. They are very stony in places. Their inherent fertility is moderate.

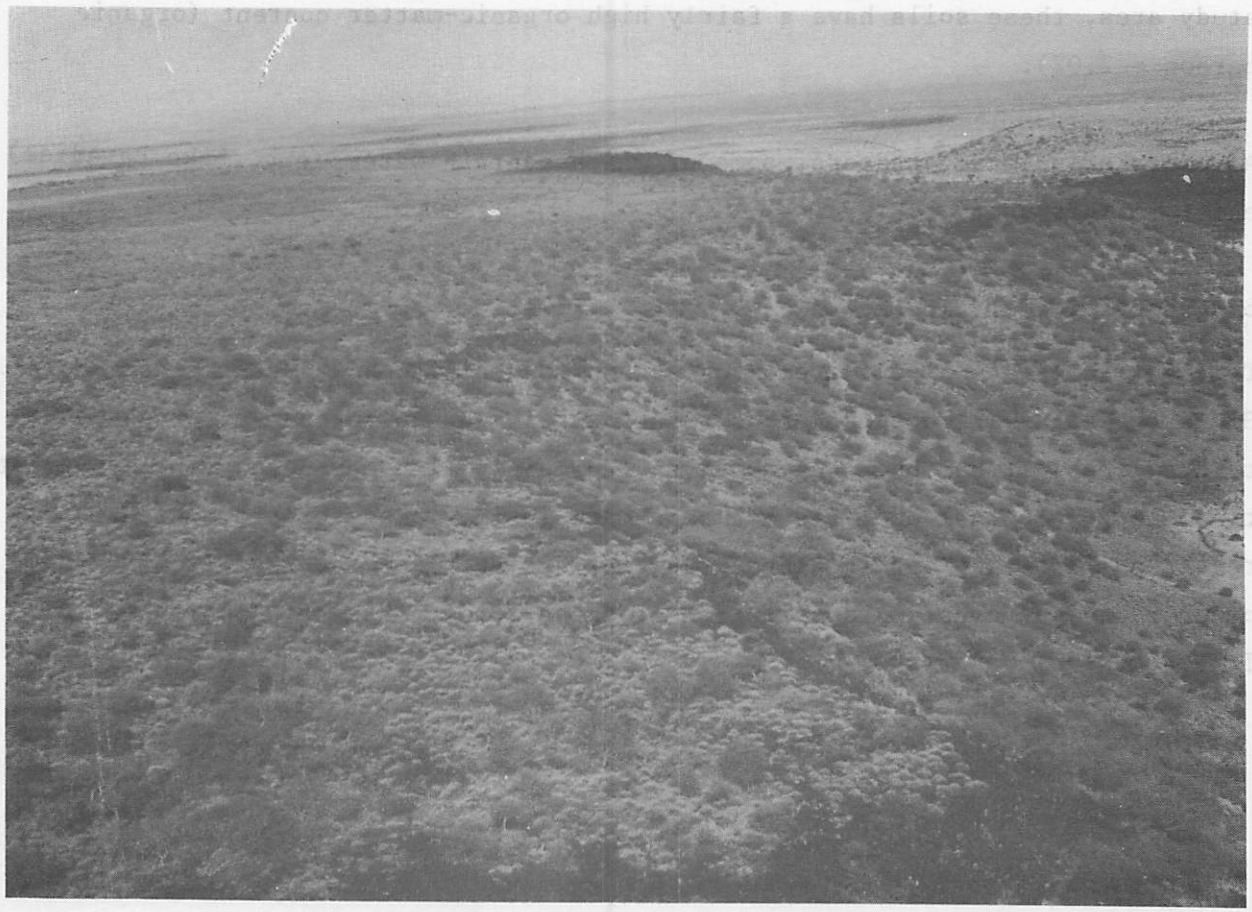
All available nutrients are moderately well supplied. In the context of the study area, these soils have a fairly high organic-matter content (organic carbon = 2.0%).

A number of volcanic craters, some of which contain water (e.g. Lake Paradise) exist in this unit.

b. Vegetation attributes

This unit consists of evergreen forests on mountain tops at Marsabit and Kulal. Since the rainfall in these areas is not sufficient to support a forest of this calibre, it has been suggested that precipitation may be augmented by mist trapping. No actual analysis has been made inside these forests, which we regard as important water-catchment areas that should not be utilized for any other range purposes. A description of these forests has been published in IPAL technical reports.

8.23 Range unit 23: Lava plateau with *Acacia/Commiphora* bush and trees



a. Physical attributes

This range unit consists entirely of the volcanic plateaus near Ilaut. It is made up of loosely packed lava boulders and stones. Its southern end is about 650 m above sea level, with a dip to the NE. It is almost flat (0-2% slope), but the side slopes are very steep, forming a scarp. This unit covers an area of approximately 287 km^2.

The average annual rainfall at the southern end of the plateau around Ilaut is about 400 mm, decreasing gradually to about 200 mm at its northern end in the middle of the Hedad. The prevailing winds are south-easterlies, and these

show considerable variations in speed. Soils occurring here are developed on volcanic materials. More than 90% of the surface is covered by boulders. Below these boulders are well drained, deep to very deep, very friable, strongly calcareous clay soils. They are very stony and gravelly in places. These soils are well supplied with available nutrients, but have a low organic-matter content (organic carbon = 0.1%).

There is no significant erosion taking place within this unit at present, due to the fact that there is a cover by boulders and stones of volcanic origin.

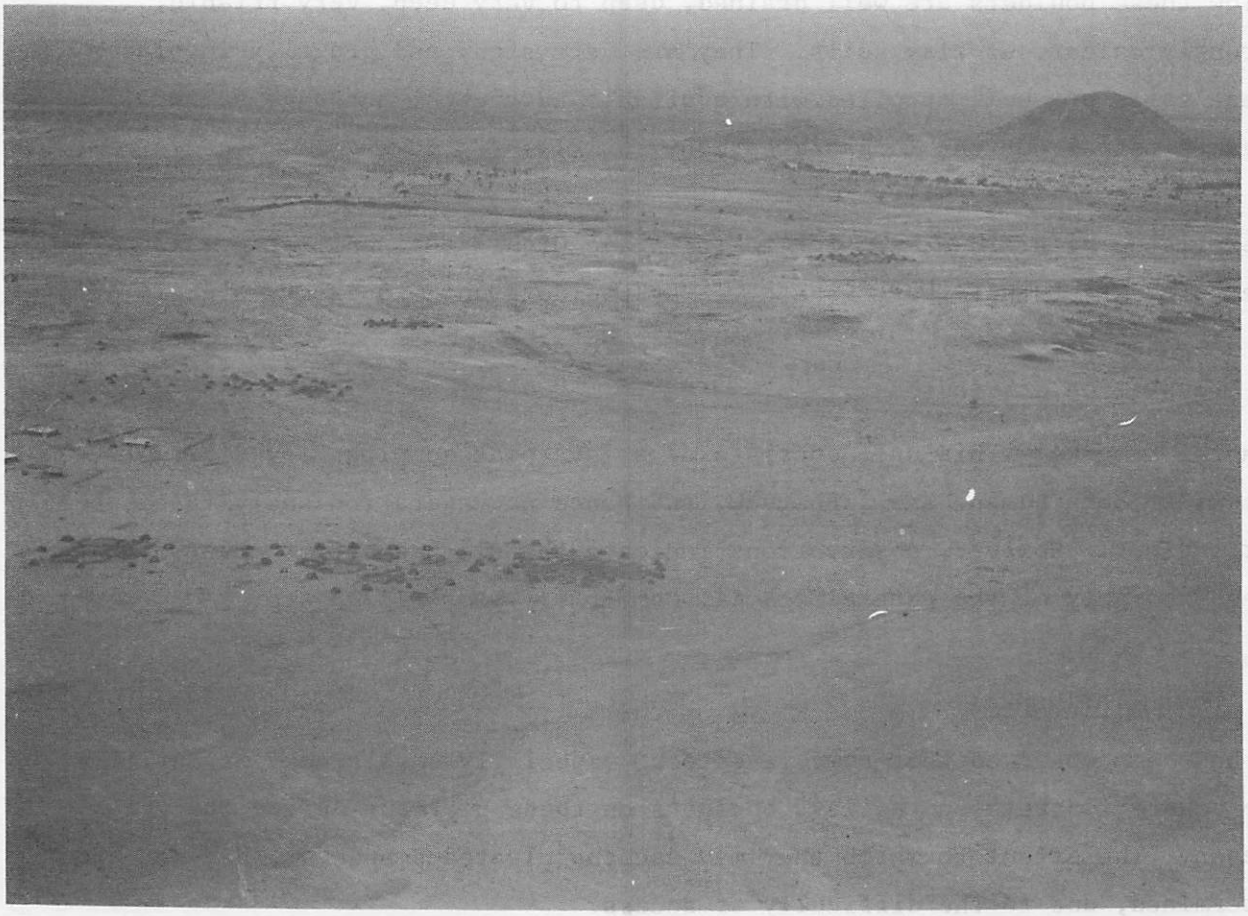
b. Vegetation attributes

General remarks: This unit consists of a lava plateau with very difficult access to both humans and livestock, and hence no vegetation analysis has been carried out. However, observations indicate that it has a fair cover of bush trees, notably of the general *Acacia, Commiphora, Boswellia,* etc.

c. Human influence

It has been observed that some livestock, especially smallstock, may utilize the vegetation between the lava boulders on these plateaus during the wet season. The extent to which they may use the pleateaus however, has not been determined, due to the difficulty of access.

8.24 Range unit 24: Man-made deserts around permanent settlements



a. Physical attributes

This range unit occurs on the highly degraded areas around Korr and Kargi. At Korr the area is at an average elevation of about 500 m above sea level, while at Kargi the elevation is approximately 450 m. Together these two areas occupy a total of about 221.1 km^2. The greater proportion of this range unit occurs around Korr (approximately 80%). The major landform around Korr is uplands, while the unit around Kargi embraces different landforms.

The average annual rainfall around Korr is about 188 mm, with a mean annual variability of about 80%. Around Kargi the annual average is about 200 mm, with estimated mean variability of about 80%. The prevailing winds in both localities are south-easterlies, and the average speeds of these winds are gentler around Kargi than at Korr.

The soils occurring within this unit are variable, depending on the parent material. Around Korr, the soils are developed on gneisses, rich in fero-magnesian minerals. This parent material gives rise to soils that are in the main somewhat excessively drained to well drained, and shallow to moderately deep. On the upper slopes the soils are slightly rocky, very stony to gravelly loamy sand to sandy loam. On the middle slopes the soils are slightly gravelly to gravelly sand loam to sandy clay loam. They tend to be deeper on the lower slopes. Around Kargi a variety of soils, ranging from shallow to deep, also occur.

In general, these soils are moderately well supplied with available nutrients. However, they have a very low organic-matter content. Their inherent fertility is therefore quite moderate. They are heavily degraded due to very heavy use by livestock and the cutting of trees as a result of sedentarization in these areas. They have actually become man-made deserts.

b. Vegetation attributes

These man-made deserts have previously been classified as potential woodlands, and this is supported by the presence of relic trees which have escaped destruction within the highly degraded areas. The present situation is a complete absence of vegetation around the settlements in an ever-increasing circle, which, at Korr, is estimated as having a 9 km radius. All peripheral vegetation types are equally affected by the impact of heavy grazing and trampling by all kinds of livestock. Some degree of regeneration has been proved possible by the IPAL exclosures in Korr and Kargi. The successional trend appears to be from annual grasses and herbs, which are the first colonizers, to dwarf shrubs with, hopefully, after long periods of protection, a return to the original vegetation.

F. WOODLAND RESOURCES

1. Introduction

Trees have three important roles in the arid zone in northern Kenya, seen from the standpoint of the pastoralists. They provide firewood, they provide materials for the construction of houses and livestock enclosures, and they provide browse for the livestock upon which the pastoralists are almost wholly dependent for their subsistence. In addition to these three essential contributions to the pastoral economy, trees are virtually a necessity as providers of shade, a very important factor in the survival of cattle and small livestock in the arid zone. Trees are valued for fruit and other useful edible and medicinal products, for fibre for rope making and for the gum of certain *Acacia* species, including the gum arabic of commerce.

The role of trees in the maintenance of soil fertility (e.g. that of *Acacia* species in nitrogen fixation) and in the reduction of soil erosion and dessication, although of crucial importance, remains to be investigated systematically and will not be discussed here.

The reduction and eventual loss of the tree layer in areas of exceptionally heavy livestock and direct human exploitation almost invariably take place several years after the degradation of the herb layer through overgrazing and trampling. Very large areas of rangeland which are now in the intermediate state between these two stages of desertification, where the soil surface is almost totally denuded but where the trees are relatively unharmed, can be seen in the Samburu and Baringo District of Kenya and in several areas in Marsabit District.

Indeed it appears that, in the process of degradation of the wooded grasslands of the arid and semi-arid zones of Eastern Africa, there is a stage at which the reduction or removal of the grass layer results in vigorous growth of small trees, mainly *Acacia* species. This is due to the lack of root competition for the seedling trees and the absence of grass fires, which normally limit tree growth and effectively maintain the patterns of scattered trees, or of woodland and grassland mosaics, characteristic of non-degraded rangelands in Eastern Africa.

The most extensive vegetation communities within the arid and semi-arid region of north-eastern Africa are the dry shrublands in which the small tree species *Acacia reficiens* and *Acacia mellifera* are dominant or co-dominant. Within the IPAL management area these communities constitute 26 per cent, while the two *Acacia* species, together with several others, occur as the dominant trees in a further 60 per cent of the region which is occupied by annual grassland and dwarf shrubland.

In addition to the two extensive *Acacia* shrubland types, which include a large proportion of the trees of the region, the third most important tree community is the *Acacia tortilis* riverine woodland, which includes nearly all of the large trees in the arid zone. Although of relatively small area, this community is important as a source of animal browse, firewood, building material and shade and it provides one of the main dry-season fodder reserves for the livestock herds.

The problem of the deterioration of the arid lands of northern Kenya and the increasing pressure on the available woodlands has already been mentioned. It is against this background of extremely uneven use of land resources that the Woodland Research Programme has been undertaken and the present management plan is designed.

2. Specific Objectives of the Woodland Component Study

2.1 Overall objectives

- to provide sound quantitative information on the status and trends of the tree populations upon which the rational management of the woodlands can be based;
- to answer the primary question:
  How can woodland exploitation be managed to ensure the maximal sustained production of wood and forage for the long-term benefit of the pastoralist peoples of the region and for the country as a whole?
- to provide alternative means for the fencing of livestock as a substitute for the thorn-tree night enclosures which are the main cause of tree destruction in the region;
- to maximize the productivity of the woodlands through the development of tree-product marketing (especially for gum arabic), as a means to diversify the present livestock-based economy.

2.2 Immediate research objectives

In order to answer the primary question, the following immediate objectives must be realized:

- to estimate human and livestock requirements;
- to measure the standing crop biomass densities of wood and foliage of the most abundant and useful tree and shrub species;
- to obtain correlations between the dry weight biomass of the component parts of each tree species and its dimensions, in order to estimate biomass and production values from systematic measurements, obtained through ground transects and on large-scale aerial photography;
- to estimate the annual production of the component parts of sample tree populations in relation to recent rainfall;
- to extrapolate detailed biomass and production values to each of the woodland communities in the study area;
- to map tree and shrub densities in relation to range type and in relation to utilization by people and livestock;
- to estimate rates of change in woodland and shrubland vegetation and to predict the future status and trends of the tree populations on the basis of present age and species structures;
- to assess the actual availability of browse material to livestock, considering height in relation to the feeding levels of the livestock;
- to estimate sustainable foliage production and offtake for the major browse species, taking into account observed or likely variability due to climate, levels of browse intensity, and exploitation for wood;
- to estimate long-term livestock carrying capacities based upon observed tree and shrub production, availability of browse, palatability, and the tolerance of tree and shrub species to browsing and lopping;
- to test alternative materials for the construction of livestock night enclosures for practicability, acceptance by pastoralists, mobility, length of life, cost, and suitability for local manufacture;
- to investigate the feasibility of harvesting woodland products other than wood and foliage, to provide commodities for local use and for external markets. In particular to undertake the systematic tapping of gum arabic producing trees (*Acacia senegal*) to obtain a sustained

yield of this commodity, and the collection of *Acacia tortilis* fruits as a supplementary feed for livestock at times of food shortage.

3. Resume of Methods

3.1 Estimation of tree density, canopy cover, biomass and production, species composition and age-class structure

a. The woodland transect method

Described by Leithead (1979), this method is similar to the point-centre-quarter method, but has proved to be a particularly rapid and effective sampling technique for the measurement of the above parameters in the conditions of the study area.

b. Tree biomass measurement

Obtained by destructive sampling of the most important tree species to obtain regressions of component weights against tree dimensions.

c. Litter collection

Used to check values of total annual foliage production in certain tree species.

d. Fruit collection

Systematic sampling of fruit production in *Acacia tortilis* to assess production for livestock use.

e. Tree growth and production

The measurement of marked trees at six-monthly intervals to obtain growth rates.

f. Interpretation of tree growth rings

The correlation of growth rings in *Acacia reficiens* with known rates and known climatic records. Growth-ring interpretation in old *Acacia tortilis* to assess long-term growth rates.

g. Wood and foliage production

Data from growth measurements are combined with those from destructive sampling and litter collection to provide estimates of wood and foliage biomass and production. Data on foliage production per m^2 of crown are extrapolated to woodland areas for woodland production estimates.

h. Woodland species and age-class structures

Transect sampling is used to obtain species and age-class structures of all woodland types with the aim of assessing woodland condition for management purposes.

3.2 Woodland community structures

a. The results of analysing large-scale aerial photography

The canopy area composition (tree, shrub, dwarf shrub, herb, and bare ground) of woodland communities is checked by aerial photography and relative production values for each layer (per hectare) estimated.

b. Oblique aerial transparency photographs

Used to check estimates of woodland composition and biomass, obtained by ground transects.

c. Livestock impact trials

The offtake of vegetation by livestock under controlled stocking rates is measured in fenced paddocks to assess carrying capacities.

d. Artificial livestock fencing trials

Over four years two livestock night enclosures made of bamboo hurdles have been tested as a substitute for thorn fencing.

e. Gum arabic harvesting trials

The collection of gum arabic from untreated and systematically tapped *Acacia senegal* trees has been undertaken to assess the feasibility of starting a local gum arabic industry to diversify the economy.

4. Major Findings and Results

4.1 Woodland descriptions and measurements

a. Introduction

The main results of the woodland analysis have been derived from transect sampling of the tree populations by the Leithead (1979) method.

These results are summarized below in a manner which is intended to present the data of greatest relevance to woodland management in an easily accessible and understandable form. Biomass values have been calculated using the results of destructive sampling of trees. Production values have been calculated from growth and population age-structure data for each type of woodland.

Most of the tree transects were carried out in parallel with the range-evaluation transects in order to ensure that the woodland measurements corresponded to the range measurements in each range type sampled. While range transects were 300 m long, woodland transects were normally 500 m long, except where it was necessary to lengthen them to include a minimum of 30 trees in a sample. Normally one transect was carried out in each of the 65 range types, but in some types two transects were completed. The data obtained for each range unit are summarized in Table 50.

b. Summary of woodland measurements

Table 50 presents the summarized data under the following headings:

1. The major range units.
2. Their areas and percentages of total management area.
3. Brief range type descriptions.
4. Brief transect location.
5. The dominant tree species.
6. The number of tree species present.
7. Tree density in trees per hectare.
8. Tree percentage canopy area.
9. Wood dry weight biomass in kg per hectare.
10. Wood dry weight production in kg per ha per year.
11. Foliage and new growth dry weight in kg per hectare.
12. Foliage dry weight production in kg/ha/year.
13. Statement on population age structure (e.g. good, moderate or bad), based upon the age-class structure histogram (see Figure 9).
14. Statement on best management strategy.
15. Estimated carrying capacity for camels and goats.

Table 50 . Summaries of the tree and large shrub communities in the range units

Range Unit	Area km^2	Dominant vegetation	Location	Dominant trees *	No. of species	Trees ha^{-1}	% canopy	Wood dry wt. $kg\ ha^{-1}$	Wood prodn. dry wt. $kg\ ha^{-1}y^{-1}$	Foliage dry wt. $kg\ ha^{-1}$	Foliage Prodn, $kg\ ha^{-1}y^{-1}$	Age struct.	Management	Stocking rates km^{-2}
1	395.2 3.113%	Annual grass and dw. shrubs with small woodland areas	Hafare area	Acre	15	25	0.3	1500	110	17	30	poor	low camels and goat stocking: limited wood collection	3 camels 3 goats
2	494 3.892%	Dwarf shrubs and scattered trees	Korr-Kargi road	Acsy Acre	10	70	2.0	800	55	18	30	poor	low camel and goat stocking: v. limited wood collection	1 camel 2 goats
3.	178.8 1.408%	Annual herb and grass with one large woodland area	N and E of Oldoinyo Mara Hills	Acre acto	12	56	3.0	1800	160	34	46	poor	low camel and goat stocking except in Acto Woodland: dead wood only	1 camel 1 goat
4	112.9 0.899%	Woodland with dwarf shrubs.	Ilaut-Ngurunit area	Acto Acnu	18	250	14.0	5300	420	105	155	good	moderate camel and goat stocking mod. wood collection.	5 camels 8 goats.
5	451.7 3.558%	Annual grass and dwarf shrubland	Hafare area and Ilaut- S. road	Acre	10	16	1.0	450	55	9	13	poor	cattle range: low camel stocking.	1 camel 0 goats.
6	160 1.260%	Annual grass with sc. trees	Between Korr - Kargi	Acto Cafa	8	30	0.9	13	2	5	5	Cafa g. others f.	low camel and goat stocking no wood collection.	1 camel 1 goat.
7	240 1.891%	Annual grass with sc. trees	Between Ilaut & S. Korr	Cosp. cafa	12	107	6.7	1294	108	53	85	Svnu g.	low camel and goat stocking: no wood collin.	1 camel 1 goats.
8	244.2 1.851%	Shrubland	Kargi - Palae rd.	Acre	14	135	11.0	6500	340	35	46	fair	low camel and goat stocking: wood collin.	2 camels 3 goats
9.	672.8 5.360%	Shrubland and dwarf shrubland	Balesaa Kulal area	Acre	12	240	14	11000	750	85	140	Acre	moderate stocking and wood collection	4 camels 4 goats

Table 50 continued: Summaries of the tree and large shrub communities in the range units

Range unit	Area km^2	Dominant vegetation	Location	Dominant trees	No. Of species	Trees ha^{-1}	% canopy	Wood dry wt. kg ha^{-2}	Wood prodn. dry wt. kg $ha^{-1}y^{-1}$	Foliage dry wt. kg ha^{-1}	Foliage d.w prodn. kg $ha^{-1}y^{-1}$	Age struct.	Management	Stocking rates km^{-2}
10	1077.5 8.488%	Shrubland and dwarf shrubland	Balessa-Kurkum-Kargi area	Acre Acme	14	160	13	3500	310	95	140	poor	Mod. camel and goat stocking: moderate wood collection.	5 camels 4 goats
11	202.3 1.594%	Perennial grassland	12 km N. of Olturot	Acnu Acme	5	3	0.5	550	42	11	21	poor	Cattle range	0 camels 0 goats
12	192.9 1.520%	Dwarf shrub and sc. trees	Olturot area	Acre Acto	12	60	8.0	8000	650	90	140	poor	Mod. camel stocking: no goats: high wood collection.	4 camels 0 goats
13	635.2 5.004%	Dwarf shrub with sc. trees	Ngurunit trees	Coca Acto	15	55	3.0	250	40	17	25	fair	Low camel and goat stocking wood cutting only in 75b.	1 camel 3 goats
14	663.4 5.226%	Dunes with dwarf shrub sc. trees, ann. and per. grasses	Between Kurkum lava and Chalbi	Cofl Eucu	8	50	3.7	610	55	21	22	fair	Mainly cattle range trees unpalatable and poor fuel.	1 camel 2 goats
15	70.6 0.556%	Very bare annual grassland	62 km Marsabit - Maikona road	Eucu Macr	5	3	0.1	29	2	1	1.	fair	unsuitable for livestock	0
16	153.6 1.186%	Annual grass and sc. trees	14 km Marsabit - Maikona road	Ortr Cafa	7	88	1.0	178	14	15	15	Ortr: g. Cafa: f.	Low goat stocking: cattle range.	2 goats
17	47.1 0.371%	Dwarf shrub and scattered trees	N.E. of Maikona	Acto Macr Sape	5	28	2.0	250	15	5	7	fair	low camel and goat stocking; wood collection of Sape only	1 camel 2 goats

Table 50 continued: Summaries of the tree and large shrub communities in the range units

Range Unit	Area km^2	Dominant vegetation	Location	Dominant trees	No. of species	Trees ha^{-2}	% canopy	Wood dry wt. $kg\ ha^{-1}$	Wood Prodn. dry wt. $kg\ ha^{-1}y^{-1}$	Foliage dry wt. $kg\ ha^{-1}$	Foliage prodn. d.w. $kg\ ha^{-1}y^{-1}$	Age struct.	Management	Stocking rates km^{-2}
18	1199.8 9.452%	Annual grass and scattered trees on lava soils	Lower fan slope of Mt. Kulal and Asie	Acre Acme	11	95	3.8	1100	95	26	34	fair	low camel and mod. goat stocking low wood collection	1 camel 5 goats
19	4512.1 35.546%	Annual grass and scattered trees on lava	Marsabit lava fields	Coca Acto	18	45	4.5	300	25	20	30	poor	low camel and goat stocking: mainly cattle no wood colln.	2 camels 3 goats
20	568.1 4.633%	Acacia woodland and shrubland: dwarf shrub understorey	Ilaut area	Acto	18	170	6.0	6500	480	110	160	fair	mod. camel and goat stocking: no wood collection.	5 camels 6 goats
21	404.6 3.187%	Bushland with perenniel grass	Southern foot-slopes of Marsabit Mountain	Coaf ortr	18	383	12.1	5400	410	121	150	fair	moderate goat stocking: cattle range mod. wood collection	8 goats

* Key to abbreviations of dominant tree species

Acacia drepanolobium	Acdr	*Cordia sinensis*	Cosi
A. elatior	Acel		
A. etbaica	Acet	*Dobera glabra*	Dogi
A. horrida	Acho	*Euphorbia cuneata*	Eucu
A. mellifera	Acme	*Grewia tenax*	Grte
A. nilotica	Acni	*Jatropha dichtar*	Jadi
A. nibica	Acnu	*J. ferox*	Jafe
A. paolii	Acpa	*Maerua crassifolia*	Macr
A. reficiens	Acre	*M. oblongifolia*	Maob
A. senegal	Acse	*Ormocarpum trichocarpum*	Ortr
A. seyal var. seyal	Acsy	*Premma racemosa*	Prra
A. seyal var. fistula	Acsf	*Salvadora persica*	Sape
A. tortilis	Acto	Unidentified tree	Unid
Acacia sp. nov.	Acno		
Balanites aegyptiaca	Baae	Other abbreviations:	
B. orbicularis	Baor	Under type description	
Boscia coriacea	Boco	annual	ann.
B. minimifolia	Bomi	scattered	sc.
Boswellia neglecta	Bone	Under location	
B. hildebrandtii	Bohi	north	N.
Cadaba farinosa	Cafa	south	S.
C. glandulosa	Cagl	east	E.
C. mirabilis	Cami	west	W.
C. ruspolii	Caru	junction	junc.
Combretum aculeatum	Coac	Under age structure	
C. molle	Como	good	g.
Commiphora africana	Coaf	fair	f.
C. candidula	Coca	poor	p.
C. erythraea	Coer	Under management	
C. flavifolia	Cofl	moderate	mod.
C. paoli	Copa	collection	colln.
C. rostrata	Coro		
Commiphora sp.	Cosp		

Note to Table 50

The table lists the range units which have been selected for management purposes and are described in section E.7. Each unit contains several distinct range types differentiated by means of aerial photography interpretation and ground verification on the basis of relative vegetative homogeneity. The data given in the table were obtained from the transect surveys of the trees and large shrubs, at least one of which was carried out in each of the range types, in combination with the range assessment surveys which concentrated upon the herb and dwarf-shrub layers. Wood and foliage biomass density and production values were obtained by the application of destructive sampling and growth data to the transect tree density and canopy cover data. The detailed results of the transect observations for each of the 140 range types (to be given in a technical report) are available for use in the management of the individual woodland and shrubland communities since it is envisaged that some of these may require management which differs from that of the range unit in which they are included. Lack of space in this document precludes the inclusion of woodland data from all the range types but Table 50 gives a summary in which the individual range type data are compounded as averages weighted according to the relative areas of the range types included.

Stocking rate estimates are based upon the known proportion of tree and large shrub-browse in the diets of camels and goats and upon the annual production of the tree foliage, modified by a factor determined by the age structure of the tree populations. Poor age structure, with few young trees, necessitates a low goat stocking level.

Stocking rates estimated on this basis, which may differ from those estimated on the basis of range production as a whole, have been applied in the overall calculations of stocking rates given in section 7, so that limitations imposed by the tree populations are adequately reflected in the recommended stocking rates. However, in some sites, where trees are very scarce, management may be based entirely upon the condition of the grass, herb and dwarf shrub layers, on the assumption that an improvement of the tree layer is not feasible or worthwhile.

Figure 9. Woodland population structure

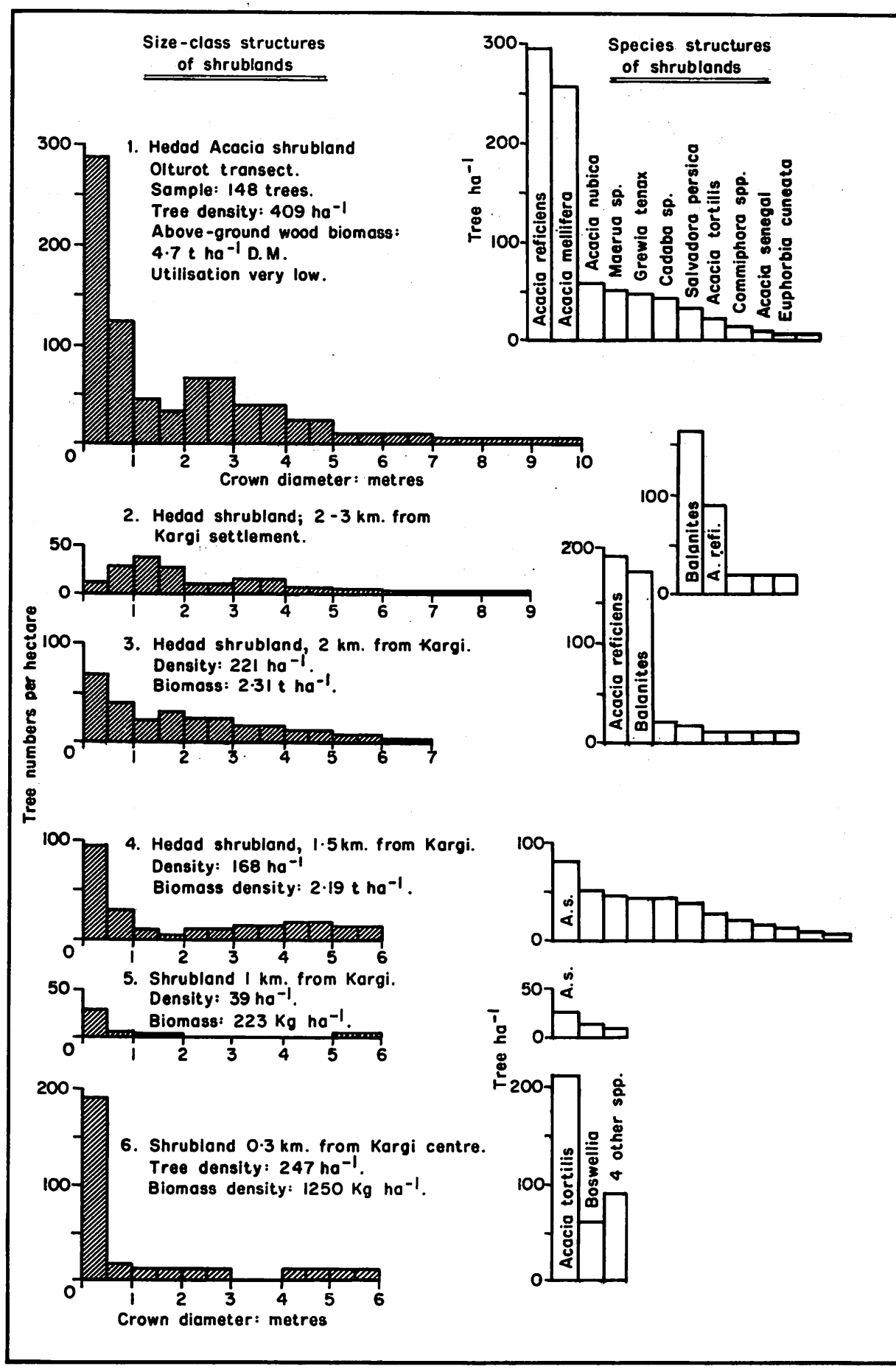


Figure 1

4.2 Wood requirements of the Rendille people

The Rendille people require wood for two main purposes: for fuel in cooking and for the construction of their livestock night enclosures. Estimates of wood requirements have been made by several research workers with the Project, including Lewis (1977), Hussein Yussuf, quoted by Synott (1979), and Walther and Herlocker (1980).

There is a general agreement between the findings of these authors, which are based upon observations of the quantities of wood used by Rendille families for their cooking fires and their livestock *bomas* at each move. The estimates, summarized by Synott (1979), are as follows:

a. Livestock night enclosures

0.33 m^3 wood/head/move. Assuming 6-8 moves per family per year, a total use of c. 1.5-3.0 m^3 head/year is indicated. If we take the upper limit of this estimate, the total quantity of wood required for *bomas* by the 12,900 Rendille people in the management area is 38,700 m^3. This figure can be expressed as 38,700 tonnes, since the specific gravity of the most important tree species for this purpose is close to 1.

b. Wood for fuel

Synott (1979) estimated that the present annual requirement for fuel-wood by the Rendille people is approximately 5 per cent of their requirement for fence-construction material, amounting to between 75 and 150 kg per person. For 12,900 Rendille people, assuming fuel-wood consumption at the higher level, the annual requirement will be 1,935 tonnes dry weight.

c. For both purposes combined, the present total annual requirement for wood is estimated at 40,635 tonnes, or 5.3 tonnes daily. If we assume that the average annual wood production of the *Acacia* shrublands of management units 9, 10, 18 and 21 is 250 kg ha^{-1}, this requirement can be satisfied by the production from 1,548 km^2 of those shrublands, provided that the collection of wood is evenly distributed. This is approximately half of the total area of the *Acacia reficiens* and *A. mellifera* shrublands of the range units mentioned above.

An alternative approach is to plan the harvesting of the 3,000 km^2 of the *Acacia* shrublands at the rate of c. 125 kg/$ha^{-1}$$year^{-1}$, which is about half

of their annual wood production, leaving a substantial margin of safety for years of low production, but not allowing for the inevitable difficulties of harvesting evenly across areas which are distant from settlements and inaccessible.

The existing situation, which is responsible for the gross depletion of tree populations in the expanding zones around the settlements, should be noted. Approximately 600 km^2 of degraded woodland and shrubland around the settlements of Korr and Kargi (5.3 per cent of the management areas) are being used as the exclusive source of wood by the 6,000 Rendille people resident in these areas, at a rate of approximately 150 kg $ha^{-1}year^{-1}$. This is calculated on the basis of a low consumption rate of 1.5 tonnes of wood per person annually, taking into account the very low availability of wood in these areas. Almost throughout the 600 km^2 of the concentration settlement areas the consumption rate of 150 kg $ha^{-1}year^{-1}$ greatly exceeds the production rate of the tree populations, so that the present rate of offtake is steadily reducing the standing crop biomass.

d. The tree population structure histograms (Figure 9) show the relative proportions of the age classes in the woodlands and shrublands of each range type. In those range types in which the relative numbers of mature trees are high, particularly those in which they are over-mature and dying or recently dead, the trees should be collected for firewood and, where livestock camps are present in the vicinity, for fencing material. This is discussed further in Volume II of this report.

4.3 Livestock fodder requirements

This subject is discussed mainly under the heading of livestock management but is summarized in this section to provide a background and introduction to the recommendations on woodland management for the provision of browse fodder and for the maintenance of the woodlands and shrublands under the impact of livestock.

a. Estimate of fodder quantities required by present livestock populations

Field gives the livestock populations of the management region (11,300 km^2) and their dietary requirements as follows:

Table 51. Livestock population of the IPAL management area

	Average weights (kgs)	Numbers	Densities (km^{-2})	TLUs (1 TLU = 250 kg)
Camels	300.6	18,643	1.65	22,371
Cattle	164.7	24,552	2.17	16,204
Sheep	23.7	43,019	3.18	3,872
Goats	24.8	64,528	5.71	6,453
Donkeys	150	235	0.02	141
Totals		150,977	13.36	49,041

Table 52. Livestock diets

	Per cent composition		
	Trees and large shrubs	Dwarf shrubs	Other plants
Camels	29.0	47.5	23.5
Cattle	1.0	3.0	96.0
Sheep	9.3	23.7	67.0
Goats	29.9	22.5	47.6

Table 53. Livestock total daily food (dry matter) intake for average animals

	Food intake as percentage of animal lives weight	For 1 animal (kgs)	For total population (kg)	Per km^2 (kg)	Per ha (kg)
Camels	1.6	4.81	89,673	7.94	0.079
Cattle	2.7	4.45	109,256	9.67	0.097
Sheep	3.2	0.76	32,694	2.89	0.029
Goats	3.4	0.84	54,203	4.80	0.048
Totals			285,826	25.30	0.253

Table 54. Livestock total annual dry matter intake

	For 1 animal (kg)	For total population (kg)	Per km^2 (kg)	Per ha (kg)
Camels	1756	32,737,108	2897	28.97
Cattle	1624	39,872,448	3528	35.28
Sheep	277	11,916,263	1054	10.54
Goats	307	19,810,096	1753	17.53
Totals		104,335,915	9233	92.33

Table 55. Daily intake of tree and large shrub browse

	For 1 animal (kg)	For total population (kg)	Per km^2 (kg)	Per ha (kg)
Camels	1.395	26,007	2.30	0.023
Cattle	0.044	1,092	0.10	0.001
Sheep	0.071	3,054	0.27	0.003
Goats	0.250	15,132	1.43	0.014
Totals		46,885	4.10	0.41

Table 56. Annual intake of tree and large shrub browse

	For 1 animal (kg)	For total population (kg)	Per km^2 (kg)	Per ha (kg)
Camels	509.2	9,492,549	840.0	8.405
Cattle	16.06	394,305	34.9	0.349
Sheep	25.90	1,114,837	98.7	0.990
Goats	91.25	5,888,180	521.1	5.210
Totals		16,889,871	1,494.7	14.947

b. Discussion on livestock fodder requirement values

The combined requirement of livestock in the region for tree fodder is 16.19 per cent of the total food requirements. Cattle do not require any tree foliage, but do take dwarf-shrub material (largely of the genus *Sericocomopsis*). Sheep take some tree foliage, mainly the fallen leaves of *Acacia mellifera*. All livestock species eat the flowers and fruits of *Acacia tortilis*, normally taking them in preference to all other foods when they are available. The nutritive value of *Acacia tortilis* fruits is very high and their importance in the diet and as a supplementary food is discussed under the heading of livestock nutrition.

Since the camel and the goat are the main browsing species, it is important to relate foliage production and availability to their requirements. It will be seen from the tabulations above that the tree fodder requirement per hectare of the camel population in the management area is 2.7 times that of the goat population. The higher reach of camels generally enables them to obtain foliage unavailable to goats in woodland and large shrubland communities, so that direct competition between these species is partially avoided in such areas. In the dwarf shrublands, competition between camels and goats is unavoidable. Sheep feed largely with their heads down near ground level, goats largely between 20 cm and 120 cm above the ground, and camels from 1.2 m to 3.0 m, except when feeding on dwarf shrubs. Thus tree fodder availability for each of the livestock species depends on its height above the ground and plant production as potential fodder must be categorized accordingly.

Palatability of the trees and shrubs varies greatly between species. Food preference are discussed under livestock nutrition, but are summarized here:

Table 57. Summary of camel and goat food species

Species	Camels	Goats
*Cordia sinensis**	3	3
*Cadaba farinosa**	3	1
*Maeru crassifolia**	3	1
*Salvadora persica**	3	2
Grewia tenax	2	3
Acacia mellifera	2	3
*Acacia tortilis**	2	2
Acacia reficiens	1	1
Acacia nubica	1	0
Balanites aegyptiaca	1	1

* non deciduous species

Palatability is given according to an ascending scale of 1-3 for camels and goats. In every tree species new growth is taken in preference to old growth during the growing season. In the dry season, only the non-deciduous species can be browsed.

4.4 Tree and large shrub fodder production

a. General

Total foliage biomass density and annual production values have been obtained for each of the 40 lowland range types in the IPAL study area which were identified by aerial photography interpretation. Rain forest and sub-humid bushlands on the mountains have been omitted. The values were derived from transect data obtained in each of the range types and from the destructive sampling of twelve of the most important tree and large shrub species in the region. The detailed biomass and production values for all the range types (to be published separately) are available but are summarized as weighted averages under the range management units in which they occur in Table 50. The foliage biomass values are also given in the range type descriptions in Section E since they have been used in conjunction with the herb and dwarf shrub layer biomass values to adduce carrying capacity levels in each range unit.

Foliage and new growth production has been measured during the last three years, during which rainfall has been approximately average. During this period the two commonest tree species in the shrublands, *Acacia reficiens* and *A. mellifera*, have given a measured standing crop biomass of 52.3 g of foliage (dry weight) per m^2 of tree canopy and, since these trees shed their leaves twice annually in normal years, annual production values of twice this amount. Other tree and large shrub species have characteristic mean foliage/crown area relationships which vary between 45 and 180 g m^{-2}. The extensive *Acacia*-dominated shrublands which have an average canopy cover of c.12 per cent (1,200 m^2 ha^{-1}) have a foliage standing crop of c. 80 kg ha^{-1} (dry weight) and an annual production of c. 130 kg ha^{-1} (dry weight). Shrubland foliage annual production is not normally double the standing crop because several species are not deciduous twice a year.

In general, biomass and production in the woodlands and shrublands are related to soil-moisture availability throughout the year. In the greater part of the region, rainfed woodland and shrubland biomass reflects the mean annual rainfall, but the annual production reflects the rainfall of the current rainy season.

The mean annual rainfall over the last ten years in the lowlands has been near 200 mm yr^{-1}, but with a range of variation of 50-350 mm. The variation in annual wood production is clearly evident in the width of the annual growth rings of the smaller *Acacia* species, which are relatively independant of groundwater and dependent upon rainfall.

In *Acacia reficiens*, annual stem-radius increments have been 2.3 mm in drought years and 4.4 mm in wet years, with a mean of 2.869 mm over 27 years (s.d. = 0.712 mm). Annual foliage production is probably similarly influenced by rainfall in this species but the range of variation has still to be determined. However, it appears likely that foliage production in the deciduous shrublands is approximately proportional to rainfall, as it is in the dwarf shrublands and grasslands.

The large species, *Acacia tortilis*, appears to be less dependant upon rainfall after its roots reach the water table. It tends to shed its leaves over a period of several months rather than twice a year as the small *Acacia* species do. Annual stem radius increment is relatively constant, with a mean of 2.25 mm annually over 127 years in one tree. A sample of 10 *Acacia tortilis* trees gave a standing crop biomass (D.M.) mean of 73 g m^{-2} in 1981. The results of collecting the fallen leaves from this species show that the annual production is c. 1.5 times the standing crop, giving a value of 110 g m^{-2} of tree crown.

The tree foliage production values given in Table 50, for each of the range types in the management area, vary from almost zero in certain parts of the annual grasslands and dwarf shrublands to 300 kg $ha^{-1}yr^{-1}$ in the denser parts of the *Acacia mellifera* shrublands on the lower slopes of the mountains. The 3,000 km^2 area of the Hedad *Acacia reficiens* shrublands, the largest single block of tree-dominated vegetation, has a mean foliage production of approximately 130 kg $ha^{-1}yr^{-1}$ (D.M.) with a canopy cover of c. 12 per cent.

In the same area the dwarf shrub production is c. 450 kg $ha^{-1}yr^{-1}$ with a canopy of between 19 and 24 per cent, and the remaining area bare ground or annual grass. These production values combined have been used as the basis for the stocking-rate estimates given in the tables. The stocking rates, given for camels, smallstock and cattle separately, reflect the production of fodder which is suitable for each livestock species and accessible to it.

The accessibility of tree and shrub foliage to livestock of the different species can be described as follows. Sheep normally take tree foliage either after it has fallen or when it is within 20 cm of the ground. Goats take it from about 20 cm to 120 cm, but most goats do not reach above 100 cm. Camels normally take tree foliage between 1 m and 3 m high. All foliage above 3 m is inaccessible. The foliage of small trees up to 2.5 m high and 3 m in crown diameter is wholly accessible to camels. Above this height and diameter increasing proportions of the tree foliage are inaccessible to camels. Thus the estimation of the proportions of tree

foliage which are available to livestock of the different species is not simple. Nevertheless, in each woodland or shrubland community an estimate of available fodder for each livestock species can be given on the basis of the tree and shrub density and size-class structure. In the shrublands near to settlement, where there is a lack of trees in the small size classes, due to excessive browsing by goats (as shown by the size-class histograms) and the bulk of the tree populations are made up of mature trees, relatively little browse fodder is available to goats but a high proportion may be available to camels. In other areas where there has been excessive collection of mature trees for firewood and fence construction, but with some regeneration of young trees, the reverse may be true. In general, a woodland of balanced age structure will be suitable for camels and goats at approximately equal stocking rates judged on an animal biomass basis, and under these circumstances it is assumed that half the production of foliage is available as fodder.

In over-mature woodlands only a small proportion of the foliage is available (even to camels) and very little is available for goats. Exceptions occur in *Acacia mellifera* shrubland and *Acacia tortilis* woodland which are composed of mature trees. The foliage becomes available to sheep when it drops and large proportions of the leaf production of these woodlands may be regarded as potential food for sheep. Similarly, the fruit of *Acacia tortilis* produced only by mature trees, is valuable fodder, with a high protein content, and is used by all livestock species. The measured annual fruit production of a sample of 25 trees was 0.25 kg per m^{-2} of crown area in 1981 and 1982. In mature *Acacia tortilis* woodland with 4 trees ha^{-1} and 7 per cent canopy cover, the fruit production is approximately 95 kg $ha^{-1}yr^{-1}$ (D.M.) and the foliage production 76 kg ha^{-1} yr^{-1}.

Acacia reficiens, the commonest tree in the management area and over the greater part of the arid country of northern and eastern Kenya, is relatively unpalatable to livestock. Its foliage is eaten by camels as new growth and it constitutes a very large reserve of fodder early in the dry season before its leaves fall. In most years this species is taken very little by the browsing animals. The food value of *Acacia reficiens* shrubland lies mainly in the foliage of the less common tree species which together

normally constitute about half of the total biomass and production. These are *Cadaba* spp., *Maerua* spp., *Salvadora persica*, *Cordia sinensis*, *Acacia mellifera*, and *Acacia senegal*. While it is not a good fodder tree, *Acacia reficiens* is the main source of wood for the Rendille people, and is discussed below under the heading of wood production.

b. Woodland and large shrubland carrying capacities for livestock

This subject has been introduced and discussed in section E.6 on rangeland carrying capacities. Age-class structure, as a factor in determining optimum stocking rates in woodlands and shrublands, has been mentioned briefly in that section but its importance for the future management of tree and large shrub communities in northern Kenya calls for a more thorough explanation here.

Where serious overstocking by goats and camels has occurred in recent years the tree and large shrub species composition and age-class distribution are likely to be degraded. This is well illustrated in the age-class and species composition histograms of shrublands measured at varying distances from Kargi settlement (Figure 9). The histograms of the unexploited woodland in an insecure area 40 km from the settlement provide an example of a balanced and self-sustaining woodland structure with twelve species present, a dominant and co-dominant species which constitute more than half of the tree and shrub biomass, with enough plants in each size class to ensure adequate recruitment to the next size-class allowing for natural mortality. The age-class histogram follows a curve which is characteristic of a self-sustaining shrubland community. By contrast the heavily browsed shrublands near to the settlement show age-class structures in which the younger trees are too few to provide adequate recruitment to the older age classes and the number of species present has been reduced. To the uncritical observer the shrubland may appear to be in good condition since it includes numerous large shrubs. He may not notice that the shrubland is over-mature and will shortly die out due to insufficient regeneration. Under these circumstances, despite the high biomass and production of the mature trees, the woodland or shrubland is in poor condition and should be rested from livestock browsing to provide an opportunity for a new generation of young trees to grow above the goat-vulnerable height. This may take four or five years to achieve but

is necessary for the survival of the shrubland over the next decades. Since adequate regeneration may only occur in years of good rainfall, it may be necessary to prolong the resting period until a series of relatively wet years occurs.

Outside the areas of relative insecurity, the age-class structure of the woodlands and large shrublands is generally poor and is leading to widespread decline in tree densities in the next two decades. Even a considerable reduction in the browsing pressure will not remedy this decline quickly and a period of at least ten years for the shrublands and twenty years for the woodlands will elapse before the results of a reduction in browsing impact will be clearly apparent. However, there is an immediate need to implement management measures to ensure the recovery of the tree and large shrub communities over large areas. Management proposals for the rehabilitation of the degraded woodlands and shrublands are given in Part II of this plan.

c. Wood biomass and production

Table 50 gives wood biomass and production values per hectare for each of the range units. These values were obtained by combining the results of weighing air-dried samples of the common tree species to obtain dry-weight/crown-diameter regressions (and dry-weight/stem diameter regressions), with those of the woodland transects and large-scale aerial photography.

Figure 10 shows regressions obtained for two common tree species *Acacia reficiens* and *A. mellifera*, based upon samples of twenty trees, over a range of sizes of each species, which were dissected into their (above ground) components. Similar regressions have been obtained for the following other common tree and shrub species: *Acacia tortilis*, *Acacia nubica*, *Cordia sinensis*, *Salvadora persica*, *Maerua crassifolia*, *Cadaba farinosa*, *Cadaba resinosa*, *Balanites aegyptiaca*, *Salsola dendroides*.

All the wood from the sampling was air-dried and sub-samples were oven dried to obtain conversion factors. The oven-dry weight was found to be 93 per cent (+ 1.5) of the air-dry weight in all species which were weighed.

Transect counting of each woodland and large shrubland type, identified initially in the 1972 photography survey and checked on the ground, provided

Figure 10. Dry-weight/crown-diameter regressions for two *Acacia* species

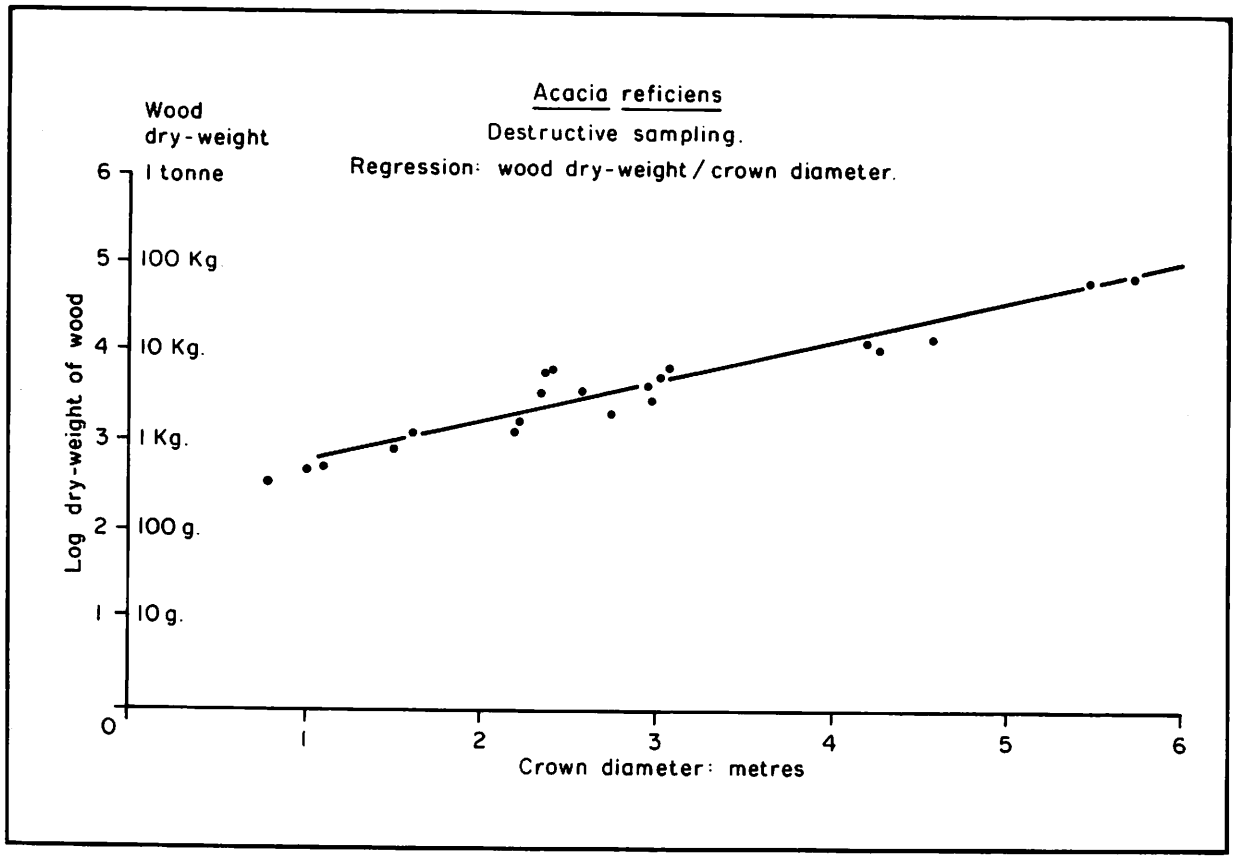


Figure 4

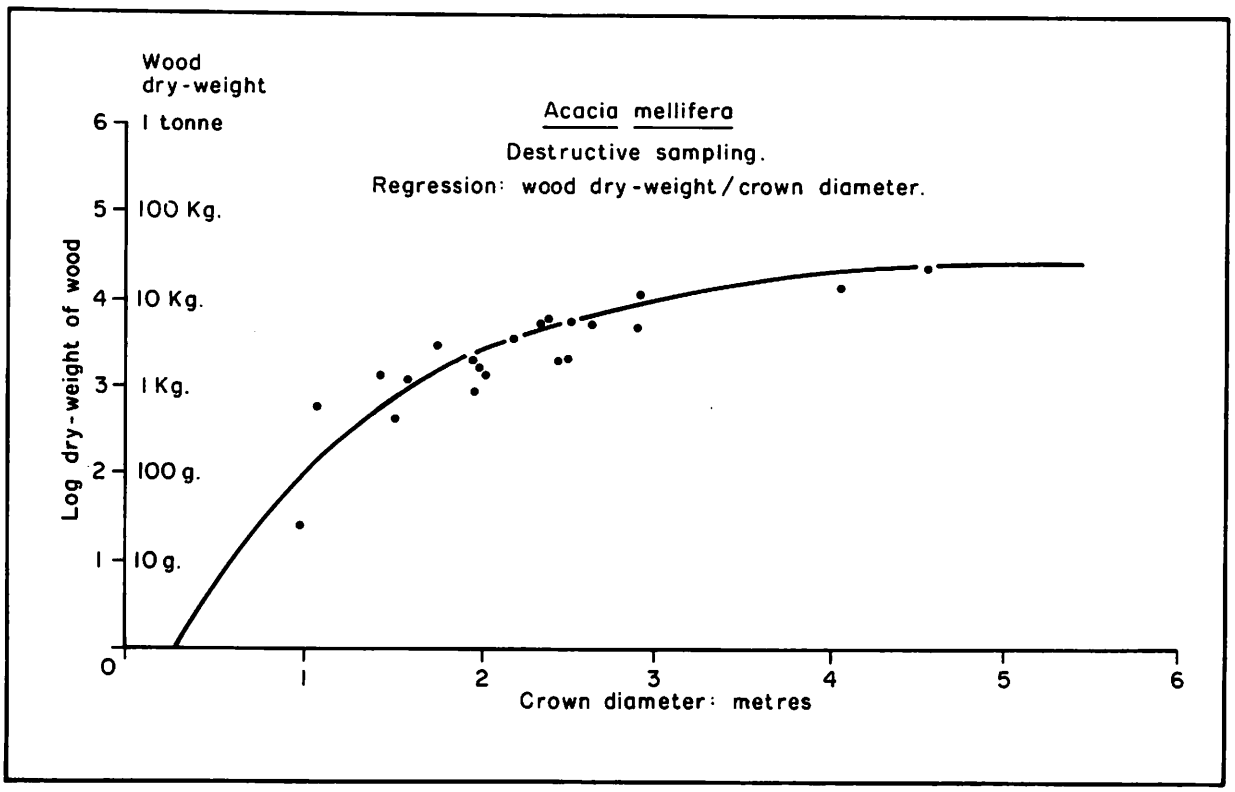


Figure 5

data from which the following woodland and shrubland values were obtained:

- the tree and shrub species present;
- the relative frequency (dominance) of the species;
- tree and shrub densities (all species combined);
- tree and shrub densities (the common species estimated separately);
- canopy cover percentage and absolute canopy area of woodland or shrubland and of the common species separately;
- size-class structure of the common species and of the woodland as a whole;
- biomass of wood and foliage, estimated with the use of destructive sampling data.

d. Tree growth and production

Tree growth rates are being monitored at six sites in the management area with a total of over 300 trees of eight species being measured at yearly or six monthly intervals. The measurements normally taken are: stem diameter at ground level; crown diameter; height.
Examples of growth data are as follows:

Acacia tortilis: 70 small (protected) trees at Kargi; mean annual rainfall, 210 mm.
Mean annual increments: Height, 0.24 m; crown diameter, 0.21 m; stem diameter, 5.4 mm.
8 large trees at Balesa Kulal: mean annual rainfall: 230 mm.
Mean annual increments: Height, 0.0 m; crown diameter, 0.26 m; stem diameter, 4.5 mm; (radius increment, 2.25 mm).
Annual growth rates have been obtained for seven other species.

e. Interpretation of tree growth rings

In the light of the data on tree growth rates, an attempt has been made to interpret the growth rings of specimens of *Acacia reficiens* and *Acacia tortilis*, using basal cross sections of their trunks. The details are as follows:

Acacia reficiens: Site, Hedad shrubland; mean annual rainfall 210 mm.
Height: 3.25 m; crown diameter: 5.4 m; stem diameter: 15.05 cm.
Air-dry weight of wood: 80.7 kg. Foliage nil (not in leaf).
Mean annual radius increment: 2.87 mm (s.d. 0.712 mm).

Diagnostic years:	1955:	serious drought:	2.3 mm increment.
	1958:	normal rains:	4.5 mm increment.
	1960:	drought:	2.6 mm increment.
	1961:	heavy rains:	3.6 mm increment.
	1962:	heavy rains:	3.5 mm increment
	1968-76:	drought:	2.3 mm annual average increment.
	1977:	heavy rains:	4.4 mm increment.

Acacia tortilis: Site, Olturot mature woodland. Height: 10.1 m; crown diameter: 14.85 m; stem diameter: 62 cm.
Air-dry weight of wood: 1,862 kg.
Air-dry weight of foliage: 21 kg.
Number of apparent growth rings: 143.
Apparent mean annual radius increment: 2.06 mm.
(Compare with the mean annual growth of 8 trees above: 2.25 mm).

It is understood that this interpretation of annual growth should be regarded with caution. However, the mean annual increment estimated from the growth rings is consistent with the measured growth rate in the region and the chronology suggested above is supported by the correspondence between growth ring width and the climatic record since 1984 (see Sobania, 1979).

The successive annual weight increments of an average tree of each important species have been obtained, based upon the results of the destructive sampling together with data on mean annual stem diameter increments. The pattern of wood biomass production in each of eight species has been calculated and regressions obtained in which $\log_{10}$ wood dry weight is plotted against stem diameter and approximate age in years.

f. Wood production

Data from the growth studies and measurements of annual stem diameter increment, combined with wood-biomass/tree-dimension regressions, provide estimates of wood production in the different shrubland and woodland communities. The values for wood biomass and annual production given in Table 50 for the different range units in the management area have been

obtained in this way. Two examples are given below:

1. Mixed *Acacia* shrubland: 230 mm mean annual rainfall.
   Wood biomass 4.7 t ha^{-1} dry weight.
   Wood annual production 375 kg $ha^{-1}yr^{-1}$ dry weight.

2. *Acacia reficiens* shrubland: 200 mm mean annual rainfall.
   Wood biomass 3.65 t ha^{-1} dry weight.
   Wood annual production 290 kg $ha^{-1}yr^{-1}$

Data of this kind from all range types have been used to determine the potential rate of wood collection from all parts of the management area.

g. Tree foliage production

In the case of the deciduous tree and shrub species which shed their leaves after the short rains and again after the long rains, the complete collection of leaves twice yearly provides a near estimate of annual foliage production. In 1981 and 1982 the destructive sampling of eight of the commonest tree species (at least 10 trees per species), provided dry-weight values in relation to tree dimensions. The most useful relationship obtained is foliage dry weight per square metre of tree canopy, a value that permits the estimation of foliage biomass density from the results of transect counting and from large-scale aerial photography. In the flat-crowned *Acacia* species, the mean foliage dry weight per m^2 has a low standard deviation:

Acacia reficiens: n = 18 trees.
52.33 g m^{-2} foliage dry weight/canopy area (s.d. 34.33)
Acacia mellifera: n = 18 trees.
52.34 g m^{-2} foliage dry weight/canopy area (s.d. 35.23)
Acacia tortilis: n = 10 trees
72.86 g m^{-2} foliage dry weight/canopy area (s.d. 36.77)
Acacia nubica: n = 10 trees.
40.72 g m^{-2} foliage dry weight/canopy area (s.d. 19.37)
Cordia sinensis, another important species has a leaf production of 133.54 g m^{-2} (n = 4, s.d. = 50.74).

Other important species give more variable leaf weight : crown area ratios, but samples of 10 of each species have given useable relationships for

obtaining production values:

Salvadora persica: 173.0 g m^{-2} (s.d. 109.2)
Maerua spp.: 108.9 g m^{-2} (s.d. 94.2)
Cadaba farinosa: 117.2 g m^{-2} (s.d. 93.7)

With the completion of the destructive sampling programme in 1984, a further six species can be included in the calculations of woodland foliage production. The values for foliage biomass, combined with the data obtained from the transect sampling of woodlands to give woodland species and canopy structure, provide values for foliage biomass per hectare for each woodland type. In the case of the deciduous tree species, it has been assumed that two leaf flushes per year (in normal years) will give annual production rates of twice the standing crop biomass. In the case of the evergreen species, leaf collection under the tree canopies indicates that the standing crop during the rains represents the annual production. *Acacia tortilis* appears to have an annual production of about 1.5 times the standing crop of foliage, judging from the results of leaf litter collection. Foliage standing crop biomass and production values for each woodland sub-type are given in Table 50.

h. Woodland and shrubland canopy structure

The relative areas covered by the canopies of the trees, the shrubs, the dwarf shrubs and the herb layer and the area of bare ground have been measured for each range sub-type, using data obtained in the ground transects.

In a small number of woodland communities, these canopy structures have been checked by using a dot-grid transparency on large-scale aerial photographs. Two examples are given below of woodland canopy structures measured by both methods.

1. Riverine *Acacia* woodland at Balesa Kulal

Trees (crown diameter greater than 4 m):	6%
Trees (crown diameter less than 4 m):	8%
Dwarf shrubs:	10%
Tall grass (greater than 0.5 m high):	31%
Short perennial grass (less than 0.5 m):	26%
Annual grass:	5%
Bare sand:	14%
	100%

2. Hedad *Acacia reficiens* shrubland, Balesa Kulal

Site A

Trees:	14.5%
Dwarf shrubs:	24.5%
Annual grass and bare ground:	61.0%
	100.0%

Site B

Trees:	13.75%
Dwarf shrubs:	19.25%
Annual grass and bare ground:	67.00%
	100.00%

Note. Over large areas of the *Acacia* shrublands, with dwarf-shrub and/or grass under-storey, the normal tree canopy percentage area is 11 - 14%. Taking the values for foliage biomass for *Acacia reficiens* and *Acacia mellifera*, this canopy percentage gives a tree foliage biomass density of 60 - 73 kg^{-1} dry weight. As an indication of the relative biomass densities of the different canopy layers in *Acacia* shrubland, the following values for an area of the western Hedad are given:

Table 58. Biomass densities of canopy layers in *Acacia* shrubland

			kg per ha
Tree	(a)	wood:	5,700
	(b)	foliage:	73
Dwarf shrubs	(a)	wood:	58
	(b)	foliage:	20
Grass:			370
Total dry weight:			6,221
Total wood:			5,758
Total foliage:			463

i. The results of large-scale aerial photography

Low-level aerial photography has been used for a variety of purposes, mainly

to provide checks against ecological values measured on the ground. Vertical photography at a scale of 1:500 has been used for the following purposes:

- to assess range canopy structure;
- to measure the crown dimensions and growth of individual trees;
- to estimate tree and dwarf-shrub densities.

Dwarf shrubs can be counted on the photographs and their biomass and density estimated using repeated positioning of a small square frame representing 100 m^2 on the ground. In the Balesa Kulal area and across the Hedad shrublands, as well as in the sand-dune areas bordering the Chalbi desert, stands of the very common dwarf shrub *Indigofera spinosa* occur at a density of 12,000 ha^{-1} ($\pm$ 2,000), a canopy cover of 33%, a wood dry weight biomass density of c. 575 kg ha^{-1} and an annual leaf production of c. 205 kg ha^{-1}.

j. The results of woodland observations on systematic survey flights

Vegetation photography carried out on a recent systematic survey flight has been analysed to provide estimates of tree and shrub densities in each of the 10 x 10 map grid squares in the management area in order to check the biomass and production measurements obtained from ground transect observations and to check the identification of woodland and rangeland types on the range condition map. The relative greenness of the woodland and shrubland vegetation and the estimated canopy cover percentage are recorded for each half square as a part of the data base for the systematic livestock survey flights in order to relate livestock numbers and distribution to environmental conditions and seasonal changes.

k. Livestock stocking trials

A large quantity of data have been obtained during the livestock offtake and impact trials carried out at the Balesa experimental fenced plots in the riverine woodland and shrubland between 1981 and 1983. The trials are continuing with the intention of assessing critically the long-term effects of heavy stocking rates in this important range type. Some useful preliminary conclusions can be drawn from the outcome of the trials to date.

Camels have been herded at simulated stocking rates equivalent to 14 TLU $km^{-2}y^{-1}$ in a riverine woodland community with an average dry matter forage production of 800 - 1,000 kg $ha^{-1}y^{-1}$. During recent trials, which were intended to last for 21 days in the wet season and the same period in the dry season, with the aim of simulating a high stocking rate of 18 TLU $km^{-2}y^{-1}$, the camels consumed tree, shrub and dwarf-shrub foliage (and a small quantity of grass) amounting to 800 kg $ha^{-1}y^{-1}$ dry weight, thus taking virtually the whole of the annual production. However, they achieved this offtake after a total of 28 days (21 in the wet season and 7 in the dry season) and the final stocking rate when the animals were taken out of the plot was 14 TLU $km^{-2}y^{-1}$. This deliberate overstocking, in which the annual forage production was completely consumed, has provided a strong indication that, if the accepted level of offtake for the proper use of the range is 50 per cent of the available production, the correct carrying capacity for the riverine vegetation in the last two years of approximately average rainfall, was about half (or less) of the actual stocking rate, i.e. 7 TLU $km^{-2}y^{-1}$(c. 6 camels $km^{-2}y^{-1}$). This agrees with the predicted carrying capacity for the riverine woodland vegetation in this rainfall zone (allowing for the effect of the ground water) and also with the estimated carrying capacity derived from the measured biomass and production levels.

In the same trials, sheep and goats were herded together in a different paddock in the same vegetation community, also at a stocking rate of 14 TLU $km^{-2}y^{-1}$. During the second (dry season) phase of the most recent trial, lasting seven days, the animals completely removed the available forage and began to lose weight rapidly. It was deduced that the deliberate overstocking amounted to at least twice the carrying capacity. It was also observed that a high proportion of the vegetation (mainly standing dead material), probably amounting to 20 per cent of the offtake, was removed by the trampling effect rather than by actual consumption.

In the cattle paddock which was stocked at the equivalent of 9.5 TLU $km^{2}y^{-1}$, all the available cattle forage was removed, indicating that the carrying capacity for cattle in that vegetation was 4 - 5 TLU $km^{-2}y^{-1}$.

G. LIVESTOCK RESOURCES

1. Introduction

Livestock, through the direct impact of their grazing and trampling and indirect effects such as the construction of their night enclosures, are the most important component in the pastoral ecosystems of northern Kenya. They are the main source of food, principally milk and meat, for the traditional nomad. Furthermore they provide useful byproducts and are valued for socio-economic reasons. Camels and donkeys are also essential for transport.

2. The Problem

The main problem with Rendille livestock is that, while theoretically they should be adequate in numbers to supply human needs, they are relatively unproductive. They suffer from diseases and high levels of mortality. For example, it is estimated that between 20 and 30% of all cattle in Marsabit District died in the drought of 1971 and again in 1981 (F.A.O., 1971; Field, 1981).

Overstocking of animals leads to localized destruction of the range resource and desert encroachment. This process appears to take place in the following manner. The human population is increasing both in total numbers (Government of Kenya, 1981) and in localized densities due to settlement or sedentarization (Dolan, 1980). Pastoralists who become sedentarized usually move some of their livestock into the settlements with them, since they often have no alternative source of subsistence. While nomadic use of desert pastures allows for rest and recovery between grazing periods, this is not possible in a settled situation and the vegetation suffers and becomes depleted. Continous grazing and trampling lead to a change in plant composition and the reduction of palatable species, which enables less palatable species to flourish. Eventually even these are reduced and the soil surface is exposed to accelerated erosion. In areas where the depth of soil is shallow, permanent changes occur which prevent the recovery of the original forage plants.

The decline in both the quantity and quality of herbage in overgrazed settled areas also places the herbivores at a nutritional disadvantage, which is apparent in a reduction of their growth rates and milk yields.

Animals under these conditions often face drought periods with inadequate body reserves and are unable to resist normal disease challenges to which they easily succumb.

The pastoralist is caught in a dilemma, since in order to provide the immediate food needs of his family he must keep more animals than would have been required had they been more productive. At this stage, rather than further exacerbate the risks to his flock, he usually minimizes the number in the settlement, leaving the majority in nomadic camps. Some pastoralists have accepted the need to diversify outside the economy. Shortages of food are then supplemented by begging from external-aid sources. If these are not forthcoming, the pastoralist may slaughter some livestock and also he may undergo a form of aestivation, minimizing all physical activity and living partly on his own body reserves.

If these strategies fail and the drought is excessively prolonged, the forage around permanent water becomes exhausted, whether there is permanent settlement or not. This may occur quite suddenly at foci over a wide area. At this point mortality of cattle can be expected, since they are the most vulnerable category of livestock, being the most dependent on water. The rapidity of the change often catches aid organizations and occasionally the pastoralists themselves unawares. In such a situation starvation is inevitable.

3. Specific Objectives of the Component Study

3.1 Livestock numbers and distribution

(i) To survey the study area to determine annual and seasonal livestock and wildlife numbers and their fluctuations.

(ii) To estimate actual stocking rates and distributions in relation to a variety of environmental parameters.

3.2 Livestock nutrition

(i) For the four main species of livestock (namely camels, cattle, sheep and goats) to determine at regular intervals the key food plants in relation to their availability in the range.

(ii) To determine the seasonal fluctuations in the forage available for livestock and its nutritional value.

3.3 Livestock production

(i) In different areas and under conditions of varying food availability to monitor milk production and growth of the four main livestock species.

(ii) To measure the quantity and where appropriate the quality of food products and to identify periods of arrested production and their causes. This information is used to identify situations where unthriftiness occurs and in the recommendation of solutions. Herd growth is also determined to predict future offtake and expected returns.

3.4 Disease as a constraint to production

(i) To monitor the effects of disease on livestock production and determine whether treatment is cost effective with respect to increased productivity.

(ii) On the basis of this to recommend appropriate veterinary measures which may be applied to each species and sex and age class of livestock.

3.5 Livestock and human interrelations

(i) To evaluate the present use to which livestock are put by their owners and to determine their effectiveness in meeting the needs of the society.

(ii) To recommend appropriate adjustments to fulfil shortages and enable the pastoralist to participate in the national economy.

3.6 Livestock offtake

To identify constraints to offtake, in particular marketing, and to recommend improvements.

3.7 Management recommendations

This information is used to develop an integrated management plan for livestock which will lead to:

(i) recovery of the range;

(ii) sustained yield of livestock food products for the Rendille people to enable them to be self-supporting in food and to participate more fully in the national economy.

4. Methods Used in This Study

4.1 Livestock numbers and distribution

The principal method used involves systematic reconnaissance flights

(S.R.F.s) over a 6% sample of the study area. The method is described in Norton-Griffiths (1975) and Field *et al.* (1981). The aircraft is used as an observatory from which livestock, wildlife and household numbers are recorded and their distributions related to a variety of environmental parameters which are monitored simultaneously.

4.2 Livestock nutrition

a. Food habits

The food habits of livestock have been studied in several range types using the proportion of time spent on a given plant species and/or plant part as an index of the proportion in the diet (Field, 1978; Schwartz, 1980). This method is adequate for (a) detecting seasonal changes in food habits, and (b) determining key food plants. It does not yield proportions in terms of dry-matter intake. The range section is currently using oesophageally fistulated animals to check the method.

b. Food intake

The consumption of food has been determined for cattle and goats, using the chromic oxide ratio method. Intake by camels was determined by weighing their total faecal output over a 24-hour period. Analyses of camel food plants enabled the calculation of the digestibility of the diet, the indigestible fraction of which was represented by the faeces. The digestible and indigestible fractions were summed to give total intake of food.

c. Food quality and the reconstruction of diets

Chemical analyses have been carried out on forage plants which comprise 80% of the diet. The analyses include dry matter, protein, energy, fibre, minerals and digestibility. The chemical compositions of diets are reconstituted from these figures.

d. Water intake

The volume of water consumed by livestock has been measured when they drink at wells.

4.3 Livestock production

Experimental animals owned by or contracted to IPAL have been monitored intensively on a monthly basis.

The following experimental animals have been studied:

Table 59. Experimental animals under observation

Species	Place	Period	Approximate Number
Camel	Kulal area	1976-present	5-25
Camel	Ngurunit-Korr	1981-present	120-135
Galla goats and Somali sheep	Kulal area	1976-present	30-210
East African goats	Ngurunit	1979-present	
East African goats and Somali sheep	Korr area	1980-present	120-320
East African Zebu Cattle	Kulal/Ngurunit and Korr area	1980-present	110-175

For comparison, indigenous livestock have also been sampled.

a. Milk production

Monitoring of milk production is carried out in the morning and evening when half of the udder is milked out and the volume measured.

With camels the time that the calf is separated from its mother is recorded. Milk production is then calculated on a 24 hour basis and estimated for the entire udder.

b. Growth

The growth of animals is monitored at regular intervals by taking live-weights. These are usually measured on the morning prior to watering of the dehydrated animal. In the case of camels and cattle, where weighing equipment is cumbersome, use is made of the relationship between live-weight and body size, in particular thoracic girth (Field, 1979).

c. Flock and herd dynamics

Details of recruitment and mortality of livestock are recorded with

information on matings and abortions to assist in the interpretation of the gross data.

4.4 Disease studies

While general management of experimental flocks and herds has followed the traditional pattern of the pastoral herds of the study area, each of the experimental flocks and herds has been divided into two parts. One has been subjected to a package of inputs, mainly veterinary drugs, while the other has acted as an untreated control. Differences in productivity between the treatment and non-treatment herds have been compared with the costs of the supplementary inputs.

The chief parameters of veterinary significance that have been monitored include:

- monthly faecal worm egg outputs, comparing untreated animals with those subjected to regular anthelmintic treatment;
- blood packed-cell volumes, and the effects on them of regular anthelmintic, acaricidal, and *ad hoc* trypanocidal treatment;
- monthly numbers and species of ticks feeding on the animals with and without weekly spraying with acaricide;
- bi-monthly levels of serum antibodies to trypanosomiasis in camels; and
- causes of clinical disease and mortality as it has occurred, and the effects of therapy on disease where appropriate.

Certain surveys have taken place from time to time, from which information has been obtained on the diseases in the pastoral livestock.

Recently some data have been acquired on the clinical conditions affecting pastoral herds through the operation of a subsidized veterinary clinical service.

4.5 Livestock and human interrelations

The main method used to investigate livestock and human interactions has been the household survey. Data have been stored on computer. In addition to questions asked, measurements are taken on site of livestock numbers, weights, milk production and occasionally blood.

4.6 Livestock offtake

The main method has again been the questionnaire survey, with emphasis on traders as well as households. One small marketing exercise on cattle was carried out.

5. Results

The following is a summary of results which are relevant to the management recommendations. They are based on thirty-one publications and reports by the IPAL livestock section (listed at the end of this report), together with other literature referred to in the text. Some experiments have recently been completed and analysis is still going on. In these cases conclusions are, for the time being, tentative.

5.1 Animal numbers, densities and distributions

a. Animal numbers

The mean numbers of animals have been calculated from the computer prints for eleven surveys of the northern Rendille area and ten surveys of the southern Rendille area, from July 1976 to August 1981 (see Tables 60 and 61).

Table 60. Estimated livestock populations in the Rendille areas.

	Rendille north (6,100 km^2)			Rendille south (5,200 km^2)		
Species	Number	Tropical Livestock Units*	Density	Number	Tropical Livestock Units*	Density
Camels	8,664	10,401	1.42	9,979	11,980	1.92
Cattle	11,060	7,300	1.81	13,492	8,906	2.59
Sheep	22,082	1,987	3.62	20,937	1,884	4.03
Goats	33,123	3,312	5.43	31,405	3,141	6.04
Donkeys	83	83	0.01	152	152	0.03
Total	66,348	23,083	12.29	75,813	26,063	14.61

* A tropical livestock unit is equivalent to a 250 kg cow.

Table 61. Combined livestock populations in the Rendille scheme (11,300 km^2)

Species	Number	Density (animals/ km^2)	Tropical Livestock Units	Animals per person	Animals per household	Units per household
Camels	18,643	1.65	22,380	1.4	11.6	13.88
Cattle	24,552	2.17	16,206	1.9	15.2	10.05
Sheep	43,019	3.81	3,872	3.3	26.7	2.40
Goats	64,528	5.71	6,453	5.0	40.0	4.00
Donkeys	235	0.02	235	0.02	0.1	0.15
Total	150,977	13.36	49,146	11.62	93.6	30.48

In the study area a weighted average is used for each species (see section 5.2.d.). The proportion of sheep to goats is 1:1.5. A population of 12,900 Rendille people is used for the calculation of the number owned per person, and a figure of eight per household* for the calculation of the livestock owned per household.

The individual survey results show that livestock densities were significantly lower ($P<0.05$) during 1976 than in subsequent years. This was due to emigration during a prolonged drought in the area. Wildlife however showed very little fluctuation. Since the area has been an open system with respect to livestock movements, the survey data do not lend themselves readily to an analysis of population trends.

Density distribution maps have been drawn (Figure 11-15). In calculating population size, only half the numbers of animals in blocks 8L, 17G, and 18G have been used.

*In this section a household consists of a man, his wife or wives and their dependants, including widowed mothers and occasionally hired herdsmen.

In all cases higher population densities of livestock are recorded from the southern than from the northern Rendille area. The maps show that with the exception of Mt. Kulal the western portion of both areas is lightly populated when compared with the east. Lack of water is sometimes cited as the principle reason for this patchy distribution, but this is unlikely, since Lake Turkana is within reach of camels and the springs on the east side of Mt. Kulal may be used by other livestock. Furthermore, about half of the surveys were made during the rains when surface water and green forage was abundantly available.

A major factor affecting the distribution of the livestock in this area is insecurity. Raids by Turkana bandits (*ngorokos*) from the southwest and Gabra from the north-west and north render the northern and western parts of the range unattractive. By contrast, in the south and east the Rendille are allied by tradition and intermarriage to the Samburu and form an intermediate group called the Ariaal or Masagera (Spencer, 1973). They also have affinities with the Somalis to the east and, notwithstanding the occasional raid by *shifta*, they feel relatively secure in this area.

The distribution pattern has important management implications.

b. Animal densities

(i) Camels

The mean densities of camels in the two areas differs by 35%, the higher densities (>20 km^{-2}) occurring in the northern range at Karole, an important desert waterhole, and Firimasion, a traditional area where the Rendille circumcision takes place. A mean density of almost 15 km^{-2} is recorded from Ngurunit, where camels concentrate to water and feed in dry seasons.

Although secure, the annual grasslands of the lower slopes of Mt. Marsabit are often avoided while the upper slopes of Mt. Kulal and Mt. Marsabit are avoided because they are too cold.

(ii) Cattle

The mean densities of cattle in the two areas differ by 4%. In addition to security, water appears to have an effect on cattle distributions, since the lower slopes of Marsabit, the central Hedad, and the Kaisut desert are all beyond the normal range of cattle from permanent water in dry seasons.

Figure 11. Mean densities of camels per km^2
(standard deviations in parentheses)

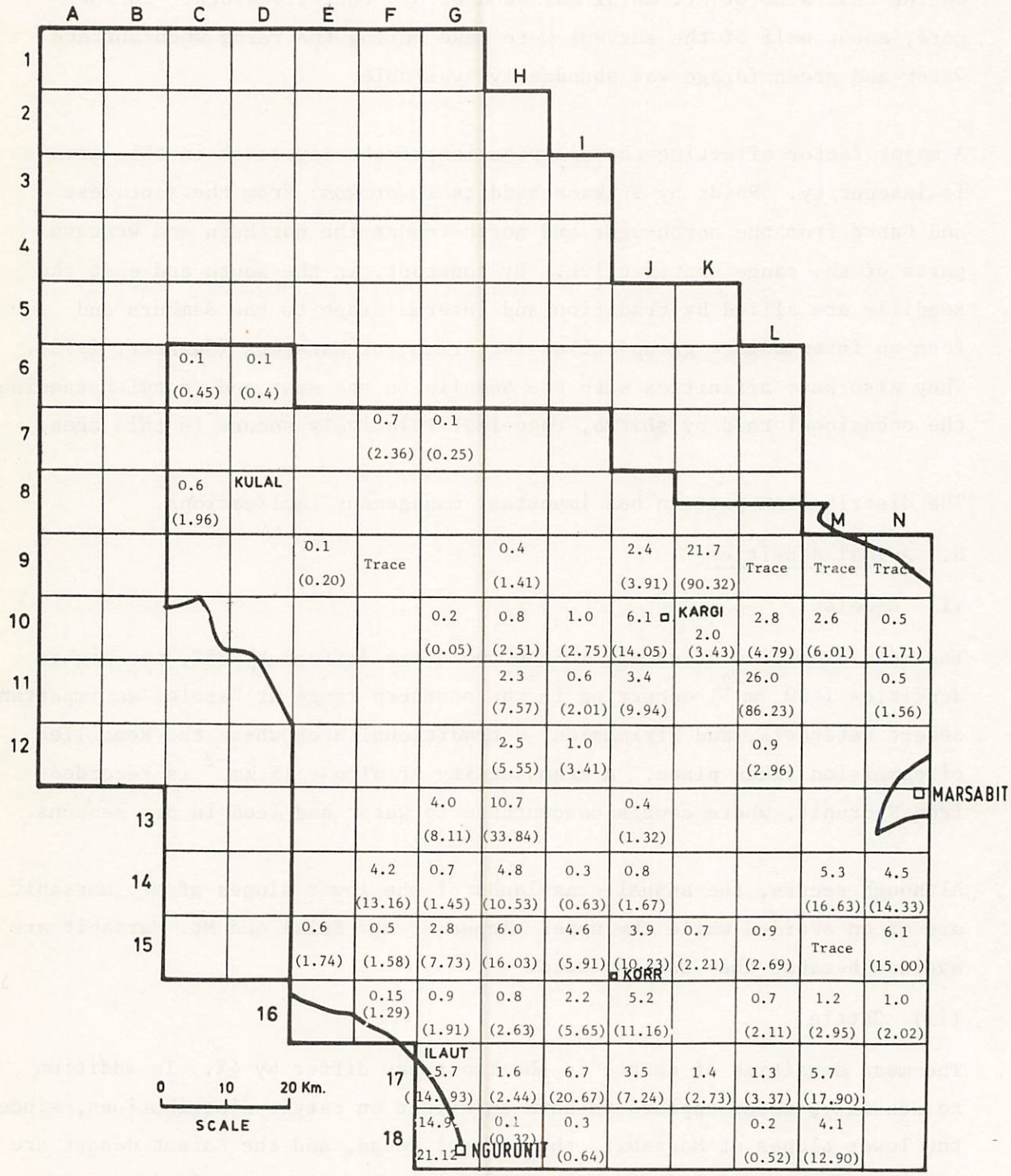
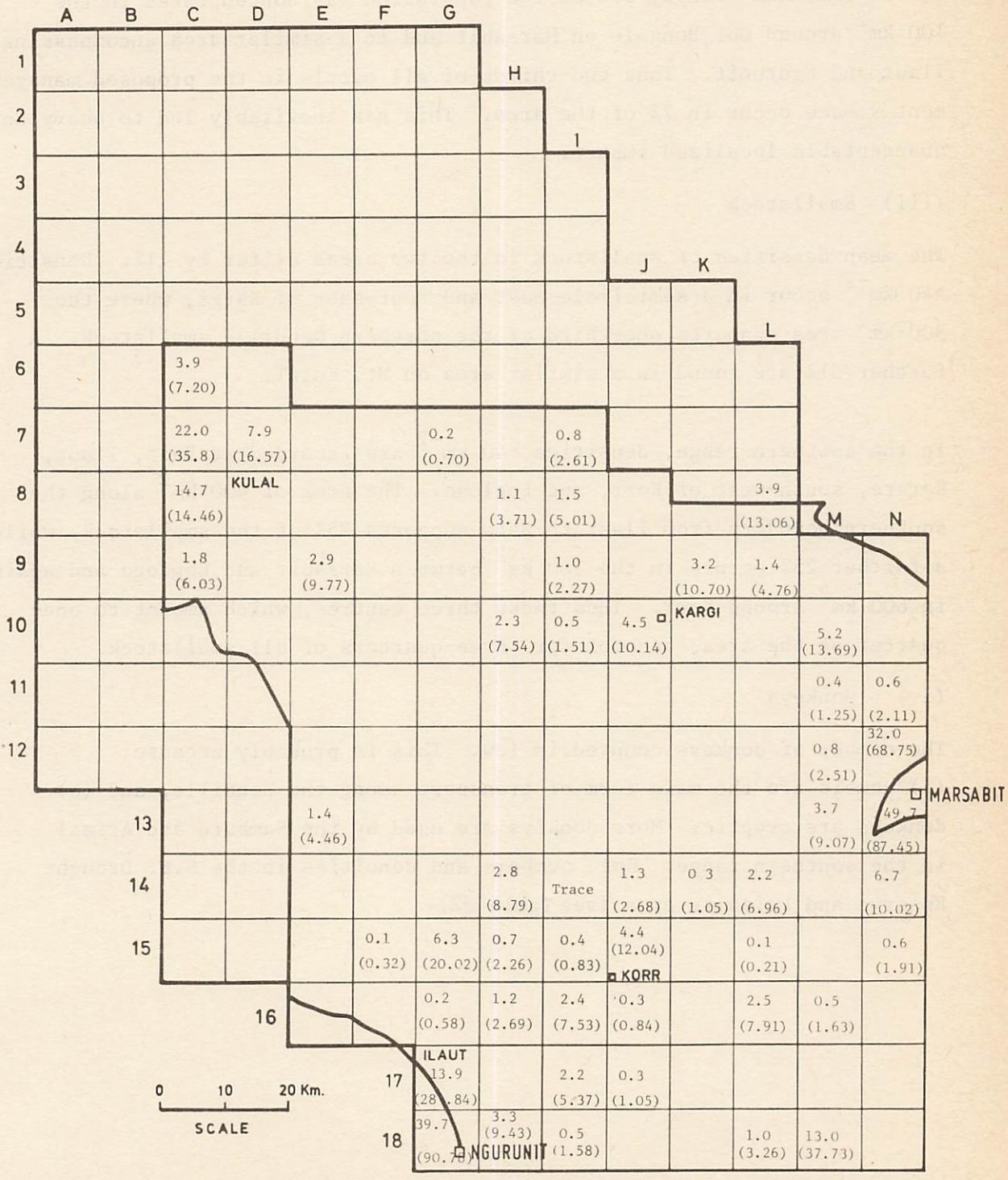


Figure 12. Mean densities of cattle per km^2
(standard deviations in parentheses)



In the northern range, 75% of all cattle occurred in the 600 km^2 of perennial grassland and evergreen and semi-deciduous woodland and bushland on Mts. Kulal and Marsabit.

In the southern range, 57% of the population was concentrated in the 100 km^2 around Gof Bongole on Marsabit and in a similar area encompassing Ilaut and Ngurunit. Thus two-thirds of all cattle in the proposed management scheme occur in 7% of the area. This has inevitably led to heavy and unacceptable localized impact.

(iii) Smallstock

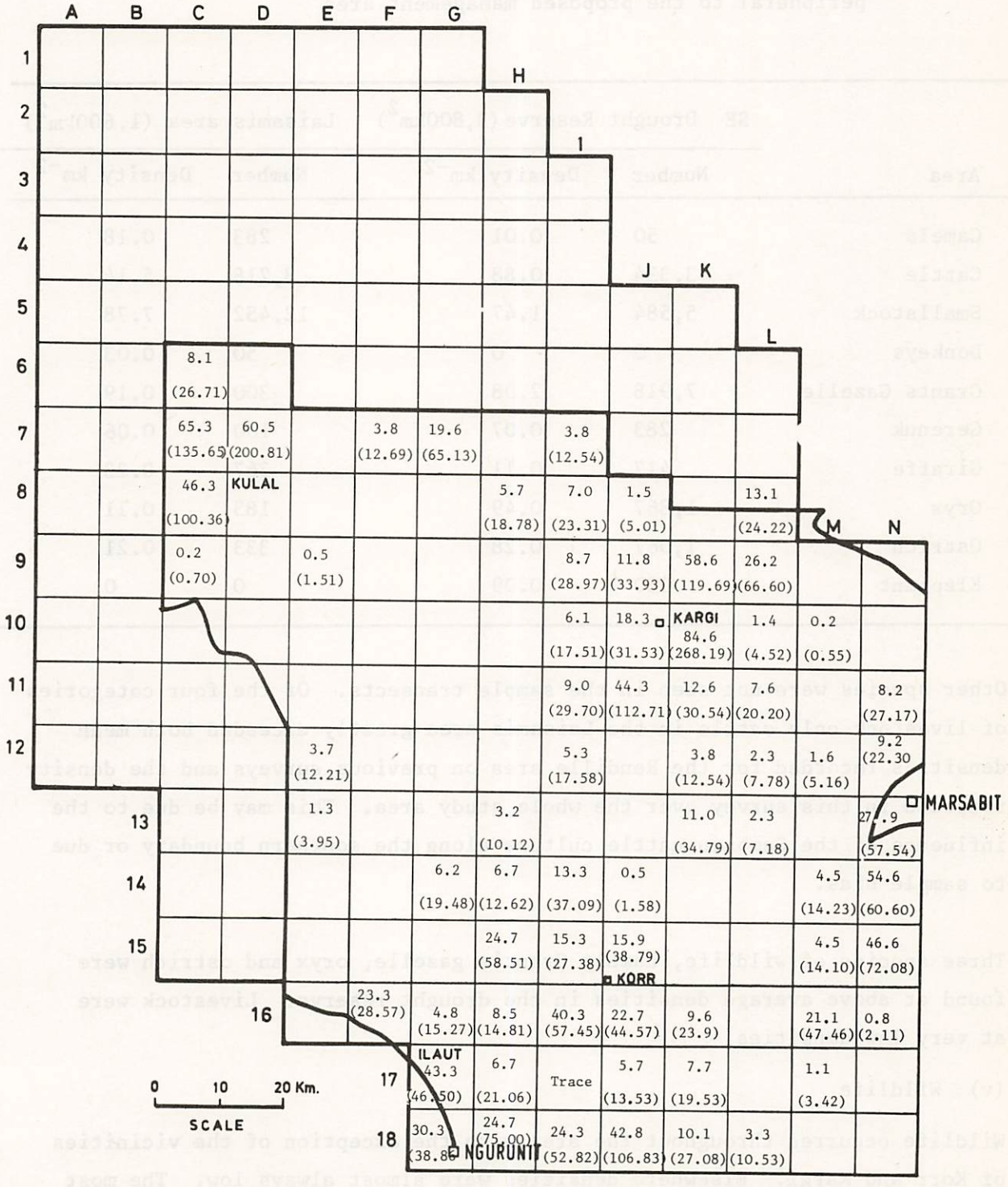
The mean densities of smallstock in the two areas differ by 11%. Densities >40 km^{-2} occur in a semicircle east and sout-east of Kargi, where the 300 km^2 area supports one-third of the northern Rendille smallstock. A further 31% are found in a similar area on Mt. Kulal.

In the southern range, densities >40 km^{-2} are recorded at Baio, Ilaut, Karare, south-west of Korr, and Loglogo. The area of 400 km^2 along the southern boundary from Ilaut to Baio supports 25% of the smallstock, while a further 25% occurs in the 300 km^2 between Marsabit and Loglogo and again in 600 km^2 around Korr. Thus these three centres, which amount to one-quarter of the area, account for three-quarters of all smallstock.

(iv) Donkeys

The number of donkeys counted is low. This is probably because: (a) camels are the main form of transport among the Rendille, and (b) donkeys are cryptic. More donkeys are used by the Samburu and Ariaal in the southern range. For numbers and densities in the S.E. Drought Reserve and Laisamis area (see Table 62).

Figure 13. Mean densities of smallstock per km^2
(standard deviations in parentheses)



One survey carried out in May 1983 has yielded preliminary estimates of population numbers and densities as follows:

Table 62. Estimates of numbers and densities of animals in two areas peripheral to the proposed management area

	SE Drought Reserve (3,800km^2)		Laisamis area (1,600km^2)	
Area	Number	Density km^{-2}	Number	Density km^{-2}
Camels	50	0.01	283	0.18
Cattle	3,334	0.88	8,218	5.14
Smallstock	5,584	1.47	12,452	7.78
Donkeys	0	0	50	0.03
Grants Gazelle	7,918	2.08	300	0.19
Gerenuk	283	0.07	100	0.06
Giraffe	417	0.11	367	0.23
Oryx	1,867	0.49	183	0.11
Ostrich	1,067	0.28	333	0.21
Elephant	350	0.09	0	0

Other species were not seen in the sample transects. Of the four categories of livestock only cattle in the Laisamis area greatly exceeded both mean densities recorded for the Rendille area on previous surveys and the density recorded in this survey over the whole study area. This may be due to the influence of the Samburu cattle culture along the southern boundary or due to sample bias.

Three species of wildlife, namely Grant's gazelle, oryx and ostrich were found at above average densities in the drought reserve. Livestock were at very low densities.

(v) Wildlife

Wildlife occurred throughout the area with the exception of the vicinities of Korr and Kargi. Elsewhere densities were almost always low. The most popular areas were the desert spring of Korole and surrounding regions, the lower Balesa, the drainage at the foot of the Marsabit lava, the Milgis drainage and from Ilaut to west of Kargi.

Figure 14. Mean wildlife densities in TLU per km^2
(standard deviation in parentheses)

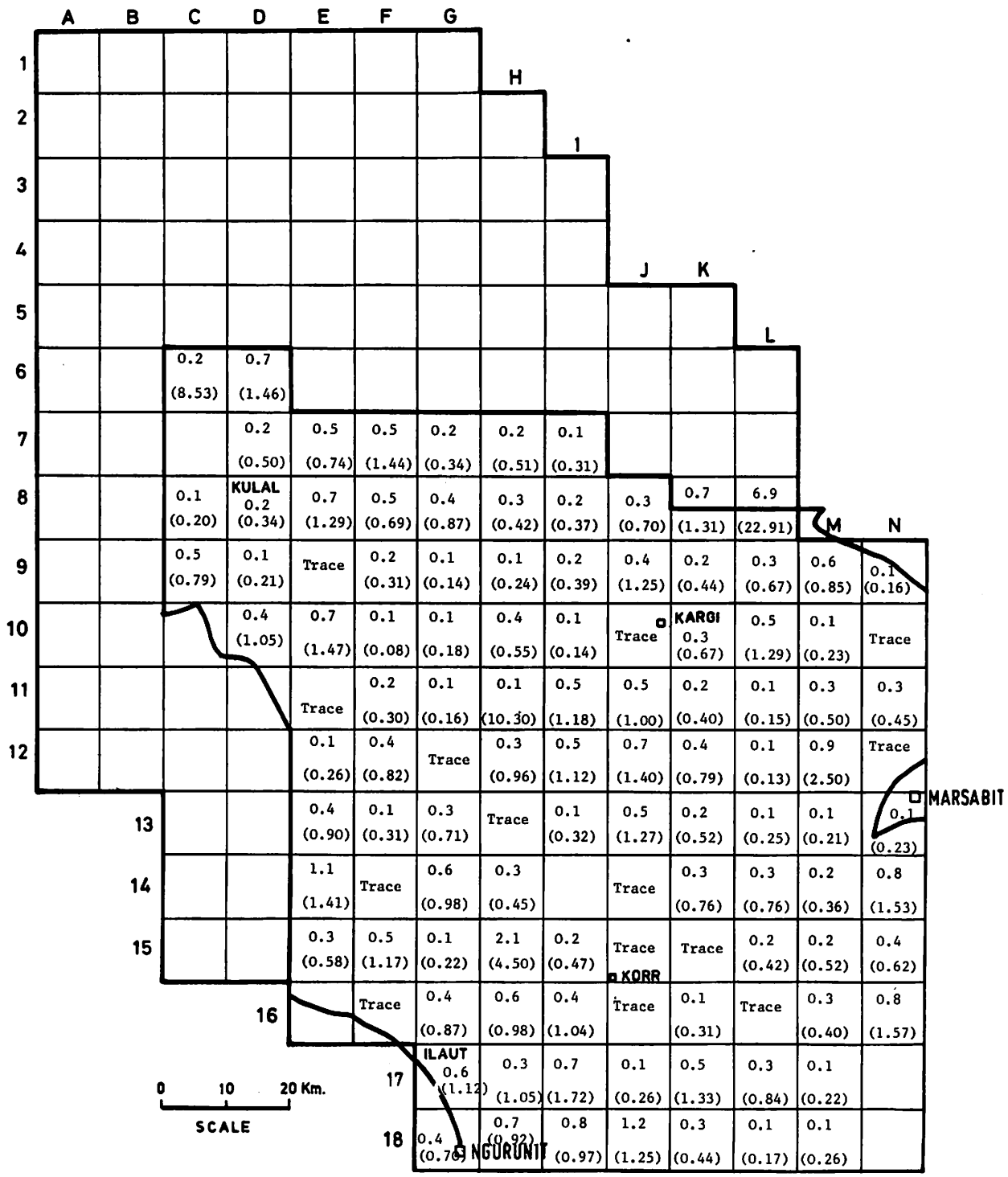
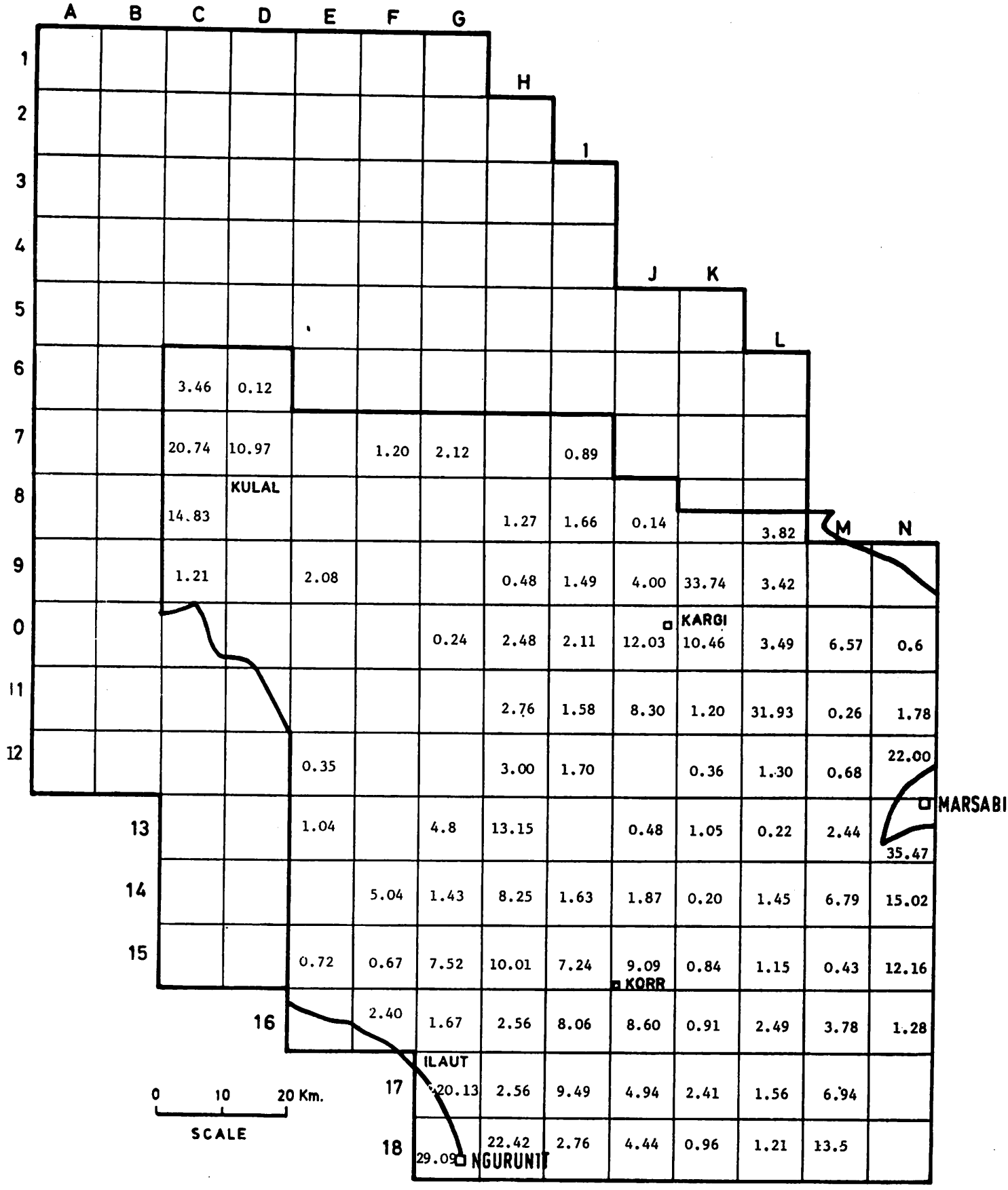
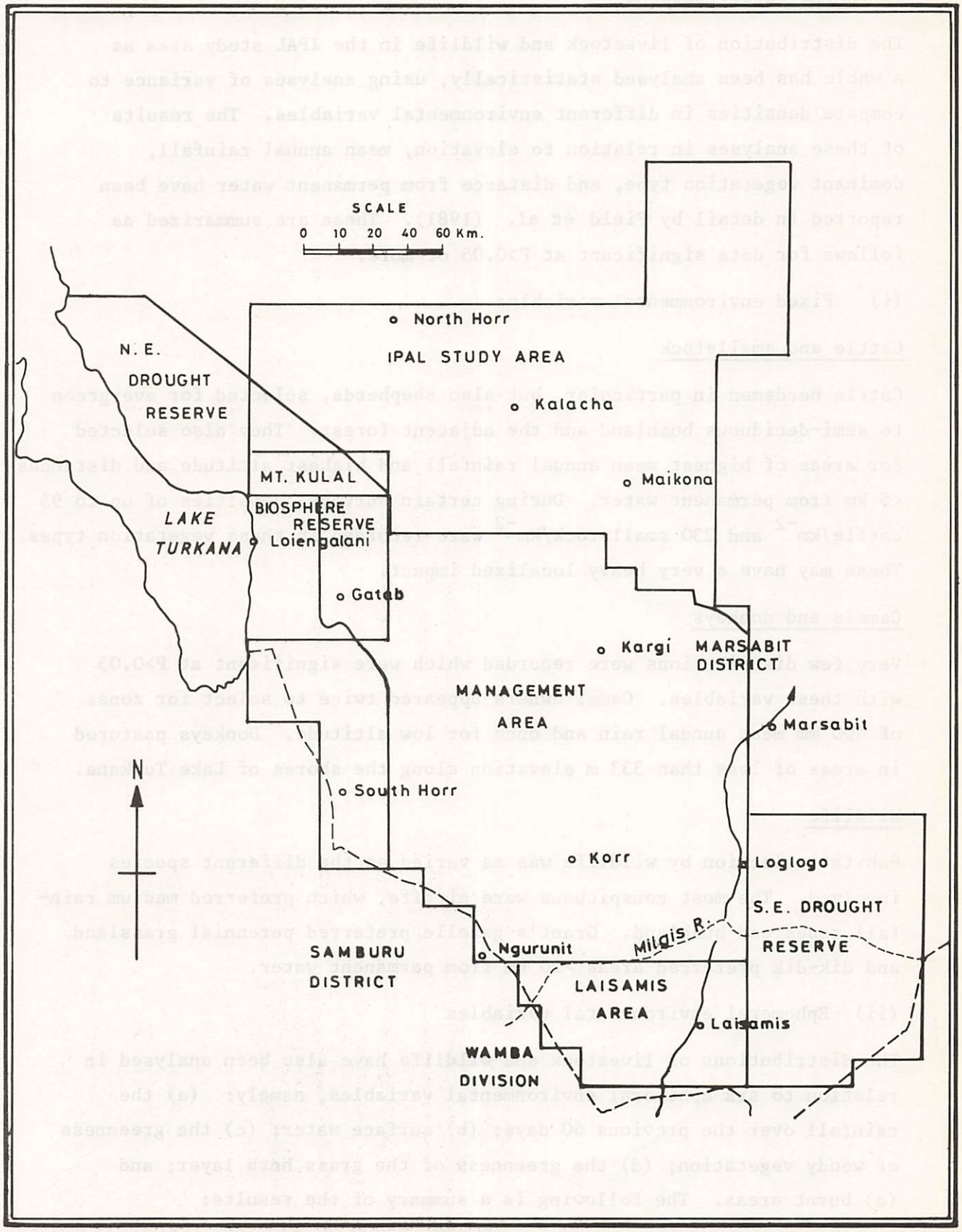


Figure 15. Mean livestock densities in TLU per km^2



Map 16. IPAL study area showing locality of the drought reserves



d. Animal distributions

The distribution of livestock and wildlife in the IPAL study area as a whole has been analysed statistically, using analyses of variance to compare densities in different environmental variables. The results of these analyses in relation to elevation, mean annual rainfall, dominant vegetation type, and distance from permanent water have been reported in detail by Field *et al.* (1981). These are summarized as follows for data significant at P>0.05 or more.

(i) Fixed environmental variables

Cattle and smallstock

Cattle herdsmen in particular, but also shepherds, selected for evergreen to semi-deciduous bushland and the adjacent forest. They also selected for areas of highest mean annual rainfall and highest altitude and distances <5 km from permanent water. During certain surveys, densities of up to 95 cattle/km^{-2} and 230 smallstock/km^{-2} were recorded in these vegetation types. These may have a very heavy localized impact.

Camels and donkeys

Very few distributions were recorded which were significant at P>0.05 with these variables. Camel owners appeared twice to select for zones of 400 mm mean annual rain and once for low altitude. Donkeys pastured in areas of less than 333 m elevation along the shores of Lake Turkana.

Wildlife

Habitat selection by wildlife was as varied as the different species involved. The most conspicuous were giraffe, which preferred medium rainfall zones and bushland. Grant's gazelle preferred perennial grassland and dik-dik preferred areas >20 km from permanent water.

(ii) Ephemeral environmental variables

The distributions of livestock and wildlife have also been analysed in relation to six ephemeral environmental variables, namely: (a) the rainfall over the previous 60 days; (b) surface water; (c) the greenness of woody vegetation; (d) the greenness of the grass herb layer; and (e) burnt areas. The following is a summary of the results:

Cattle and smallstock

On 20% of the surveys both cattle herdsmen and shepherds selected for areas

of higher recent rainfall. On 40% of the occasions they selected for areas of significant to extensive green woody vegetation. This also held among shepherds for green riverine vegetation, but selection by cattle herdsmen for this type was significant in only 20% of the surveys. Green grass was selected on one survey.

Camels

Areas of highest recent rain were selected only once by camel herdsmen, but moderate to extensive green woody vegetation was selected on two surveys. Areas without green grass were selected once.

Wildlife

Wildlife appeared to select for intermediate zones with respect to recent rainfall, with the exception of ostrich.

Significant ($P>0.05$) results are summarized as follows:

Giraffe in 40% of surveys selected for >10 mm and <400 mm rain
Zebra in 30% of surveys selected for >TRACE and <100 mm rain
Oryx in 20% of surveys selected for >20 mm and <200 mm rain
Gerenuk in 20% of surveys selected for >TRACE and <100 mm rain

Moderate to extensive green riverine vegetation was selected by giraffe on 30% of surveys.

Bearing in mind the small numbers of animals involved, it is surprising that so many analyses prove to be significant among wildlife. This may be because wildlife are better able to reach and remain in preferred areas whereas livestock have to return to night pens and to regular watering at wells, which may not be preferred feeding areas. The relative independence of water shown by wildlife is further emphasized by zebra, gerenuk and dikdik which all showed preference for dry areas at certain times.

In the latest survey to be analysed statistically (August 1981) the vegetative cover has also been included. This reveals that dik-dik preferred areas of 30% woody vegetation cover (a tribute to our observers) and camels areas of 20% tree cover. Zebra and Grant's gazelle preferred areas where there was no tree cover.

5.2 Population structures

Population structures of livestock have been determined by sampling herds and flocks in different areas and assigning individuals to sex and age categories. Additional information comes from the assignment of 150 found camel skulls into age classes based on tooth wear and replacement.

a. Smallstock

Data are summarized from indigenous flocks as follows:

Table 63. Smallstock flock structures at Gatab and Ngurunit, 1976-1977, ratios (n = 8 flocks)

	Sheep : Goats	Adult females : Young	Males : Females	
			0 incisors	2-8 incisors
Gatab	1 : 2.0	Sheep 1 : 1.1	1: 1.3	1: 6.4
Ngurunit	1 : 1.5	Goats 1 : 1.0	1: 1.4	1: 3.4
		Sheep 1 : 0.6	1: 3.0	1: 23.0
		Goats 1 : 0.6	1: 0.6	1: 7.5

Table 64. Goat flock structures at Ngurunit, 1979-1980, percentages (n = 1,058 animals)

Breeding does	Breeding bucks and castrates	Immatures
44.0 ± 8.48	21.6 ± 6.88	34.4 ± 11.52

Table 65. Flock structures of smallstock at Korr and Kargi in 1981. Data are based on surveys of 113 households

	Mean number all ages	Percentage composition Immatures	2-8 years	more than 8 years
Sheep	42.5	27	39	34
Goats	43.5	27	40	33
Total per flock	86.0	Sheep to goat ratio: 1: 1.02		

Sources of information: Table 63: Field, A.C. (1978)
Table 64: Schwartz (1980)
Table 65: Mburugu (1981)

Table 66. Percentage composition of IPAL goat flock at Ngurunit under traditional management

	March 1979	March 1980	March 1982	October 1982	Mean
Breeding females	61	59	46	39	51
Breeding males	2	2	2	2	2
Mature castrates	18	16	10	12	14
Immatures	19	22	42	47	33
Number of animals	91	80	125	129	-

Table 67. Percentage composition of IPAL Korr fora smallstock under traditional management

	March 1982		October 1982	
	Sheep	Goats	Sheep	Goats
Breeding females	51	52	49	44
Breeding males	2	2	15*	3
Castrates	0	0	0	0
Immatures	47	46	36	53
Number of animals	53	61	74	72

*To be castrated.

These tables may be summarized as follows:

1. The sheep to goat ratio ranges from 1:1 in Korr and Kargi to 1:1.15 in Ngurunit and 1:2 at Gatab. It appears that on the poorest range sheep almost equal goats, while under wetter conditions (e.g. on Kulal and Ngurunit) up to twice as many goats are found as sheep.

2. There is considerable seasonal and annual fluctuation in composition.

3. Immatures range from 19-53%, depending on peaks of parturitions and mortality. (See Tables 66 and 67). In over-utilized areas the entire crop of kids and lambs may die during a drought.

4. Breeding females range from 33-61%, although a healthy flock might be expected to have at least 50% females.

5. Breeding males generally range from 2-3%.

6. Castrates comprise from 10-30% but may drop to zero during drought, when all animals may be slaughtered for food.

b. Cattle

The sources of data for cattle herd composition in the proposed management area are as follows:

Table 68. Percentage composition of three Rendille cattle herds at Kargi (Lewis, 1977).

Number of animals	Calves <1 year	Immatures			Adults		
		males	castrates	females	males	castrates	females
136	3	6	2	15	4	6	64

Table 69. Percentage composition of Samburu cattle herds at Kulal (Field, 1981).

Category		Calves of	Immatures			Adults		
Season	Area	both sex	M	C	F	M	C	F
Dry season	Gatab	4	21	13	20	5	12	25
	Arabel	0	10	20	0	5	18	47
Wet season	Gatab	0	14	13	17	10	12	34
	Arabel	8	12	11	8	11	12	38
	Mean	3	14	14	11	8	13	36

M - Males C - Castrates F - Females

Table 70. Percentage composition of the IPAL untreated cattle herd under traditional management (Field, unpublished).

Category	Calves of both sex	Immatures			Adults		
		M	C	F	M	C	F
September 1981	32	5	0	24	3	8	28
July 1982	35	6	0	14	4	3	37

M - Males C - Castrates F - Females

At Kulal the mean number per Samburu household was 32, while at Kargi and Korr among the Rendille it was 11. The proportion of adult castrates (steers), in particular at Kulal, is very high.

c. Camels

The composition of herds of camels has been recorded in the Rendille area by five different scientists over a period of eight years. Results are summarized in Table 71 as follows:

Table 71. Percentage composition of camel herds.

Year	1974	1976	1977-1979	1979	1982	
Source of data	1	2	3	4	5	Mean
Category						
Mature males	3	7	8	5	3	5.2
Castrates	15	9	12	14	10	12.0
Females	61	67	46	61	40	55.0
Immatures	10		17	11	27	
Calves	11	17	17	9	20	27.8

Source of information:
1. Sato in Schwartz (1980)
2. Fratkin in Schwartz (1980)
3. Field (unpublished)
4. Schwartz (1980)
5. Simpkin (unpublished)

Detailed information concerning the herd structure of Ariaal and Rendille camel herds, and fora herds compared with households, is available from 76 surveys completed by IPAL staff.

A camel survivorship curve has been drawn based on the eruption of molar teeth and their wear classes in found skulls. Although ageing is quite accurate up to 7 years, beyond this there is only one known age skull (22 years).

From the curve only half of the population remains at the age of approximately 13 years. Highest mortality occurs in the first two years after birth, when approximately 40% of all animals die. Subsequently, mortality is very low for the next ten years but increases thereafter, with a maximum longevity under these conditions of about 28 years. The skulls indicate that approximately 58% of all animals born will reach sexual maturity and of these the life expectancy will average about 19 years. Assuming that a female camel first breeds at five and then calves at intervals of every two years, it will have seven calves in its lifetime.

With respect to the use of camels for water-transport purposes, Schwartz (1979) has pointed out that only households with seven or more camels are able to utilize the full range, since on average one of these would be a loading camel. The overall average of 12% castrated male camels suggests a minimum herd size in this respect of 8 animals. Among the 43 households (excluding *foras*) surveyed by IPAL, only 16% failed to exceed this number and all were close to water.

Among 23 additional households surveyed at Kargi during the *soriu* ceremony, when *fora* animals were present, 80 castrated males were counted, equivalent to 3.5 per household (Field, 1979). Assuming one of these was a fat camel and one an immature undergoing training, there would still be sufficient castrate camels to carry water to enable these households to be independent of permanent settlement. Thus the problem of transport camels may not be due to the lack of suitable male animals but rather to the unwillingness of household owners to live in remote areas and/or to train and load camels.

d. Mean weights of livestock

The age specific composition of the herds or flocks of each species have been used together with data on weights at age to calculate a mean liveweight. The product of this figure and the mean daily dry matter intake (D.M.I.) of each livestock species as a percentage of liveweight is then obtained. This is used in the following table as the mean intake (in Kg. dry matter per day) of a typical animal of the species in question and is essential for the determination of forage offtake and carrying capacities.

Table 72. Liveweight and food intake of different livestock species in the IPAL study area

Species	Mean liveweight in Kg.	TLU's	% DMI per day	DMI in kg d^{-1}	DMI plus 10% for production
Camels	300.6	1.20	1.67	5.02	5.52
Cattle	164.7	0.66	3.27	5.39	5.92
Sheep	23.7	0.09	2.65	0.63	0.69
Goats	24.8	0.10	2.58	0.64	0.70

T.L.U. = Tropical Livestock Unit with Reference to a 250 kg cow.

In the above Table an additional column shows estimated DMI plus an additional 10% for growth and increased lactation. This is a necessary consideration since at present intake is often depressed by the poor quality of the available forage. Better range management might be expected to be accompanied by an increase in food intake.

These figures compare favourably with other information obtained independently in Mali in the arid zone of West Africa (Wilson, 1982).

5.3 Livestock nutrition

Data are presented on food habits, chemical composition of forage plants, and the quantity of food and water ingested. Food supplementation has also been investigated.

a. Food habits

A total of 263 sets of feeding observations have been completed at different times and it is not possible to detail all the results here. Most of the observations have been on IPAL experimental livestock at Gatab, Balesa, Olturot, Korr and Ngurunit. A summary of the information follows. Details of seasonal changes in diet are available in Field, A.C. (1978), Field C.R. (1978), Said and Schwartz (1981), Kayongo-Male and Field (1981) and Kayongo-Male (1983).

(i) Camels

The percentage composition of the diet of camels in five range units was as follows:

Table 73. Percentage composition of camel diets in terms of plant categories.

Unit	Locality/Altitude	Trees	Dwarf Shrubs	Herbs	Grass
22b *Acacia drepanolobium* with *Duosperma*. *A. mellifera, Commiphora* with *Euphorbia* and *Plectranthus*	Luai, Kulal 1,500 m	65	34	<1	<1
	Kulal south 1,000 m	14	80	6	<1
18 *A. mellifera, A. reficiens* with *Sericocomopsis*	Balesa 667 m	28	38	17	17
12 *A. tortilis* with *Duosperma* and *Indigofera*	Balesa 667 m	18	45	29	8
10 *A. reficiens* bushland	Kargi 600 m	3	52	13	33

The mean percentage composition of the diet of camels on six different types was as follows:

Table 74. Percentage camel diet composition for key food plants only.

Place	Balesa				Olturot	Kargi	Lependera	Tumalanten
Range unit	18		12		12	10	20b.	13
Year and numbers of sets of observations	1977-1980		1977-1980					
	3	2	9	6	10	3	18	1
GRASSES:								
Aristida mutabilis	15	-	-	-	-	30	2	26
Eragrostis cilianensis	-	-	-	-	-	-	-	-
Grass litter	-	-	-	-	-	-	3	15
HERBS:								
Blepharis linariifolia	-	-	10	-	-	-	-	-
Kedrostis gijef	-	-	5	-	-	-	1	-
DWARF SHRUBS:								
Barleria proxima	-	35	-	12	14	-	1	-
Cadaba farinosa/ruspoli	-	-	-	-	-	-	2	12
Duosperma eremophilum	11	-	-	-	-	-	22	-
Heliotropium albohispidum	11	-	-	-	-	-	2	-
Indigofera cliffordiana	-	-	-	-	-	-	12	-
I. spinosa	-	13	36	16	-	13	12	9
Sericocomopsis hildebrandtii	-	11	-	-	-	28	-	-
LARGE SHRUBS & TREES:								
Cordia sinensis	-	-	-	-	-	-	4	-
Maerua crassifolia	-	-	-	-	-	-	7	16
Salvadora persica	-	-	5	-	18	-	-	-
All others	63	41	44	72	68	29	32	22

Dwarf shrubs, in particular *Indigofera spinosa*, are the most favoured food of camels. Those plant species with food preferences of more than 75% were as follows:

RANGE UNIT 12: *Blepharis linariifolia, Boscia coriacea, Cordia sinensis, Indigofera spinosa, I. cliffordiana, Leptothrium senegalense, Kedrostis gijef Maerua crassifolia* and *Sericocomopsis hildebrandtii*.

RANGE UNIT 10. *Aristida mutabilis, Duosperma eremophilum, Indigofera spinosa, I. cliffordiana* and *Sericocomopsis hildebrandtii*.

Range Unit 12, in the Balesa riverine woodland, was in good condition, while Range Unit 10 was degraded. The latter accounts for the relative palatability of *Aristida* and *Duosperma*, which are not normally preferred plants.

(ii) Cattle

Under wet conditions, Lewis (1977) recorded the following % composition of cattle diet in the Hedad west of Kargi:

Perennial grasses 70% Sedges 13% Annual grasses 9% Herbs 5% Dwarf shrubs 3%.

Table 75 is a summary of 28 sets of observations made in 1981 and 1982 (Kayongo-Male and Field, 1981).

The most consistent components in the diet of cattle, bearing in mind the variable number of observation sets, are *Aristida mutabilis, Eragrostis cilianensis* and grass litter. Other important grasses are *Brachiaria leersioides,* and the perennials *Sporobolus fimbriatus* and *Themeda triandra* in highland areas. An unidentified grass was important in Range Unit 13.

Grass litter consists mostly of fallen hay from annual grasses, which is of reasonable quality although soil contamination may accelerate tooth wear in the grazing cow.

(iii) Sheep

Feeding observations have only been made on sheep in the Olturot-Balesa region of the management areas and at Gatab on Mt. Kulal. Results are as in Table 76.

Table 75. Percentage composition of the Key plants in cattle diets.

Place	Olturot	Ngurunit	Lependera	Tumalanten	Halisurwa	Dhur	Ballah	Kulal
Range Unit	12	20b	20b	13	13	13	24	22b
Number of sets of observations	3	3	6	6	2	2	2	4
Plant species								
ANNUAL GRASSES:								
Aristida adscensionis	-	-	-	-	-	-	12	-
Aristida mutabilis	20	1	24	14	-	62	16	-
Brachiaria leersioides	1	2	13	6	-	-	-	-
Digitaria sp.	-	8	6	8	-	-	-	-
Eragrostis cilianensis	16	12	-	12	-	-	-	-
Dactyloctenium sp.	12	-	-	-	-	2	-	-
Setaria verticillata	-	-	-	5	-	-	-	-
Tetrapogon tenellus	4	7	-	-	-	-	-	-
PERENNIAL GRASSES								
Bothriochloa insculpta	-	-	-	-	-	-	-	4
Chrysopogon plumulosus	-	-	-	-	-	-	-	9
Hyparrhenia sp.	-	-	-	-	-	-	-	4
Sporobolus fimbriatus	3	-	-	-	6	-	-	21
Themeda triandra	-	-	-	-	-	-	-	18
Grass litter	-	36	39	41	12	-	58	-
HERBS								
Dyschoriste radicans	-	-	-	-	-	-	-	5
DWARF SHRUBS								
Duosperma eremophilum	-	-	-	-	8	-	-	-
Indigofera cliffordiana	-	-	-	-	7	-	-	-
Sericocomopsis hildebrandtii	8	-	-	-	-	-	-	-
Trees								
Acacia tortilis	-	15	-	-	-	-	-	-
Unidentified grass	-	-	-	-	42	18	-	-
All other plants	36	19	18	14	25	18	14	39

Table 76. Percentage composition of the diet of sheep.

Sets of observations	Balesa 1979 8	Olturot 1980 9
TREES AND SHRUBS		
Acacia mellifera litter	5	2
Heliotropium albohispidum	8	1
Indigofera spinosa	11	1
GRASSES		
Aristida adscensionis	4	11
A. mutabilis	17	11
Cenchrus ciliaris	8	13
Chloris virgata	1	3
Leptothrium senegalense	7	1
Microchloa/Oropetium	0	4
Sporobolus fimbriatus	2	4
Tetrapogon tenellus	1	8
HERBS		
Rhynchosia sp.	3	1
All other species	33	40

The main component of the diet of sheep was short annual grasses. Two species of dwarf shrub were important at Balesa, as were the fallen leaves of *Acacia mellifera*.

Field, A.C. (1978) recorded the percentage diet of sheep as follows:

Trees: 3%; Shrubs 7%; Dwarf shrubs 24%; Herbs 30%; Grass 37%.

(iv) Goats

Feeding observations of goats have been made at Balesa, Olturot, the Korr area and Ngurunit. Field, A.C. (1978) records the diet of goats as follows:

Trees 15%; Shrubs 15%; Dwarf shrubs 23%; Herbs 22%; Grass 25%.

A summary of plant species utilized in two of these areas is as follows:

Table 77. Percentage composition of the diet of goats

Sets of observations	Balesa 1979 8	Olturot 9
TREES AND SHRUBS		
Acacia mellifera	6	7
A. reficiens	1	4
Barleria proxima	4	2
Heliotropium albohispidum	0	4
Indigofera spinosa	16	2
Sericocomopsis hildebrandtii	5	6
HERBS		
Justicia fischeri	5	8
Rhynchosia sp.	4	0
GRASSES		
Aristida adscensionis	2	5
A. mutabilis	6	4
Cenchrus ciliaris	5	3
Leptothrium senegalense	6	2
Sporobolus fimbriatus	2	5
Tetrapogon tenellus	0	4
Tricholaena tenerrifae		
Total	68	53

Diet preference of goats and camels from "feeding seconds"

Observation technique

Using data from "feeding seconds" observation collected from April to December 1981 from goats and camels at Korr and Ngurunit an attempt is made to rank plant species in terms of preference. (see Table 78).

The "feeding seconds" technique, involved observing twelve animals, each separately for a period of ten minutes. The amount of time spent feeding on a particular plant species was recorded in seconds and the number of times an animal changed to each plant species was also recorded. The total feeding time in seconds spent by the 12 animals on each plant species was then summarized and expressed as percent of total time. Also recorded was the part of the plant consumed by the animals.

The mean percentage time spent by goats and camels on each plant species during the experimental period was calculated and used as a scale for plant preference. The species which made 80% of the diet were clipped and processed for chemical analysis and digestibility determination. The "feeding seconds" method, however, does not take into account the amount of plant species available and hence may overestimate preference of those plants which are more available.

A wider range of trees and shrubs are used by goats than sheep, while grasses form a smaller proportion of the diet than among sheep. At Ngurunit, on the basis of 19 sets of observations, Schwartz (1981) reports that *Duosperma eremophilum* forms up to 40% of the diet in dry seasons, but is not preferred in wet seasons, when *Clerodendrum glabra* and *Grewia tenax* form the bulk of the diet. At other times the flowers and pods of *Acacia tortilis* are important.

(v) Food supplementation of calves using *Acacia tortilis* pods

The high mortality of calves in the drought of 1981 and the clear preference shown by all stock for *Acacia tortilis* pods indicated that a food supplement experiment was justified.

Twenty calves were offered 0.5 kg each daily for 61 days during the dry season (January to March 1982) and their growth performance compared with twenty calves not receiving supplement. No *Acacia tortilis* pods were eaten among the available range forage, as indicated by the complete absence of seeds in the faeces of the control group of calves.

Table 78. Percentage composition of camel and goats diets

Place	NGURUNIT - KORR		KORR		NGURUNIT		DIGESTIBILITY Coefficient (in Vitro)
	Percentage Composition of Camel and Goats Diets						
Animal Species:	Camels		Goats		Goats		
Plant Species	P		P		P		
Cucumis sp.					5.8	3	
Ipomea sp.					3.3	9	49
Combretum aculeatum					2.9	9	44
Lpukenyi					4.5	4	
Lawsonia inermis					3.0	8	
Acacia tortilis leaves					2.1	13	42
Commiphora boiviniana					1.7	14	34
Commelina bengalensis					2.5	12	47
Salvadora persica			0.2	18	0.1	26	
Chloris virgata			0.3	17			44
Blepharis linariifolia			0.8	14			
Raleria prionites			0.2	18	0.8	20	34
Vernonia sp.					1.7	19	49
Psychotria kirkii					1.3	18	65
Sterculia africana					0.8	20	39
Terminalia orbicularis					0.8	20	
Abutilon					0.1	26	42
Acacia senegal					0.2	25	39
Thunbergia					0.8	20	46

P = ranking of the percentage of plant species in the diets and used as preference.

Table 78 (continued): Percentage composition of camel and goats diets

Place	NGURUNIT - KORR		KORR		NGURUNIT		DIGESTIBILITY Coefficient (in Vitro)
	Percentage Composition of Camel and Goats Diets						
Animal Species:	Camels		Goats		Goats		
Plant Species		P		P		P	
Indigofera spinosa	15.0	1	9.0	3			32
Indigofera cliffordiana	14.5	2	2.4	9			33
Duosperma eremophilum	14.5	3	6.1	5	12.6	1	44
Maerua crassifolia	9.8	4			0.3	24	46
Cordia sinensis	5.2	5	1.4	10	4.4	5	22
Cadaba farinosa	3.5	6	1.1	12			33
Premna racemosa	3.2	7			2.7	11	57
Sericocomopsis hildebrandti	2.9	8	0.4	20			40
Cordia Sinensis	2.6	9			1.4	15	
Grass litter	2.5	10	12.8	1	2.8	10	36
Balanites aegyptiaca	1.9	11					43
Heliotropium steudnerii	1.5	12					
Justicia sp.	1.2	13	0.3				
Kedrostis gijef	0.9	14			1.3	16	30
Grewia tenax	0.8	15	0.3		4.2	6	48
Aristida mutabilis			9.8	2			43
Eragrostis cilianensis			5.5	6	1.0	20	40
Brachiaria leersioides			6.7	4	0.3	24	43
Cadaba ruspolii			3.0	7			37
Aristida adscensionsis			2.7	8			
Aristida keniesis			1.0	11			
Commiphora candidula			0.8	14			51
Portulaca sp.			0.6	15			
Heliotropium albohispidum			0.8	14			
Acacia reficiens			0.6	15			37
Boswellia sp.			0.6	15			
Digitaria			0.5	16	1.3	15	46
Commiphora paolii			0.6	15	0.7	22	
Acacia mellifera			0.3	17			
Commiphora flaviflora							
Acacia tortilis flowers			0.6	15	7.3	2	27

Results in terms of mean weight gain in grams per day are as follows:

Group with supplement	Group without supplement
163.5 ± 106.4	126.2 ± 112.0

With the individual variation experienced and the small sample size, the difference between the two groups was only significant at the 80% level of confidence. A further experiment is indicated using a larger sample size and supplementing under more severe drought conditions.

c. The quality of the diet

Information on the chemical composition of the diet of forage plants involves approximately 5,000 analyses. Selected examples for key plants are presented here.

Table 79. Chemical composition of forage plants (grasses) used by cattle and sheep

The tabulation gives percentage chemical composition, except where otherwise indicated. (Upper figure = Mean; lower figure = Range)

Species	No.	Crude protein	Energy K cal gm^{-1}	Ca	P	% in vitro OMD
Aristida mutabilis	5	6.9 3.2-14.7	4.07 4.00-4.17	0.21 0.15-0.39	0.13 0.06-0.29	40.5 29.8-54.3
Brachiaria leersioides	3	6.1 3.8-10.0	4.11 4.10-4.12	0.53 0.45-0.62	0.19 0.09-0.28	47.8 37.8-53.1
Chloris virgata	3	8.2 6.7-10.8	4.04 4.00-4.13	0.29 0.24-0.38	0.20 0.15-0.24	44.9 42.3-47.7
Eragrostis cilianensis	6	6.6 4.0-11.8	4.04 3.98-4.19	0.44 0.32-0.50	0.18 0.13-0.23	44.4 27.4-56.4
Sporobolus fimbriatus	4	9.0 5.7-15.5	4.06 3.99-4.12	0.25 0.16-0.34	0.11 0.08-0.22	47.0 40.6-55.4
Tetrapogon tenellus	3	4.4 3.1-5.5	4.08 4.01-4.13	0.47 0.35-0.56	0.14 0.08-0.20	44.1 34.9-50.8
Grass litter	6	5.1 2.5-8.6	3.93 3.82-4.02	0.42 0.24-0.57	0.09 0.04-0.19	-

Ca = Calcium P = Phosphorus OMD = Organic Matter Digestibility

Data from Kayongo-Male and Field (1981); Kayongo-Male (1983).

Table 80. Chemical composition of forage plants used by camels and goats

The tabulation shows percentage chemical composition, except where otherwise indicated.
(Upper figure = mean; lower figure = range)

Species	No.	Crude protein	Energy mj/kg	Ca	P	% in vitro OMD
Acacia mellifera	6	11.2	6.2	3.06	0.07	45.4
		9.5-13.9	5.9-6.4	0.91-6.77	0.05-0.08	43.1-47.1
Barleria proxima	8	13.1	6.1	-	-	44.9
		10.6-18.4	5.2-7.0	2.42-3.15	0.09	38.2-52.3
Cordia sinensis	5	14.5	5.6	-	-	41.3
		11.3-21.1	5.2-6.6	-	-	37.4-49.2
Duosperma eremophilum	6	12.1	7.0	-	-	51.5
		9.5-14.6	6.2-7.8	-	-	45.8-57.2
Grewia tenax	4	-	-	-	-	-
		7.6-19.5	7.7-8.1	1.73-2.37	0.07	57.0-59.4
Indigofera spinosa	11	12.3	6.4	-	-	46.9
		8.7-18.3	5.3-7.9	-	-	38.4-57.9
I. cliffordiana	4	15.1	7.4	-	-	54.8
		10.3-20.0	7.1-8.0	-	-	52.4-58.7
Sericocomopsis hildebrandtii	7	9.7	6.3	2.01	0.06	45.8
		6.4-12.7	5.2-7.2	1.57-2.42	0.05-0.06	37.5-52.9
Salvadora persica	9	13.4	7.6	6.35	0.06	55.6
		11.1-17.4	7.2-8.1	4.71-9.56	0.05-0.08	52.6-58.9
Salsola dendroides	3	16.6	-	1.10	0.06	-
		13.8-18.7	-	0.77-1.27	0.05-0.06	-

Ca = Calcium; P = Phosphorus; OMD = organic matter digestibility - No data available

Comments:

1. All mean protein levels were higher in browse than in grasses. Wet season levels were up to three times higher than dry season levels.
2. The calcium content of browse was relatively high and the phosphorus content low. Grasses had Ca and P in more optimal proportions than browse.
3. The ash content of the halophytic shrubs *Salvadora persica* and *Salsola dendroides* was very high (average 25.5-27.6%). This was probably due to the accumulation of sodium chloride in the leaves.
4. The gross energy content of grasses was remarkably consistent, varying by only 10% in thirty samples. Protein rather than energy may be the major limiting factor in dry-season grass forage.

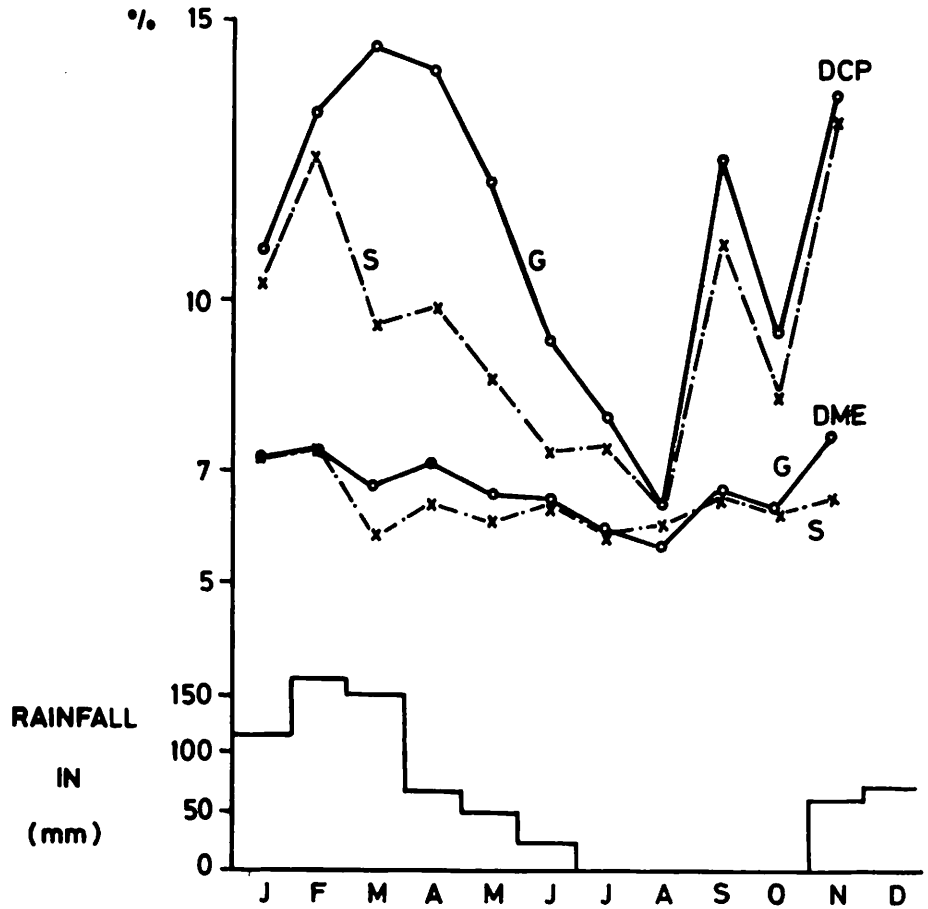


Figure 16. Seasonal variations in dietary crude protein (DCP) and metabolizable energy (DME) in sheep (S) and goats (G) Histograms show two monthly running totals of rainfall

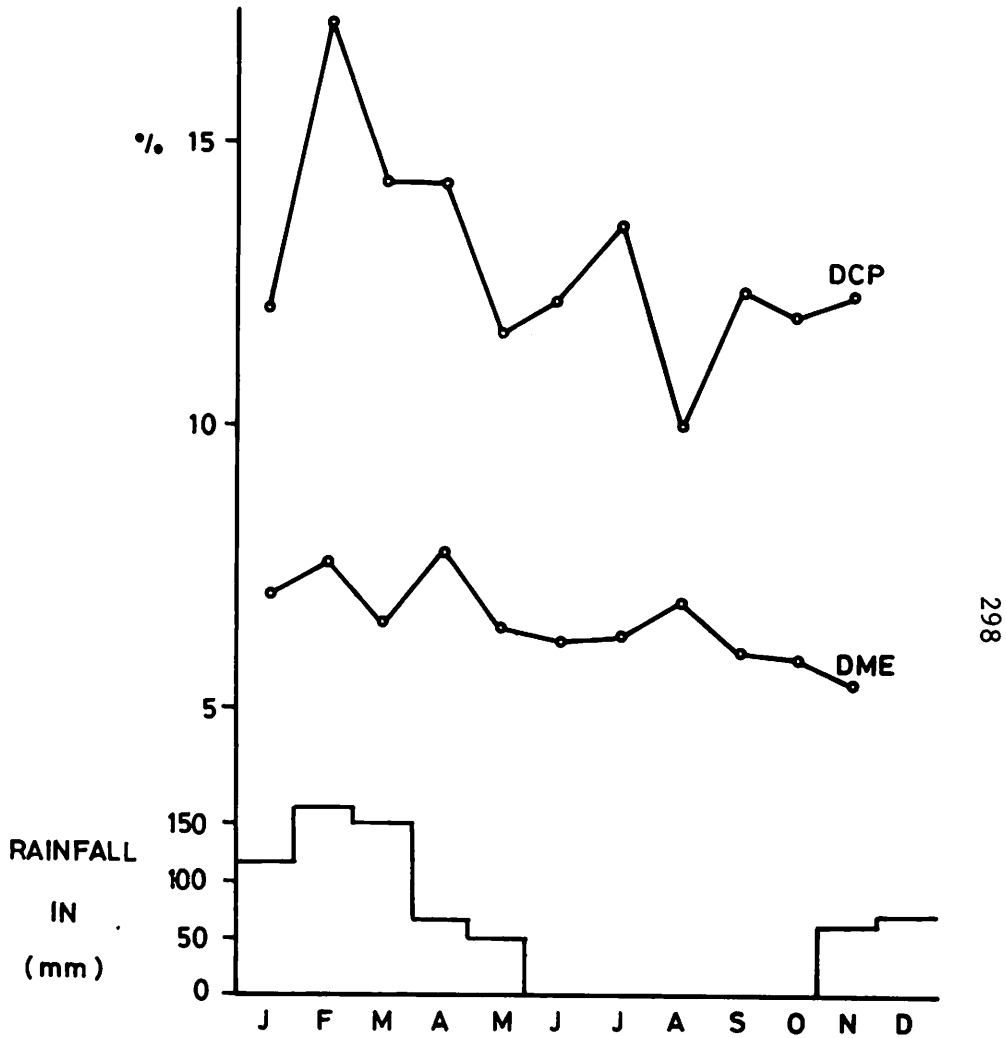


Figure 17. Seasonal variations in dietary crude protein (DCP) metabolizable energy (DME) in camels Histograms show two monthly running totals of rainfall

Figure 18. Estimated protein intake of the IPAL camel herd during 1979-1980

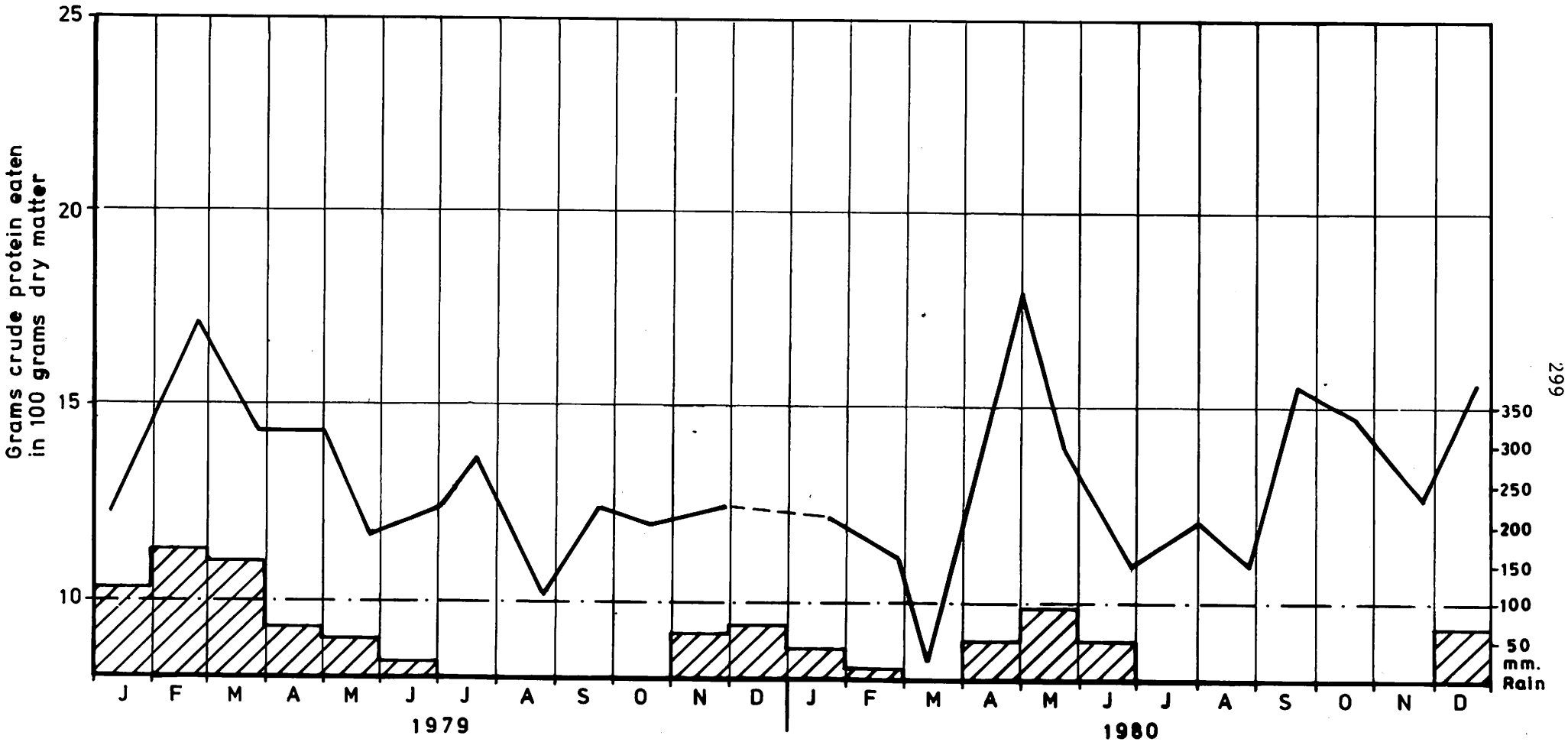


Figure 19. Estimated protein intake of the IPAL camel herd during 1981-1982

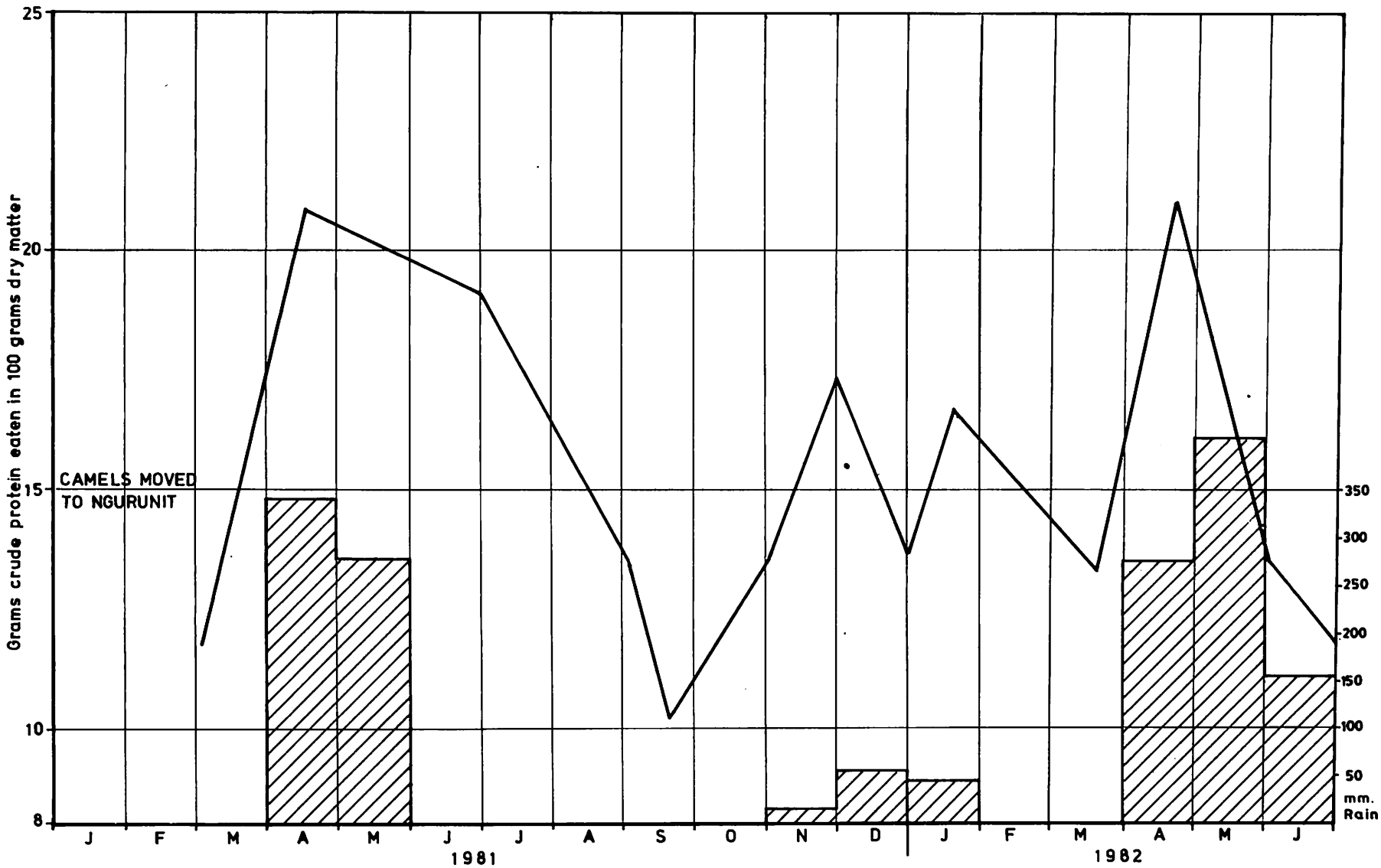
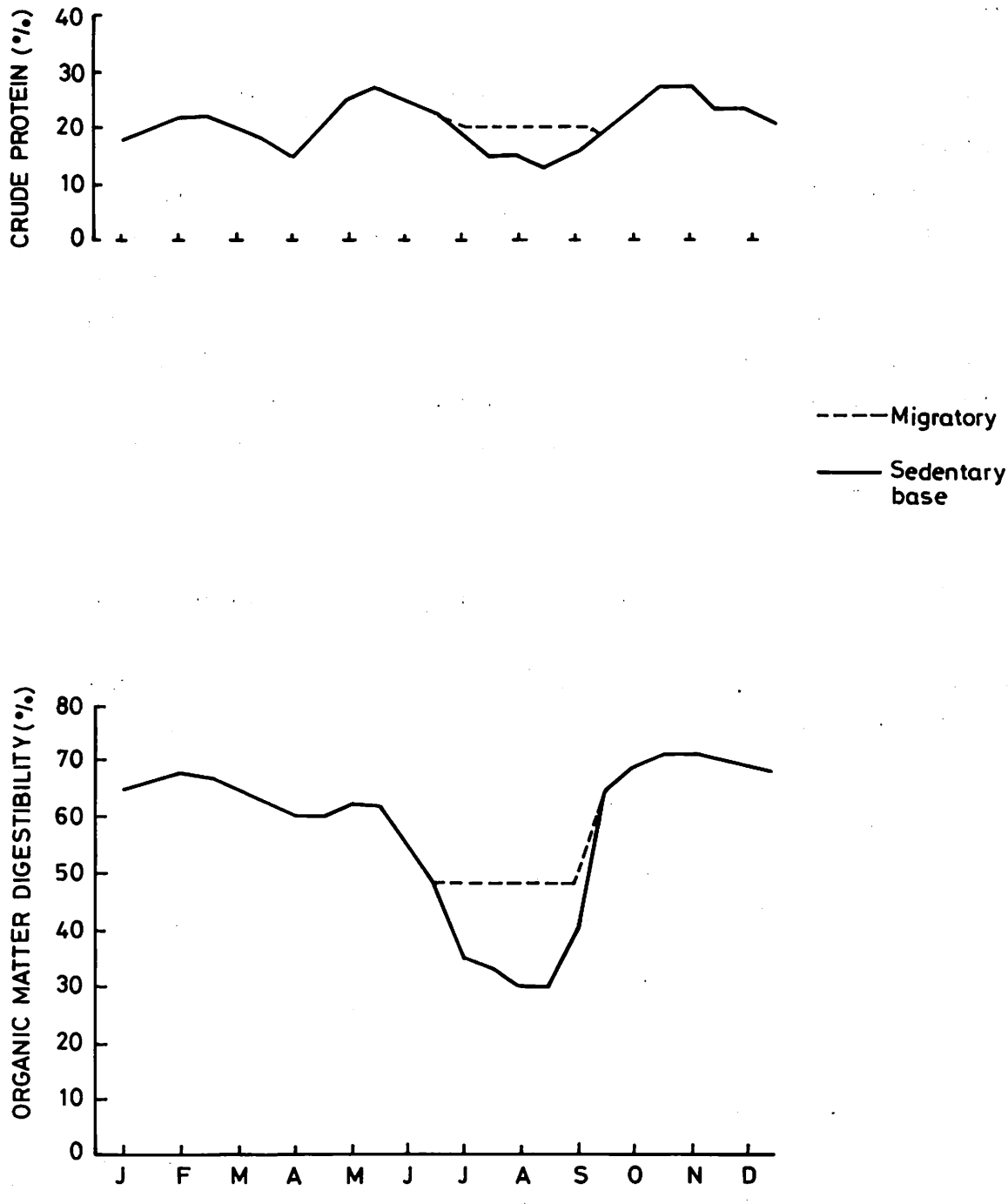


Fig. 20. Semi-monthly forage quality for three production systems (Redrawn from Smith *et al* 1982)



d. Reconstitution of diets

The composition of the diet of livestock has been reconstituted, taking into account the proportions of the key plant species ingested and their chemical constituents.

Results are illustrated graphically in Figures 12-15 as follows:

Smallstock and *camels*, (Field 1981 and unpublished).
Figure 12 shows that in a year of above-average rainfall (319 mm) the dietary crude protein intake of sheep and goats fell below the minimum acceptable level of 7% in one month of the year and only recovered as a result of the availability of *Acacia tortilis* pods. The protein intake of camels (Figures 18 & 19) remained above 10% throughout a period of three and a half years. Peaks coincided with two-monthly running totals of rainfall and were between 15 and 18% at Olturot and 18 and 21% at Ngurunit where there was a higher rainfall.

Goats, Ngurunit 1979 (Smith et al., 1981)

Figure 20 shows that crude protein in the diet also remained above 10% throughout the year in this area, where rainfall was higher than at Olturot. The advantage of the migratory over the sedentary system with respect to forage protein and organic matter digestibility is clearly seen.

Cattle at Kulal, Ngurunit and Korr 1981-1982. (Field, unpublished).

Figure 21 shows that in contrast to the other species the estimated protein intake of cattle fell below 7% on eight occasions. On one of these (March, 1981) there was a high mortality of cows and calves (20%). Clearly cows were under much greater nutritional stress than the other species.

e. Food and water intake

Tables 81, 82 and 83 give a broad indication of food and water requirements of livestock in the management areas.

Figure 21. Estimated - protein intake of the IPAL cattle herd during 1981-1982

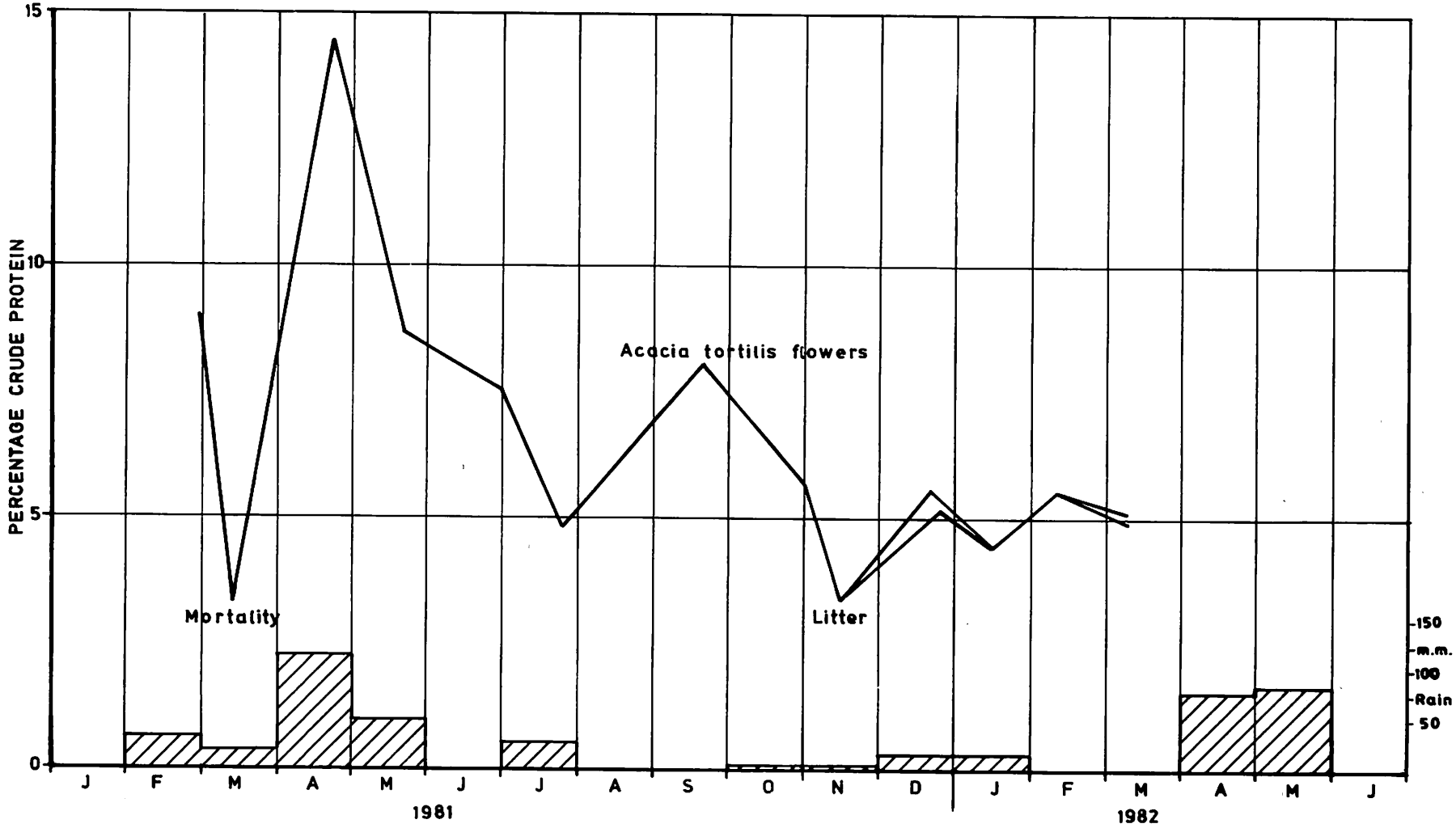


Table 81. Daily dry matter food intake expressed as a % of liveweight of cattle.

Cattle	(wet season)	Calves 3.35%	Immatures 3.45%	Adults 3.03%
	(dry season)	Calves 4.08%	Immatures 3.11%	Adults 2.60%

(Kayongo-Male and Field, 1981, and Kayongo-Male, mimeo 1983).

Table 82. Daily dry matter food intake expressed as a % of liveweight of smallstock and camels

Goats	Adults 1.75-3.4% (Field, A.C., 1978; Said and Schwartz, 1981)
Sheep	Adults 2.1-3.2% (Field, A.C., 1978)
Camels	Immatures and adults 1.33-2.18; average 1.67 (Field, C.R., 1980)

Table 83. Drinking water intake in $ml/kg^{-1}d^{-1}$ for different livestock categories.

Cattle	70.75 (dry season)(Field, C.R., unpublished)
Camels	3.37 (rains) to 25.24 (dry)(Field, C.R., 1980)
Sheep and Goats	24.69 (wet) to 76.01 (dry)(Field, A.C., unpublished)

It is expected to be able to refine these figures as more data become available.

Frequency of watering varies with availability. It occurs daily for all livestock during the rains when surface water is available from pools. It then decreases to alternate daily (average for cattle) to every third day (average for smallstock and extreme for cattle), to every fourth day (the extreme for smallstock). Camels water on average every seventh day, but may extend to every fourteen days or more in the extreme. After the cessation of rain camels are often trained to tolerate water deprivation by withholding water for up to ten weeks.

5.4 Present management and movement in the grazing area

a. Movements within the area

There are four kinds of movement in the area, as follows:

1. Daily movement from night *bomas* to grazing areas and back.
2. Movement to wells and back.
3. Seasonal movement to and from wet and dry season grazing areas, usually within the management areas. This is known as transhumance.
4. Irregular nomadic movement by mostly *fora* herds, often within the management area but sometimes well outside. For example, in 1980-81 some livestock from Laisamis travelled to Allia Bay, a distance of 290 km in a straight line and undoubtedly further by the route actually followed.

The major movements of livestock are illustrated in the Map 17. Solid lines refer to regular moves either daily or seasonally, dashed lines indicate less regular moves as the climate dictates.

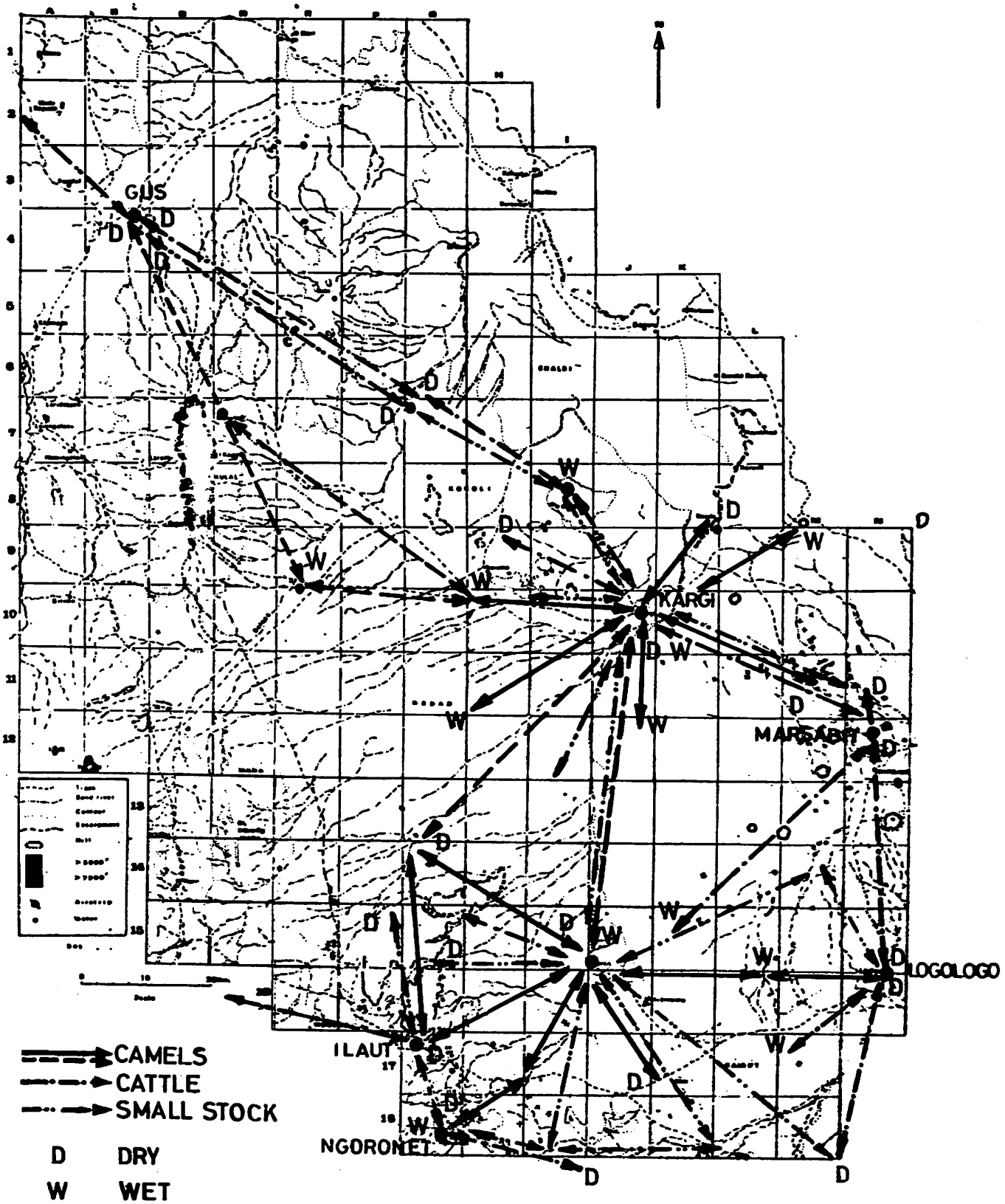
Maps of dry-season and wet-season distributions of cattle and camels are illustrated in Field (1981). This is based on 7 years of experience and is not a fixed pattern as there is considerable variability from year to year.

b. Choice of area

A number of factors dictate choice of area by the herdsman. These factors may vary in importance, depending upon whether the livestock are part of a settlement or *fora*, what category of livestock are involved, and whether conditions are wet-season or dry-season. These factors in probable order of importance are as follows:

1. Widespread wet season	Dry season
a. Security from theft and predators	a. Adequate forage
b. Absence of disease	b. Adequate water
c. Adequate forage	c. Security
d. Adequate water	d. Absence of disease
e. Adequate building materials	e. Adequate building materials
2 Settlement	Fora
a. Security	a. Adequate forage

Map 17. Major movement of livestock



b. Adequate water		b. Absence of disease
c. Adequate forage		c. Security
d. Absence of disease		d. Water
e. Adequate building materials		e. Adequate building materials

3. Camels	Cattle	Smallstock
a. Adequate forage	a. Adequate forage	a. Adequate forage
b. Absence of disease	b. Adequate water	b. Security
c. Security	c. Security	c. Adequate water
d. Water	d. Absence of disease	d. Absence of disease
e. Adequate building material	e. Adequate building material	e. Adequate building material

(Availability of labour may be a constraint to the choice of area).

During some wet seasons the occurrence of rains is very localized and green vegetation with water may only be available in certain parts of the range. This may lead to over-exploitation of growing vegetation, as all livestock concentrate on these areas. An example of this occurred between Marsabit and Firimasion in May 1982. It will be essential to monitor the use of such areas carefully to avoid permanent destruction of the range.

5.5 Livestock productivity

The earlier phase of IPAL was designed to describe the current livestock husbandry practices, in particular with regard to productivity. Subsequently, experiments were designed to determine whether (a) veterinary medicine, (b) feed supplement and (c) improved husbandry could improve yields.

a. Camel production

(i) Camel growth

Data are summarized as follows:

Table 84. Comparison of growth of indigenous animals suckling only twice a day with IPAL calves prevented from suckling only at night (Field, 1981)

(Figures in g/day)

Age	Indigenous calves		IPAL calves
	wet years	dry years	wet years
<6 months	270-310	170-206	371-638
>6<12 months	90-315	-	520-530
>12<18 months	50	-	200-230

Thus rates of growth are up to two and a half times higher when the calf is not deprived of milk.

Table 85. Comparison of growth rates of breeds (Field, Simpkin, in preparation)

(Figures in g/day)

Age	Rendille Gabra (n = 4-6)	Somali (n = 3-5)
<3 months	540	710
>3<6 months	420	400
>6<9 months	360	360
>9<12 months	300	230
>12<18 months	290	160
>18<24 months	2	100
>24<30 months	240	80
>30<36 months	0	80

Apart from the first three months, it appears that Somali camels do not grow faster than Rendille and Gabra camels.

Table 86. Comparison of camels receiving veterinary treatment with those without treatment. Growth rate in grams/day (Simpkin, unpublished). See Figure 22.

Age	n	Untreated animals	n	Treated animals
0-4 months	6	296 ± 57.2	20	376 ± 61.3
4-48 months	26	106 ± 96.0	14	149 ± 70.0

The increase in growth rate of treated calves is significant (P>0.01).

(ii) Camel milk production

Milk production by camels has been summarized by Simpkin (unpublished) as follows; see also Figure 23.

Table 87. Lactation parameters for camels under traditional and health management

	Ngurunit			Olturot
	Treated	Not treated		Treated
	with calves	with calves	without calves	with calves
Mean total yields in litres	1290	-	429	1686
Mean duration of lactation in weeks	64±9	38**	38±20	52
Mean total yield over 38 weeks	916	606	350	-
Mean daily yield for whole lactation	2.5	-	1.1	4.6
Mean daily yield over 38 weeks	3.4±1.5	2.3±1.0*	1.3	

*Significant at P>0.005 **P>0.1

Figure 22. Mean growth rate of camel calves Kg/month

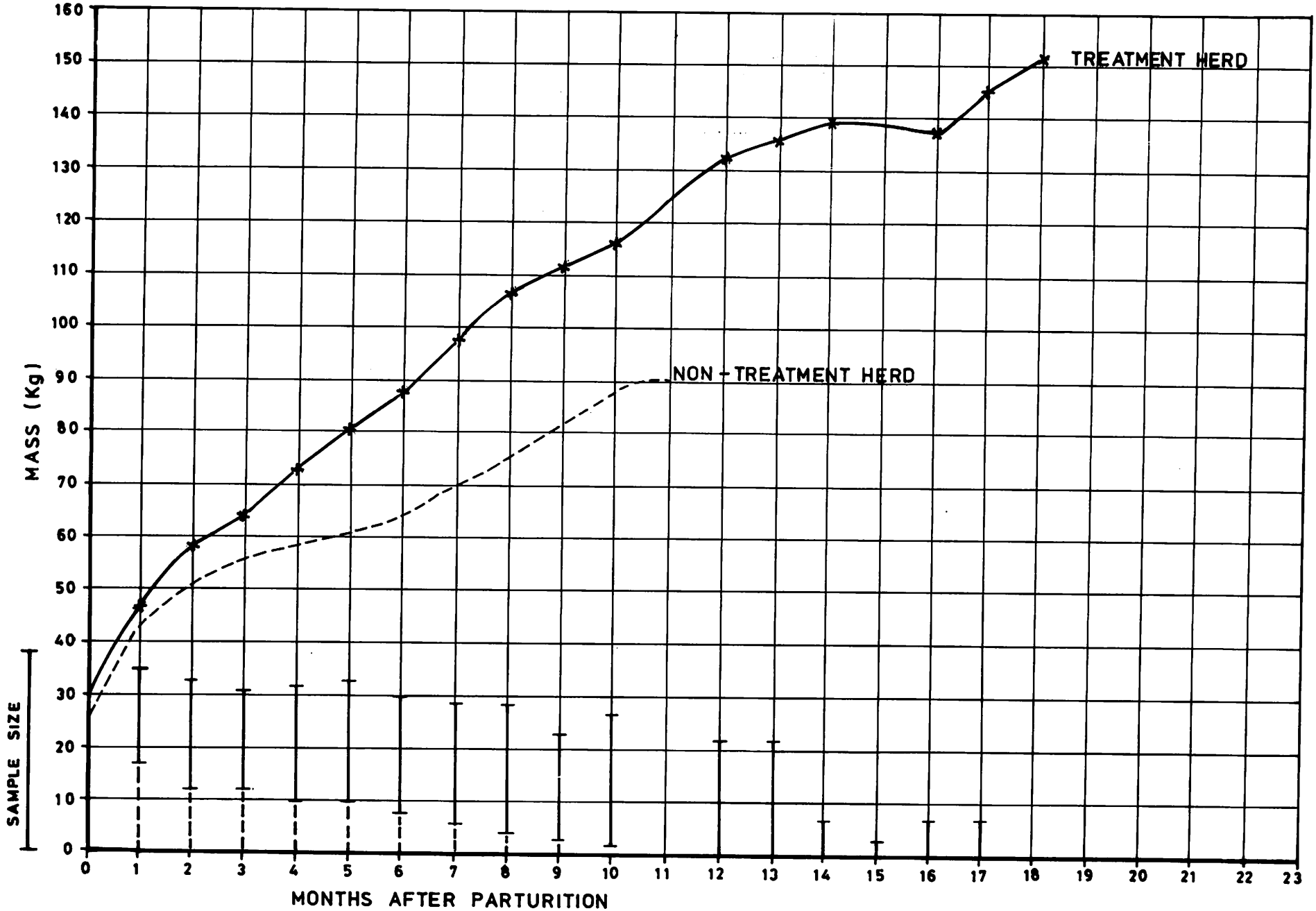
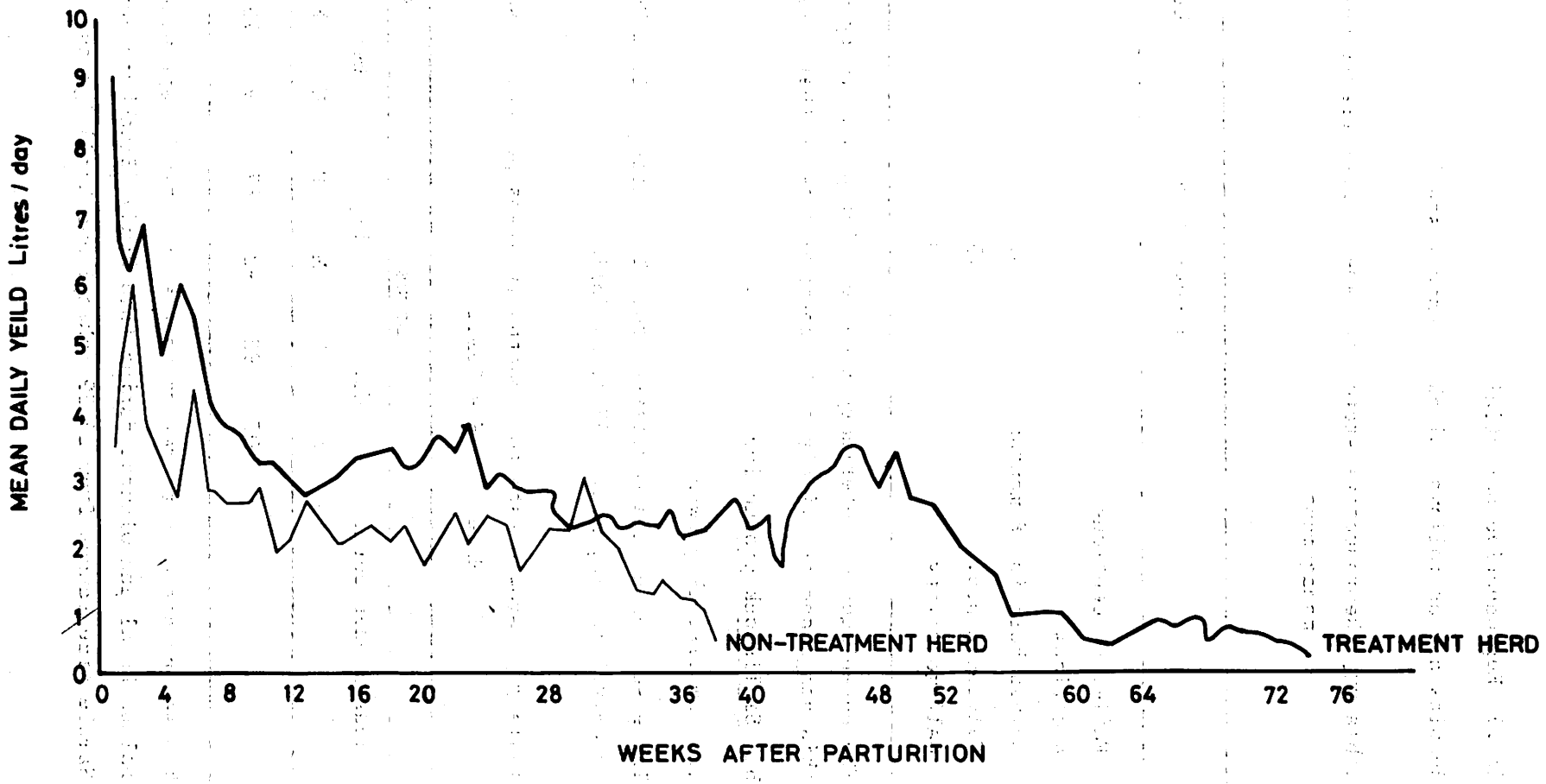


Figure 23. Mean lactation for treatment and non treatment camels with surviving calves (litres per day)



(iii) Reproductive potential

Results are as follows (Simpkin, unpublished):

Table 88. Reproductive status of camels under traditional and health management

	Treated herd	Untreated herd
Failed conceptions	2	3
Abortions	2	7
Calves born in 18 months	31	16
Calving % p.a.	45	32
Calf mortality %	10	75

The advantages of veterinary treatment for productivity are apparent at this stage and are likely to be confirmed as further data are forthcoming.

b. Smallstock production

(i) Smallstock growth

Three sets of data are referred to. The first is from Balesa Kulal from 1976-1977 (Field, A.C., 1978), as follows:

Table 89. Growth rate to 5 months in grams per day of smallstock 1976-1979
M = Male F = Female

	Lambs				Kids			
Season when born:	Wet		Dry		Wet		Dry	
	M	F	M	F	M	F	M	F
	107	92	92	87	99	75	48	44

The second set of data refers to the IPAL flock kept principally at Balesa Kulal and Olturot during this study (Blackburn and Field, in press). Sample size ranges from 24-39 (sheep) and 24-33 (goats).

Table 90. Growth rates of smallstock from birth to 10 months 1979-1980

Season when born:	Lambs		Kids	
Age	Wet	Dry	Wet	Dry
0-5 months	82	98*	66	63
5-10 months	5	39	36	40

*Over the first 5 months growth of lambs born in dry seasons was significantly ($P>0.05$) faster than those born in wet seasons. This was not the case for kids. There was no significant difference in growth of the two sexes, except occasionally in favour of male kids.

Those kids and lambs born in 1978 were significantly ($P>0.05$) heavier than in subsequent years, no doubt due to the wetter conditions. Twin kids, although lighter at birth, soon caught up.

The third set of data refers to the growth of sheep and goats at Korr and Ngurunit under traditional management and a health programme, which have been analysed using a modified von Bertalanffy growth equation. (Carles, 1983 unpublished).

At Korr the growth rates of sheep and goats under the two management systems differed significantly in all cases at the 95% level regardless of sex or whether the animals were purchased or born during the experiment. It indicates that the health programme increased the mature size of animals by about 15% overall. There also appears to be a trend under traditional management for animals to mature earlier. Once they start breeding, females in particular are likely to be permanently stunted.

Detailed analyses are also being carried out on the effects upon growth of sheep and goats at Korr during the period from birth to about 6 months of age. Effects examined involve species, sex, management, birth period and rainfall level during 4-6 months of age. Regarding the body weight at the end of the period sheep were significantly larger than goats ($P<0.05$), males were significantly larger than females ($P<0.05$) and animals born up to

two weeks after a significant rainfall were significantly ($P<0.005$) heavier at the end of the period by 21-33% when compared with animals born when there was no rain.

With respect to growth rate there were two significant effects with the growth rate of goats being about 73% of that of sheep ($P<0.005$) and with birth period where the pattern was similar to that of body weight.

These results suggest that for meat production at Korr from the individual animal, sheep may be more productive, at least up to a year of age. (Carles, 1983 unpublished).

(ii) Smallstock milk production

Data are available from three different sources and have been summarized as follows:

Table 91. Lactational parameters for Somali sheep

Locality	Balesa	Olturot	Korr	
Management	Treated	Treated	Treated	Traditional
Years	1976-1977	1978-1980	1980-1982	1980-1982
Number of completed lactations	2	14	28	15
Mean Yield in litres per lactation	59	39	16.9	17.0
Mean Length of lactation in days	133	119	114	154

Table 92. Lactational parameters for goats

Breed:	Galla Goats		Small East African Goats			
Locality	Balesa	Olturot	Korr		Ngurunit	
Management	Treated	Treated	Treated	Traditional	Treated	Traditional
Years	1976-77	1979-80	1980-82	1980-1982	1979-82	1979-1982
Number of completed lactations	7	34	14	11	32	32
Mean Yield in litres per lactation	59	51	19.0	16.9	19.4	12.4
Mean length of lactation in days	71	119	150	154	193	137

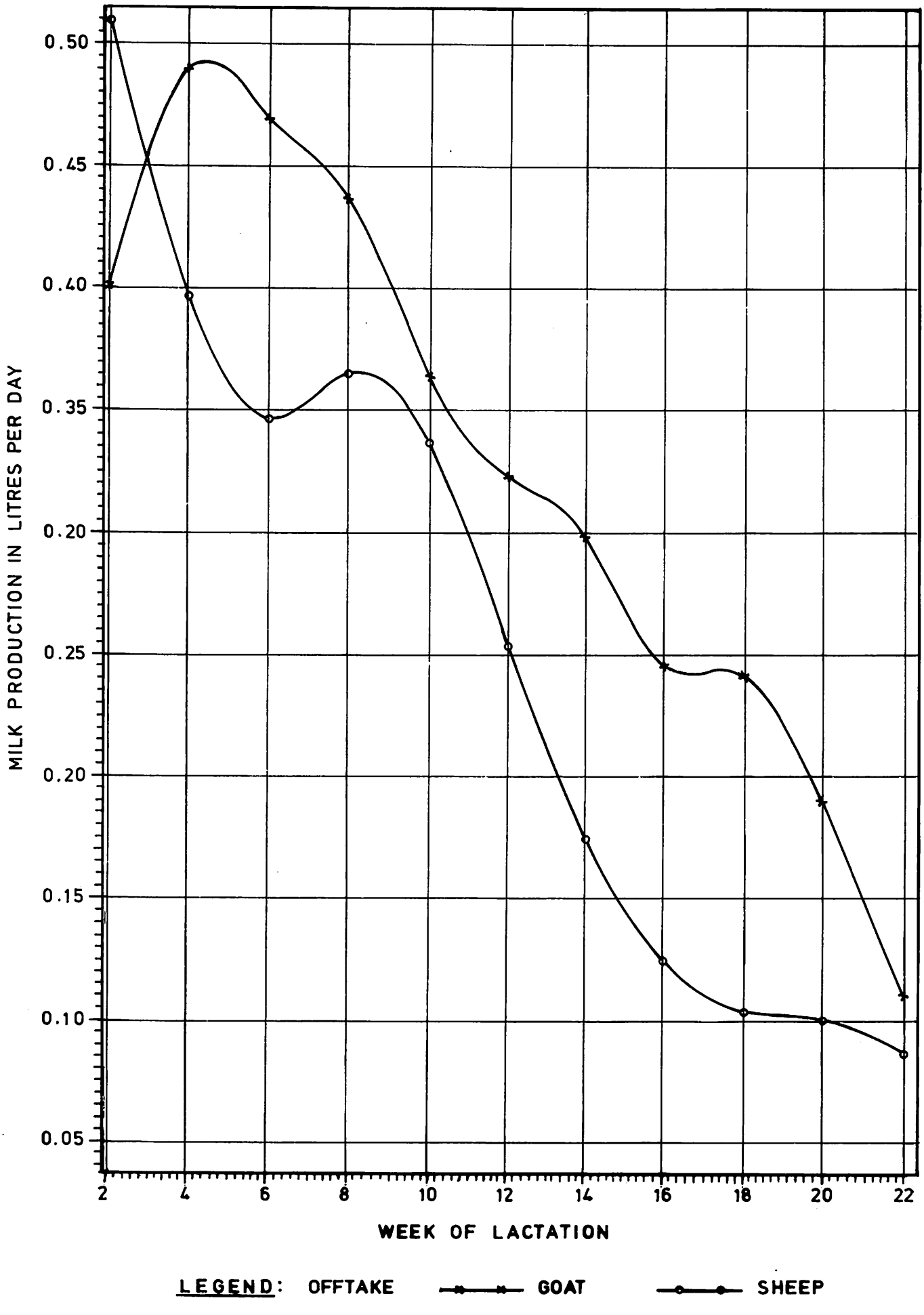
Although there are large differences according to locality the advantages of the health programme are apparent among goats at both Ngurunit and Korr.

Source of data from Balesa: Field A.C. (1978); from Olturot: Blackburn and Field (in press); from Korr and Ngurunit: Carles (1982, unpublished). The pattern of lactation of sheep and goats at Olturot is shown in Figure 24 (Blackburn & Field, in press). This demonstrates that for the most part goats yield more than sheep. It also shows the rapid decline in yield as the lactations progress. Sheep fall to 50% of their peak production by the twelfth week of lactation and goats by their eighteenth week of lactation.

(ii) Reproductive potential

The main factors contributing to reduced reproductive potential have been recorded for a traditionally managed flock of goats at Ngurunit from 1979-1980 (Schwartz and Carles, unpublished). Among them 33% of all matings failed to conceive; 26% of all conceptions were aborted and 57% of all adult females had successful parturitions. Half of all the kids born died and 27% of all adults in the flock died. The main cause of mortality in the flock was contagious caprine pleuro-pneumonia. (CCPP)

Figure 24. Lactation curves of sheep and Galla goats over 22 weeks between 1979 and 1980 in the Olturot area



Between 1980 and 1982 a traditionally managed flock increased by 56% while a flock receiving veterinary input increased by 75%. Although both of the flocks increased with the decline in CCPP the advantage of veterinary treatment is apparent.

c. Cattle production

(i) Cattle growth

Data on cattle growth are at present available only from the IPAL herd, but data from Kulal and Ngurunit household surveys will shortly be available.

Results are as follows:

Table 93. Growth rates of calves in gm d^{-1} with and without veterinary treatment. (see Figure 25).

	Born during 1981		Born during 1982	
	Treated	Untreated	Treated	Untreated
Number	6	12	15	12
Growth in gd^{-1} from birth to 8 months	120.8	127.1	219.2	230.0

Year differences are significant ($P>0.005$), since 1981 experienced drought conditions followed by extremely wet conditions. Cows calving and lactating in 1982 were in much better condition. Differences between calves receiving health treatment and untreated calves in 1982 are not significant. No significant differences were found in any of the sex and age categories of cattle receiving health treatment when compared with those under traditional management.

(ii) Milk production

Data have been collected from the contract herds and also by household survey at Kulal and Ngurunit in the management areas as follows:

Table 94. Estimated daily milk production per cow in cc in different seasons of 1981

	Dry season (Feb.)		Wet season (May)		
Gatab	Arabel	IPAL	Gatab	Arabel	IPAL
264	307	439	670	2,424	1,341

The lactation curve for 10 cows in the IPAL herd is shown in Figure 26.

Surprisingly, lactations may persist for over one year if conditions are poor and the cow fails to conceive. Peak of lactation appears to occur about six weeks after the onset of rain. Wet-season daily yield appears to be at least two to three times that of dry seasons.

The chemical composition of cows' milk has been analysed and it appears to have a fat content higher than that of camels.

5.6 Livestock disease control

a. Preamble

In the context of the major objective of management, to arrest and reverse the deterioration of the environment, a major livestock disease-control component would be counter-productive, if introduced before the distribution of livestock in the area had been reconciled with the long-term ability of the range resource to support them. Otherwise an automatic side-effect of disease control would be a tendency to enlarge the livestock population, resulting in:

- accelerated ecological degradation;
- poorer nutrition and reduced productivity of the individual animals, probably with commensurate effects on human nutrition; and
- increasing susceptibility to infections as well as nutrition-related disease.

b. Objectives

Disease control can only be justifiable in circumstances where potential

Figure 25. A comparison of calf weights with and without veterinary treatment

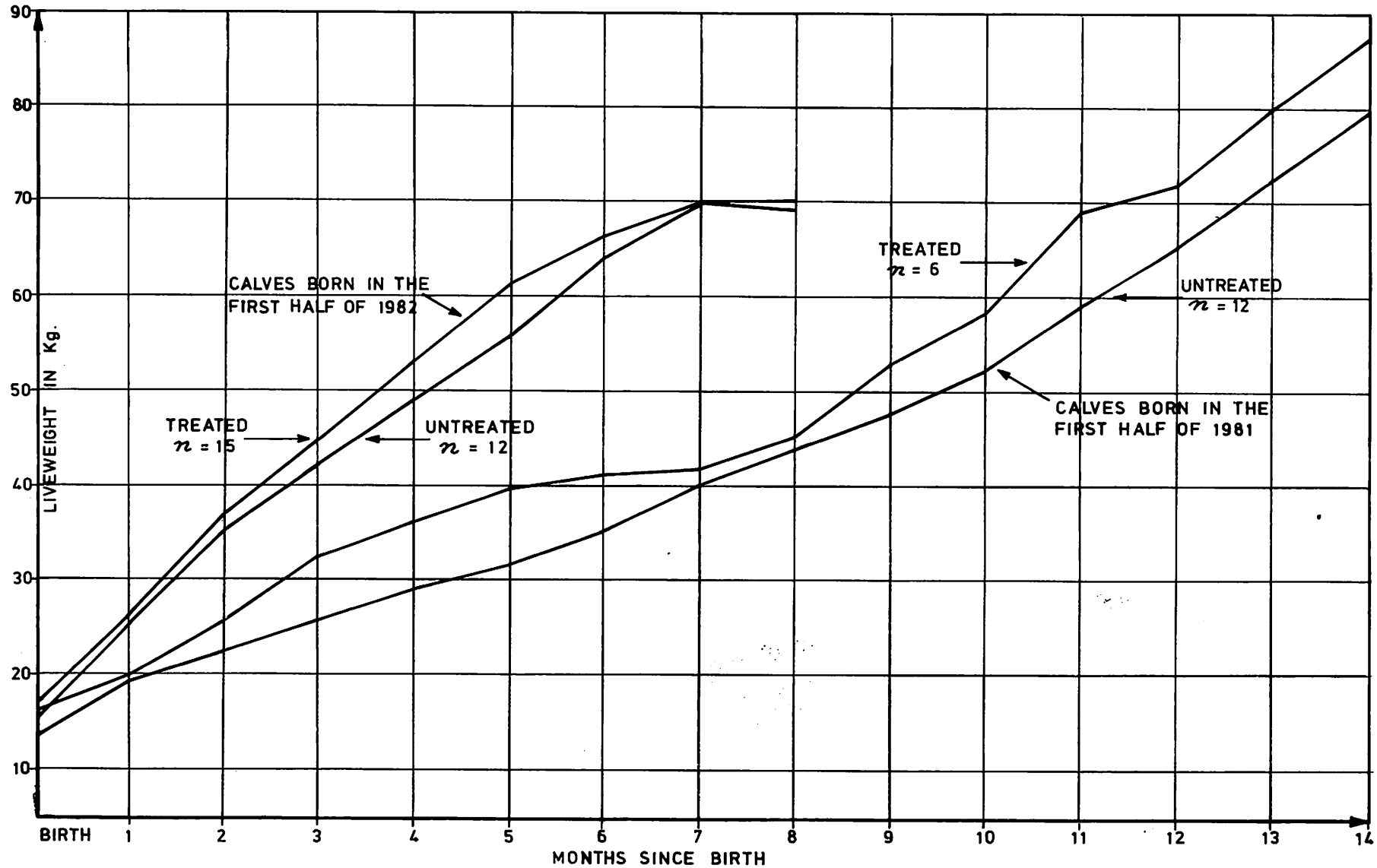
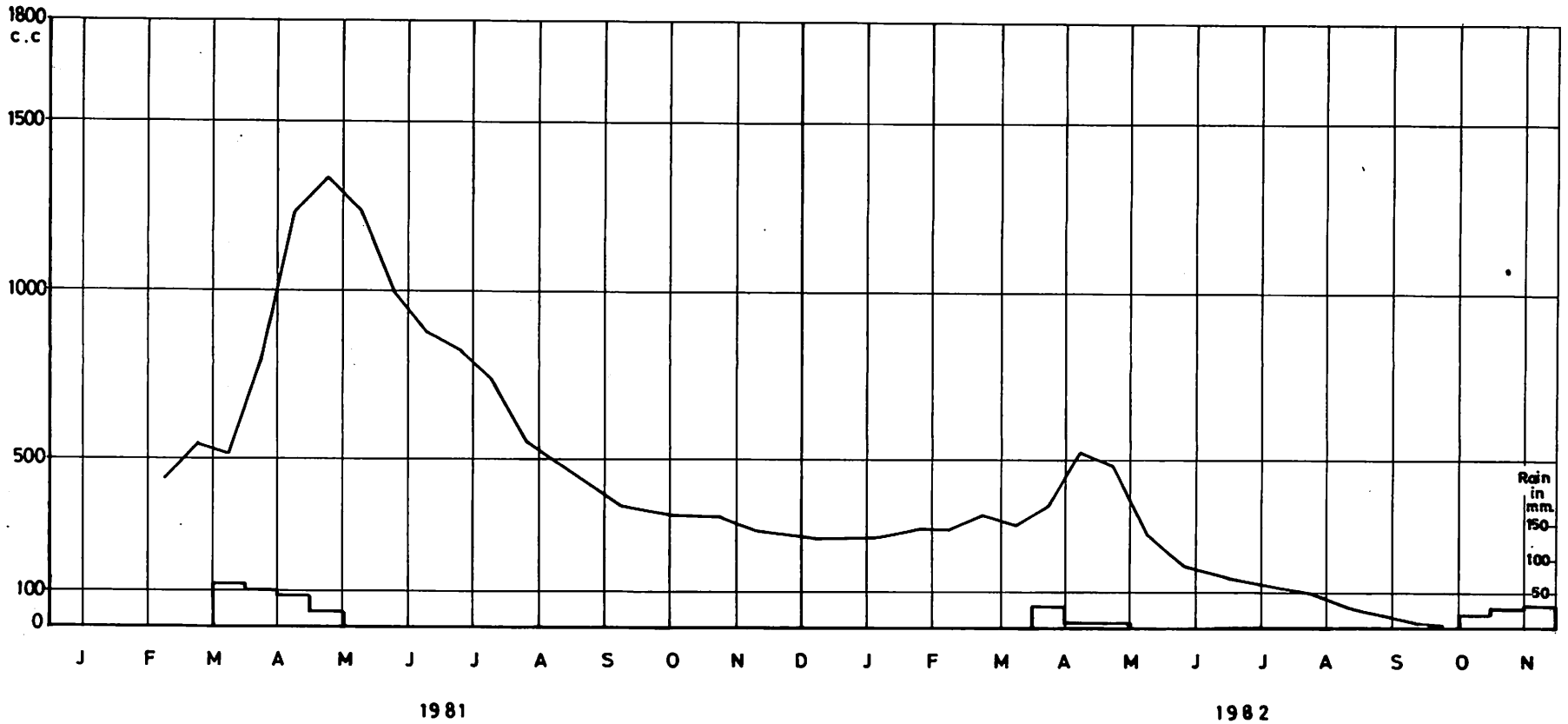


Fig. 26. Mean daily production of cows milk from half the udder

n = 10



benefits will exceed the undesirable side-effects. In the long term the control of disease will play a major role in maximizing the sustainable offtake of livestock products from the rehabilitated range resources. Initially, however, limited and localized disease-control activities will be recommended:

For public relations purposes:

1. to stimulate co-operation with destocking and grazing-control programmes;
2. to demonstrate methods of maintaining or improving productivity without increasing livestock numbers; and
3. to assure the co-operation of livestock owners with continuing investigation into the local constraints on livestock productivity.

There are also reasons for attempting:

4. to control those livestock diseases that are infectious to the human population;
5. to avoid an increase in the number of households whose livestock holdings are below the minimum necessary for subsistence (including an adequate milk diet for children); and
6. to reduce the fear of disaster due to epidemics that at present stimulate people to maximize their livestock holdings for insurance purposes.

It is also important that:

7. the livestock trends be facilitated as far as possible in compliance with veterinary regulations, but in this respect few problems are foreseen in the present project area.

c. Results

While significant effects of the input packages have been noted for the experimental herds, the recommendations following are mainly based on the findings of productivity effects given elsewhere. In general the input packages have proved beneficial, except in cattle kept under desert conditions, where cost-effectiveness has not been shown.

d. Findings in detail

(i) Camels

In a survey of 10 Rendille and Gabra settlements in the drought year of 1976, the causes of death of 204 camels were ascertained. Of these, 35% were attributed to drought, 22% to tick infections, and 19% to camel pox. Calves less than 2 years old experienced 45% mortality, and 76% of deaths in this age group were due to tick infections and/or camel pox (*IPAL Technical Report E-1a*).

A survey of diseases of two camel herds in the IPAL study area between August 1979 and January 1981 (*IPAL Technical Report E-6*) gave findings as follows:

Table 95. Incidence rate (%) of trypanosomiasis over the survey period in different age groups

	Adults	Immatures	Calves
Patent infections by mouse inoculations:			
Herd 1 at Kulal	58	100	100
Herd 2 at Ngurunit	12	7	0
Antibodies by indirect haemagglutination:			
Herd 1 at Kulal	92	100	100
Herd 2 at Ngurunit	78	78	100

100% of isolates were of *Trypanosoma brucei* group probably *T. Evansi*, a species mechanically transmitted by biting flies other than tsetse flies. (In other livestock species trypanosomiasis is caused by tsetse-transmitted *Trypanosoma* species, and occurs only in the higher-rainfall areas where the bush is dense enough to provide a habitat for the flies.)

Point prevalence of patent infections, however, fell to much lower levels after mid-1980, and may have previously been high because 1979 was an exceptionally wet year, favouring the vectors. At Kulal, animals with clinical symptoms showed higher white-blood-cell counts than those without.

b. Mean faecal strongyle egg counts per gram in Herd 2 were probably below pathogenic levels in all age groups except adult females. (Subsequent limited clinical experience has suggested that strongyle egg counts can rise dramatically in response to stress, such as other disease, and high counts may therefore be a response to the stress of gestation and lactation.)

Table 96. Mean strongyle egg counts (± S.E.) in different months in camels

	1980				1981
	May	July	September	November	January
Calves	<100	100	100	100	100
	n=7	n=7	n=5	n=6	n=4
Immature females	118	<100	153	<100	123
	±28		±79		±34
	n=25	n=19	n=16	n=19	n=15
Adult females	800	683	567	262	308
	±20	±17	±18	±9	±10
	n=74	n=46	n=52	n=42	n=51
Immature males	128	117	88	105	133
	±38	±60	±23	±35	±50
	n=16	n=9	n=12	n=10	n=9
Adult males	260	196	248	152	190
	±7	±8	±17	±5	±11
	n=39	n=25	n=23	n=24	n=24

The major strongyle genus identified in 90% of larval cultures was *Haemonchus* while *Trichostrongylus* and *Oesophagostomum* were also seen in 30% and 20% of the samples respectively. Eggs of *Trichuris*, *Strongyloides*, *Moniezia* and *Ascaris* were also seen in some of the samples counted, as well as coccidial oocysts.

c. No haemoparasites were seen in blood films from either herd.

d. Ticks were counted, collected and identified in various months during the survey period, from both herds, as follows:

Table 97. Mean total body tick loads (± S.E.) in camels

	1980					1981
	March	May	July	September	November	January
Herd 1	57.5 ±5.3	59.9 ±10.0	72.7 ±6.6	90.3 ±6.6	83.2 ±5.2	62.8 ±8.0
Herd 2	79.8 ±9.8	47.8 ±3.3	46.0 ±3.2	100.3 ±5.5		42.6 ±1.6

The ticks collected and identified by species showed a greater abundance of *Hyalomma dromedarii*, with *H. rufipes* slightly less frequent, and seasonal resurgences of *H. truncatum*, *Rhipicephalus pulchellus* and *Amblyomma gemma*.

e. Serum assays for antibodies to foot-and-mouth disease and rinderpest showed a prevalence at one sampling of about 1% each of Type O, C, SAT II and to rinderpest.

f. Antibodies to *Brucella abortus* were found in sera, mainly of adult females, with percentage point prevalence as follows:

Table 98. Point prevalence (%) of *Brucella abortus* antibodies in camels

Herd No.	No. of samples	1979	1980				
		December	February	March	April	July	August
1	21		33.3	33.3	38.0		9.5
2	116	36.5		34.0		14.5	

The effects of brucellosis on abortions and the possible zoonotic effects were not studied.

Subsequent studies by T. Rutagwenda (unpublished data from M.Sc. thesis):

a. Compared mean packed-cell volume of blood samples from camels in Herd 2, with and without treatments as follows:

- weekly application of acaricide from May 1981, supplemented by hand-dressing of the nostrils;
- monthly drenching with 10% fenbendazole from February 1981 (bi-monthly in 1982);
- blanket initial treatment with suramin in March 1981, followed by *ad hoc* repeat treatments of animals with rising antibodies to trypanosomiasis.

Table 99. Mean packed-cell volumes in camels, analysed by t-test

Date	Treated herd	Untreated herd
May 1981	21.8	21.7
July	26.1	23.2
September	26.2	25.0
November	28.1	24.8
January 1982	27.8	25.7
March	28.2	25.8
May	28.0	24.8

All treatments were established by May 1981 when differences were not significant, but all subsequent differences are significant. ($P>0.01$).

b. Concurrently faecal strongyle egg counts were monitored monthly, and again showed consistently significant differences ($P>0.01$).

Table 100. Mean strongyle eggs per gram in camels

Date	Treated herd	Untreated herd
March 1981	15	126
April	4	127
May	97	265
June	25	509
July	0	493
August	0	277
September	0	342
October	0	275
November	0	389
December	0	238
January 1982	0	236
February	2	211
March	0	320
April	0	470
May	1.5	465

That tabulation demonstrates the relationship of strongyle egg counts to local rainfall, with peaks during or after the main wet seasons.

In subsequent courses of treatment the fenbendazole has been withheld for 3 months from August to November 1982 with no patent infestation appearing in the treatment herd, suggesting that there has been no challenge during this dry season.

c. Similarly, monthly counts of total body tick loads, carried out 5 or 6 days after the preceding acaricide application, consistently showed significant differences at the 1% level between the treatment and non-treatment herds.

No specific tick-borne diseases have been identified, but there is a possibility that a tick-toxicosis may have affected suckling camels.

d. Mortality over a 12-month period from May 1981 to May 1982 totalled 25 animals (16%), 10 of them in the treatment herd. The main causes of mortality may be summarized as follows:

Table 101. Mortality of camels 1981-1982 at Ngurunit

Malnutrition of calves	5
Predation	5
Pneumonia	4
Undiagnosed acute fever with hind-leg paralysis	2, both calves in the treatment herd
Paralysis associated with heavy tick burdens	2, both calves in the non-treatment herd
Trypanosomiasis	1
Internal parasitism	1
Bloat	1
Rupture of bladder	1
Undiagnosed	3

(ii) Cattle

From *IPAL Technical Report A-5* findings of the cattle research programme may be summarized as follows:

a. Whereas tick burdens on cattle reach high levels at higher altitudes (see also following section) and are generally substantially higher on adults than on calves, the numbers of ticks counted on cattle in desert areas probably do not justify routine acaricide treatment:

Mean tick loads at Kulal, 1,500 m = 354
Mean tick loads at Olturot, 670 m = 14

Among 5,486 ticks collected from cattle in various localities and identified, potential vectors of heart water were found at various altitudes, and those of redwater and anaplasmosis at the higher altitudes. No specific tick-borne diseases have, however, been encountered anywhere.

b. Monthly faecal examinations for eggs and oocysts of internal parasites showed generally low and probably non-pathogenic numbers under lowland conditions, except intermittently in individuals. When infections necessitated treatment, at approximately two monthly intervals 10% fenbendazole was

effective in reducing the faecal burdens of strongyle eggs. *Strongyloides, Moniezia, Parascaris* and *Coccidia* were also recognized.

c. Assay of blood samples for trypanosomiasis using *T. brucei* group antigen on two occasions gave results as follows:

Table 102. Results of assay of blood samples from cattle for trypanosomiasis

Date	No. of Samples	% Positive	% Suspicious
27.9.80	105	9.5	7.6
18.5.81	99	1.0	4.0

No patent infections of trypanosomiasis ever occurred in the experimental herd.

d. On three occasions sera were examined for antibodies to *Brucella abortus:*

Table 103. Results of examination of blood samples from cattle for *Brucella* antibodies

Date	Samples	% Positive Test: RBPT	SAT	CFT	% Positive among adult females
27.9.80	105	5.7	3.8	3.8	9.5
17.5.81	121		3.8		5.9
January 1982	153			5.2	15.8*

(*taken from section 2 below)

e. Of thirty nine losses in the experimental herd during 24 months of the study, causes were attributed as follows:

Table 104. Mortality of cattle 1981-1982

	No.	%
Undernutrition	9	23
Pneumonia, associated with undernutrition	7	18
Protracted calving, associated with undernutrition	2	5
Accidental injury	4	10
Contagious hepatitis	4	10
Calf enteritis	1	3
Predation by lion	3	7
Not diagnosed	7	18
Theft	2	5

The figures illustrate that under desert conditions malnutrition due to drought seems a far more serious constraint on cattle productivity than either parasitism or infectious disease.

A survey of diseases of cattle was carried out at Ngurunit, Korr, Mount Kulal, and Marsabit from January 1982 to June 1983 (Omara-Opyene, 1982; 1983).

a. Blood samples from 670 cattle were examined for the presence of trypanosomes by haematocrit centrifugation and mouse inoculation techniques. Only 1.5% of samples were positive, the two tests being approximately in agreement.

b. Sera from the same 670 cattle were tested for antibodies to trypanosomiasis by the Enzyme-linked Immunosorbent Assay (ELISA), and for antibodies to *Brucella abortus* by the Complement Fixation Test (see below). ELISA gave a high prevalence of positives to 3 different *Trypanosoma* species at most sampling sites, and the results are viewed with some doubt.

c. Foot-and-mouth-disease virus isolation was attempted from oesophageal/pharyngeal scrapings of 509 cattle. All were negative, although 27 animals sampled subsequently during an outbreak of disease at Kalacha, Kargi and Marsabit were positive for type O.

d. Sera from 512 cattle were assayed for antibodies to foot-and-mouth disease by the Metabolic Inhibition Test. Results suggest an endemic situation with generally recent infections of all Types O,A,C and SAT II.

e. Faecal samples from 2,227 cattle, mainly at Marsabit, were examined for the presence of eggs of helminths and for coccidial oocysts.

f. Ticks were counted on 360 cattle.

The more significant findings of the survey were as follows:

Table 105. Percentage of samples with antibodies to *Brucella abortus*

Sampling point	Total sample	% positive	Female sample	% positive
Ngurunit	100	1.0	39	0.0
Korr (IPAL herd)	153	5.2	38	15.8
Ula Ula	114	7.0	37	21.6
Marsabit North	31	3.2	13	7.7
Badassa	47	2.1	18	5.6
Karare	78	5.1	48	6.3
Loglogo	26	0.0	16	0.0
Mt. Kulal	121	3.3	54	5.6
Total	670	4.1	263	6.8

Table 106. Mean strongyle egg counts per gram (± S.E.), during dry and wet seasons

Sampling area	Season	Total no. of samples	Calves	Immatures	Adults
Marsabit:					
Ula Ula	Dry	247	27.7±7.8	537.3±137.0	172.2±27.6
	Wet	143	182.1±53.2	310.5±59.8	131.3±24.7
Badasa	Dry	215	44.0±23.4	274.6±46.9	135.6±24.0
North	Dry	321	254.8±29.8	512.5±96.5	179.1±36.4
	Wet	255	113.7±25.3	319.0±58.6	88.2±19.0
Karare	Dry	188	257.5±119.7	835.4±107.4	200.0±25.0
	Wet	104	236.8±81.3	419.7±49.1	88.9±50.7
Ngurunit	Wet	180	15.8±11.2	86.1±19.3	47.2±8.0
Mt. Kulal	Dry	50			86.7±17.9
	Wet	180	108.3±33.2	136.0±40.7	40.0±9.8
Kargi	Dry	210	13.6±7.6	133.3±35.1	53.6±9.5
Olturot	Dry	55	0	155.0±43.3	72.7±16.2
Kalacha	Dry	79	18.2±17.3	60.5±16.8	28.0±10.6

This confirms a clinical impression that animals of post-weaning age are the most severely affected by internal parasitism in the Marsabit area. In all of 63 faecal samples from highland areas cultured for strongyle identification, 100% of the larvae were *Haemonchus*.

Table 107. Mean total body tick loads (±S.E.) of cattle in highland areas

Sampling area	Age	Total sample	Total ticks counted
Marsabit:			
Ula Ula	Immature	38	444.4±24.5
	Adult	52	948.7±83.6
Badasa	Immature	30	278.8±26.9
	Adult	42	513.6±45.8
North	Immature	33	576.8±41.7
	Adult	61	684.4±38.4
Karare	Immature	30	510.4±27.0
	Adult	60	1000.6±86.8
Mt. Kulal	Adult	50	164.1±12.4

These figures represent a high level of parasitism and signify considerable blood loss and skin damage.

(iii) Smallstock

a. Within a sedentary goat flock maintained at Ngurunit, and initially consisting of 91 animals, the diagnosed causes among 40 deaths during one year included the following.

Table 108. Cause of deaths of goats

Contagious caprine pleuro-pneumonia	12
Predation	5
Other pneumonia	3
Coenurus cerebralis	2
Others	5

b. Strongyle egg counts in the same flock were performed on four occasions while a small proportion of the goats were being drenched weekly with mebendazole.

Table 109. The effect of drenching on strongyle egg burdens in goats

	Undrenched		Drenched	
	No. of goats	Mean epg ± SD	No. of goats	Mean epg + SD
28.7.79	51	380±372	21	419±219
8.12.79	50	857±679	21	38±80
8.2.80	45	500±468	17	259±578
2.3.80	67	1,373±421	15	27±103

The proportional prevalence of strongyle species in total counts of the abomasum and small intestine of 6 animals was:

Abomasum	*Haemonchus contortus*	98%
Small intestine	*Trichostrongylus colubriformis*	40%
	Trichostrongylus probolusus	59%

c. Blood packed-cell volumes were measured on three occasions:

Table 110. The effect of drenching on blood packed cell volumes in goats

	Undrenched	Drenched
9.12.79	24.2±4.1	27.4±3.6
9.2.80	26.7±3.4	29.2±3.2
30.3.80	26.6±4.5	28.3±3.3

These differences are most probably due to blood-sucking by *Haemonchus* worms.

d. On three occasions blood smears from the whole flock were examined for haemoparasites, with no evidence of such parasites being seen.

e. Sera from the flock were examined for antibodies to *Brucella melitensis* on four occasions:

Table 111. The incidence of *Brucella melitensis* antibodies in goat sera

	Per cent positive	Per cent doubtful	Total no. of samples
23.1.79	6	7	84
28.7.79	29	43	70
19.12.79	13	19	79
2.3.80	23	4	82

These results suggest that brucellosis was the cause of an overall 26% abortion rate, with a peak of abortions between April and June, 1979 *(IPAL Technical Report A-3)*.

6. Human requirements from livestock

Estimates have been made of Rendille requirements for milk and meat based on the literature, IPAL data on productivity and from household surveys. Over 150 surveys carried out among the Rendille, Ariaal and Samburu of Kargi, Korr and Ngurunit (Field 1979, Mburugu 1981, Field unpublished) both among households* and *fora* indicate the following average numbers of people and livestock.

Table 112. Average numbers of people and livestock

Number of persons	Camels	Cattle	Smallstock	Total
8	12	11	101	124
TLUs adjusted for IPAL area	14.4	7.26	9.57	31.23
Standard TLUs	15.0	11.00	9.18	35.18

*For definition of households see footnote page 268.

This may be compared with Table 61 which shows the mean over the whole study area which is equivalent to 35.8 Standard Tropical Livestock Units (Le Houérou and Hoste, 1977) or 30.5 TLUs when adjusted for age specific composition of herds.

Since about 60% of all camels are adult females and half would be lactating at any one time each household would have three to four lactating camels. Similarly 40% of cattle are adult females and half would be lactating giving two to three milking cows per household.

From the point of view of the owner who concentrates more on smallstock, the IPAL production data from goats indicates that a family consisting of a married couple and four children would require 57 milk goats and 53 meat goats totalling 10 TLU for its food requirements. A household of 8 therefore may require twice this amount for food which would leave those households surveyed 11-15 livestock units (depending on the method of calculation) to fulfil social obligations; e.g. cementing friendship bonds, ritual sacrifice and dowry. Any excess may then be used either to increase the number of breeding stock or for sale. Revenue from sales of non-breeding stock could be used to purchase energy rich food such as grain or sugar. This would relieve some of the burden on lactating animals to supply milk requirements since human protein needs are obtained from less than half of the milk required to supply energy requirements. Currently there appears to be a trend in this direction although pastoralists may not be aware of the underlying reasons.

The composition of the pastoralists' herds may vary from place to place without jeopardizing the supply of food.

Use of livestock to increase the size of the flock is necessary from time to time, although the philosophy that this is a safeguard against losses may be self defeating when numbers increase beyond the carrying capacity of the range as is the case over much of the eastern and south eastern Rendille range. Animals become prone to mortality through starvation in drought years and disease in wet years.

6.1 Offtake

This section is confined largely to a consideration of smallstock and cattle, since the offtake of camels will be theoretical until (a) the potential of the market in the Middle East is explored, and (b) the possibility of re-opening an abattoir for camels is realised.

a. Smallstock

Under traditional management smallstock are capable of a 10% increase per annum, and with veterinary medicine up to 40% p.a. might be expected in a good year. In the absence of suitable market outlets this will and does lead to overpopulation and a crash; a wasteful exercise. Limited marketing facilities exist enabling people to exchange some of their livestock for cash with which to buy food, in particular energy-rich grain and sugar. Then if smallstock were needed only for the supply of protein the average flock size required for a household would be less than half that needed to supply all the energy needs.

People will market smallstock providing the following prerequisites are fulfilled:

- they have a surplus;
- the livestock/grain exchange rate is favourable;
- they have means to store cash or its equivalent until there is a need for it.

Unfortunately, although there is a surplus of livestock, the exchange rate is often unfavourable (Njiru, 1980) and there are few incentives or facilities to store cash. People still keep mature unproductive castrate animals on the range. Although they experience seasonal extremes in their level of nutrition, they frequently convert surplus cash into other livestock rather than risk losing it.

Pastoralists are increasingly regarding smallstock as an economic investment. In the year 1979-80, Njiru (1981) estimated that about 9,600 smallstock and 46,900 skins were sold by Rendille in Marsabit District, yielding 1.3 million Kenya shillings. Nevertheless, this represents an annual offtake of only 3.3% of the population of the District. This figure increases to 26% if smallstock consumed locally are also included. An addition of 4-10% for

predation would still allow a surplus in well managed flocks in favourable years. Thus marketing should be encouraged and promoted by all possible means to remove this surplus and enable breeding stock to survive on reasonable pastures even in drought years (Field, 1982).

b. Cattle

The marketing of cattle is the most active sector of the livestock trade in the district. However, the presence of a high proportion (13%) of castrate males (steers) in outlying areas such as Kulal indicates that there is potential for further offtake (approximately 1,500 animals p.a. in the two areas).

The main constraints on cattle offtake have been identified as follows:

- poor market price;
- inadequate auction facilities in remote areas;
- poor communications;
- quarantine restrictions;
- capacity of holding grounds to keep animals while they are awaiting clearance for transshipment (Lewis, 1977).

Nevertheless, despite the belief that higher prices should be offered, a trial sale of cattle trekked on foot from Kulal to Isiolo experienced all the above problems yet still yielded a net return of 30% on the original investment.

Summary

Studies made by the Livestock Section of IPAL commenced by monitoring the traditional system with respect to population parameters, nutrition and utilization by the pastoralists. This was followed by detailed experimentation on the effect of disease as a constraint to production, the importance of nutrition to production and also stocking trials where the effect of animals on the range (impact) is being measured. These trials are ongoing and it is hoped will eventually provide information on range carrying capacity when they have covered an adequate span of time.

The management area contains an estimated population of about 151,000 head of livestock, 71% of which are smallstock. These comprise about 49,000 TLU equivalents, 78% of which are camels and cattle. For each Rendille household of eight persons there is an average of 94 animals amounting to 30 TLU equivalents.

Surveys of animal numbers indicate that nearly 5,000 Km^2 or 42% of the area is overstocked while 46% is understocked, the remainder being more or less in equilibrium. These proportions vary a little according to the criteria used. Adjacent areas permit some expansion in times of drought in particular to the SE and NW of the management area. Other areas such as Laisamis, the Gabra country around the Chalbi desert and the western half of Wamba Division are already overstocked.

Food habit studies and calculations of dry matter intake provide base line information required for the determination of range carrying capacity. It is estimated that the existing population of livestock require 107,428 tonnes of dry forage per annum, 77% of which is needed by camels and cattle. There is a strong indication from the reconstitution of diets that the plane of nutrition is frequently sub-optimal for growth and lactation of livestock in particular among cattle.

Experiments on constraints to production have provided a measure of the increased yield which may be expected with improved management in particular health care and feed supplementation.

The veterinary input has resulted in the reduction of strongyle worm egg burdens below pathogenic levels in all livestock. Another major input has been the use of acaricides against ticks. This is important for camels and other livestock species when they are in highland areas where the tick challenge is greater. A number of other veterinary inputs including prophylaxis (vaccinations) and treatments (mostly antibiotics) have been used.

The combined effect of the veterinary input has been monitored in detail in all livestock, but not all results are available. In camels there has been a significant improvement in the composition of blood as measured in terms of packed - cell volumes. There has been a reduction in the number

of abortions and an increase in the number of successful calvings. Furthermore the mortality of calves has also decreased markedly with treatment.

Similar results are being obtained in smallstock in particular in sub-humid areas. Disease challenge to cattle in the arid zone is minimal and undernutrition is the main constraint to production. Veterinary input is likely to be beneficial to cattle in the sub-humid areas also.

A preliminary cost - benefit analysis of veterinary treatment of camels indicates that the net benefit in terms of increased growth, milk production and herd size may be equivalent to KShs. 500.00 for each animal receiving the full input.

Studies of the productivity of flocks and herds, actual household livestock ownership and human requirements in particular for food indicate that there is already a surplus of livestock which is used for social obligations and/or sale. Participation in the cash economy through sale of livestock has certain benefits, but also risks for the individual. Since it may provide the key to the overall problem of environmental conservation for long term production it should be seen to have a net benefit for the community as a whole. This will remain a difficult concept for the pastoralist to grasp in the absence of any system of Land Tenure.

IV

SOCIO-ECONOMIC AND ADMINISTRATIVE ASPECTS

1. Introduction

The task of the IPAL human ecologist is to study the movement, settlement patterns, stock-management practices and pastoral household economy of pastoral groups in and around the study area. He also examines processes of change, including how these pastoral societies are integrating with the national economy and policy, and sedentarization. These aspects of the life of the pastoralists cannot be adequately treated without some study of their history, social structure, ritual and cultural values. The aim of the study is to outline:

- the development needs of the people;
- the constraints under which their pastoral economies are labouring;
- indigenous leadership structures and how these articulate with government administration; and
- those practices and strategies of the pastoralists on which developmental and environmental programmes can be based with minimum disruption to the pastoral communities.

What follows describes the settlement patterns of the Rendille pastoralists. To enhance the value of the presentation comparisons are made with the Gabra. The demography and movement of the people will be treated in some depth. Since the data have not yet been analysed and written up, the following topics will be treated briefly: the pastoral economy, change among the pastoralists, including sedentarization, and present district development structures.

The data on settlement patterns and movement were derived from aerial surveys and observations and interviews on the ground. The aerial surveys primarily yield data on the location of occupied and abandoned main camps *(manyatta)* and *fora* camps as well as the number of houses (or tents) attached to each occupied pastoral camp. Work on the ground reveals information on local knowledge with regard to the whereabouts of people and stock and the reasons why people decide to stay in, move to, or move from particular grazing sites. Large concentrations of people and stock which are identified from the air are usually widely known about.

Itinerant traders whose business it is to locate these have detailed information on current movements of stock and people. IPAL staff in their journeys through the study area come to know some of this information as well. Aerial work in human ecology began in January 1982 and to date four aerial surveys over Gabra country and two over the Rendille homelands have been analysed. The Gabra surveys took place in late January, early March and early August 1982; the Rendille surveys in late May and early August 1982. At the beginning a certain chipping and chopping preceded the final demarcation of the area to be surveyed. On the one hand, it was found unnecessary to fly over areas well known to be empty of livestock, such as sections of the Hedad in wet-season conditions. On the other hand, by confining flights over the Gabra homelands strictly within the boundaries of the study area, which for example exclude the northern part of the Hurri Hills, an inadequate picture emerges because people and livestock of the study area frequently migrate there. The more that is known about areas immediately outside the study boundaries (and beyond), the easier it is to understand the pattern and logic of movement within. This is particularly true of the Gabra, who usually use the rangelands available to them more extensively than the Rendille. Map 18 shows the area demarcated for the Rendille surveys. It covers 5,500 km^2 of rangelands.

2. Camp Size

The Rendille and Gabra pastoralists graze camels, cattle and smallstock separately. Furthermore, they split when circumstances require it - each animal species into two separate herding (or grazing) units. Weak and milch animals remain in general at the main camp where the women and young children reside, while the other animals are sent to satellite camps known in the Rendille language as *forr* camps and in Gabra as *fora* camps. This practice occurs more frequently amongst the Rendille and at times they may even send most of their animals, including milch animals, to *forr* camps.

Table 113 and 114 outlines the number of houses per main camp recorded in the May and August 1982 surveys. The Rendille camp on average has four times the number of houses of Gabra camps.

Map 18. Boundaries of The Rendille surveys

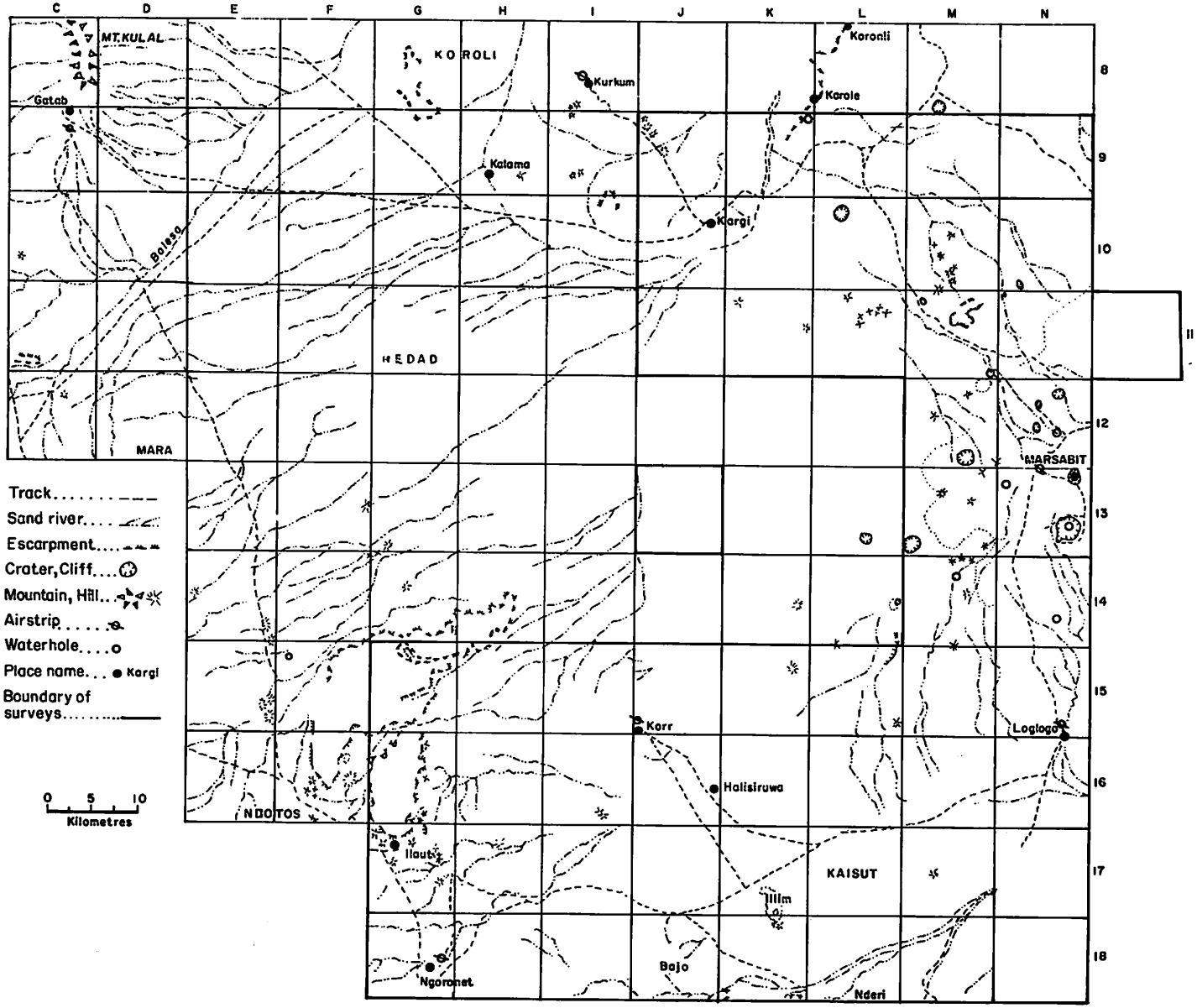


Table 113. Rendille Camp size, May 1982

Camp size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Frequency	1		2	2	2	2	4	3	1	5	3	2	3	3	2	3	4	1	2	5	5	5	2	3	3
No. of houses	1		6	8	25	12	28	24	9	50	33	24	39	42	30	48	68	18	38	100	105	110	46	72	75

Camp size	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Frequency	2	1	2	1	1		2	1	1	2		3	2	1	2	1	1	2							
No. of houses	52	27	56	29	30		64	33	34	70		11	76	39	80	41	42	86							

Camp size	52	54	55	57	64	67	71	77	78
Frequency	1	1	1	1	1	1	1	1	1
No. of houses	52	54	55	57	64	67	71	77	78

Total number of houses: 2,456
Total number of camps: 105
Average size of camp: 23.4
SD = 16.6

Table 114. Rendille camp size, August 1982

Camp size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Frequency		2	3	4	2	5	6	9	3	4	2	6	5	1	5	5	2	4	3	2	3	2	6	1	3
No. of houses		4	9	16	10	30	42	72	27	40	22	72	65	14	75	80	34	72	57	40	63	44	138	24	75

Camp size	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Frequency	5	3	3		1	1	1	1	2	3	2	1		1		1	2	1	2	1	1	2	1		
No. of houses	130	81	84		30	31	32	33	68	105	72	37		39		41	84	43	88	45	46	94	48		

Camp size	52	57	68	74	77
Frequency	2	1	1	1	1
No. of houses	104	57	68	74	77

Total number of houses: 2,730
Total number of camps: 129
Average size of camp: 21.2
SD = 15.3

3. Social Structure and Settlement

The Rendille population is divided into two contrasting sections or moieties known in the Rendille language as *Belisi-Beri* (eastern moiety) and *Belisi-Bahai* (western moiety)[1] (Sato, 1980). The former moiety is numerically larger than the latter. Each moiety is divided into a number of patrilineal clans (*gob*) and clans into subclans (*khod*). Subclans contain a number of patri-lineages (*ere*). Table 115 outlines the main clans and subclans discovered during research.[2]

The Rendille order their clans and subclans according to a system of ritual seniority (*meinan*). The Odola clan does not belong to either moiety (Beaman, 1980). The ariall Rendille who live in the southern part of the Rendille study area are regarded as Rendille who have adopted the ways of the Samburu. Their principal clans are Ongeli, Lukumai, Masula, Ilturiya and Neruguchu.

Table 115. The Rendille descent system

Moiety	Clan	Subclan
Belisi Bahai	Dubsahai	Wambille, Bulyar, Gudere, Mirigichan, Fur
	Rengumo	Ongom, Seye
	Nahagan	Dhurolo, Galgorowle, Bahaiyeyto
	Matarbah	Galgidhele, Fecha
	Uyam	Basele, Galhaile
Belisi Beri	Sale	Nebei, Goborre, Elegela, Galoroyo, Gob Gobanai, Gabana (Gabaneyo)
	Urawen	Jalle, Arigelle, Adisomelle
	Galtheilan	Kele, Mathacho, Galoro
	Tubcha	Galdydaye (Orbora), Galeithimot (Dhele)

[1] Spencer refers to these as the lower and upper moieties (Spencer, 1973)

[2] cf. Beaman, 1981; Spencer, 1983. Beaman includes in her list a comprehensive inventory of lineages attached to each subclan.

The majority of the residents of a camp belong to the same clan or subclan and camps are frequently known by their clan or subclan affiliation. At the centre of each camp there is an enclosure known as the *nabo* in which only elders (*ewen*) congregate in the evening to socialise, pray and when necessary to discuss affairs affecting the ritual and economic welfare of camp residents. In matters concerning the whole camp as a unit - such as decisions relating to moving camp - the camp leader (*jaldah*) plays a leading role and has the final say.

Each clan has its own myth of origin and plays particular roles within Rendille society (Beamann 1981, chapter 4). We did not research this aspect of Rendille life but it came to our notice that the Tubcha clan, for example, are the ritual caretakers of the Korole springs - the principal waterpoint of the northern Rendille. No animals can be watered at these wells after the long rains until elders of the clan perform the opening ceremony.

In the modern context politicians use the internal segmentation of the tribe as a means of soliciting support. Moiety or clan candidates rely mainly on support from members of their section or clan. Spencer notes a close association between tracts of rangeland and particular clans (Spencer, 1973, p.24). This seems to be breaking down.

Another over-arching structure in Rendille society is their *age-set system*, which corresponds closely to the Samburu age-set system (Spencer, 1973, pp. 33f). Every fourteen years all youths between the ages of 17 and 30 are circumcised en masse and thereby become warriors (*moran*). Boys as young as 10 years of age who are senior sons and whose fathers have died may be circumcised before their time. All the clans move camp to a limited number of places for the circumcision rites and each clan is responsible for initiating its own youths. In 1979, the year of the last public circumcision, young Rendille who were working outside the district absconded from their posts in order to participate in the rites. This is a measure of the importance that initiation rites have for individuals. Warriors are only entitled to marry 11 years after circumcision. Each set or cohort of warriors is known by a common name. Table 116 outlines the list of Rendille age sets

of this century and gives the dates when they were initiated and free to marry.

Table 116. Rendille age sets

Age set	Time of initiation	Time of marriage
Irbangutho	1895	1906
Defungutho	1909	1920
Irbalis	1923	1934
Libale	1937	1948
Irbangutho	1951	1962
Irpandif	1965	1976
Defgutho	1979	

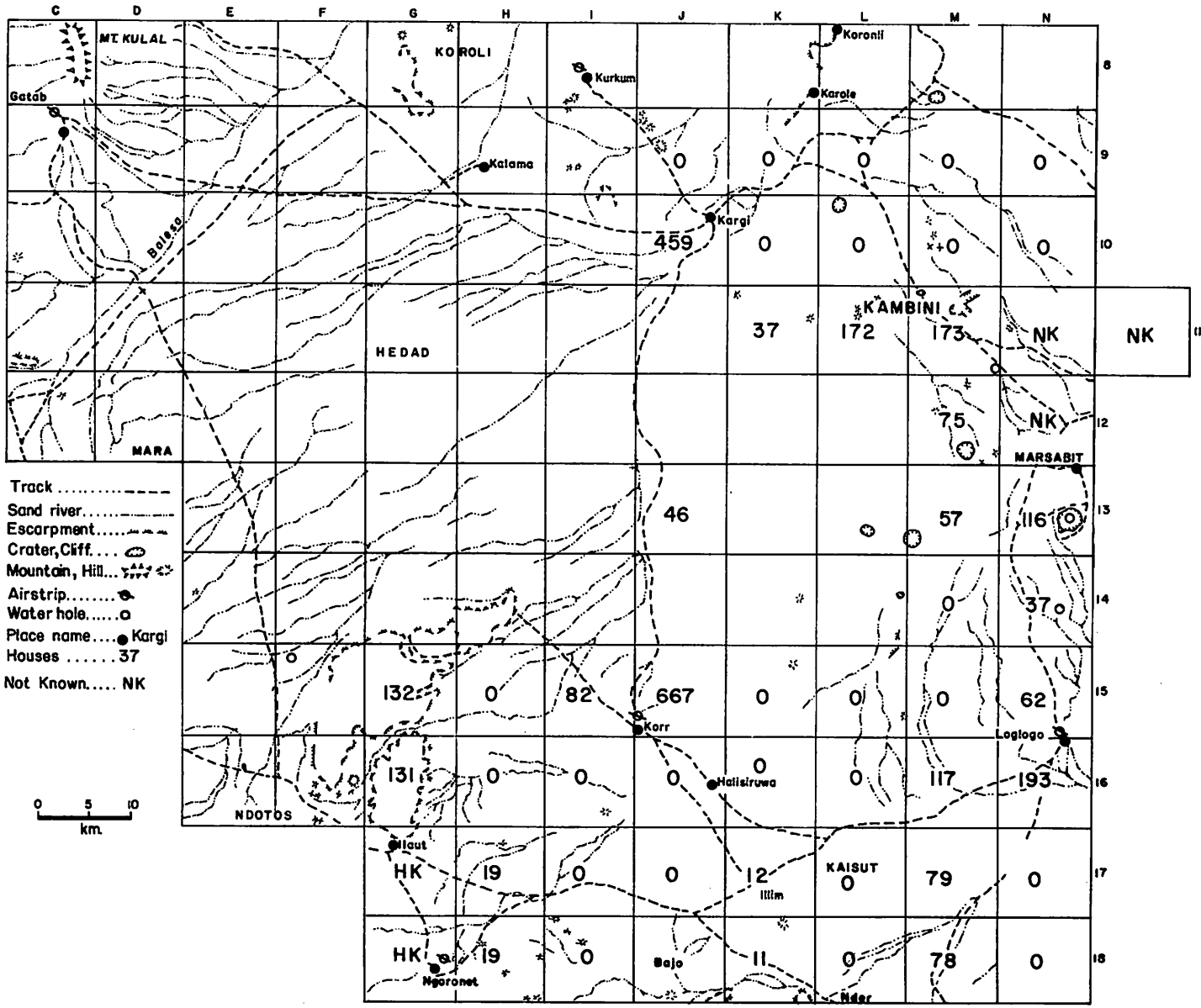
The ideal residence for warriors is the satellite camp, where their primary task is to protect livestock and assist in digging and watering stock from deep waterholes. Where there are insufficient numbers of younger siblings to herd, warriors also assume herding duties. In the evenings their delight and privilege consists in courting girls who are at the satellite camps. The warriors constitute the military wing of Rendille society and are expected to be brave and courageous, particularly against the common enemy. However, on occasions inter-clan clashes between warriors do take place which become a concern for the Rendille elders and government administration.

4. The Geographical Distribution of Camps/houses

Maps 19 and 20 illustrate the geographical distribution of houses (mainly Rendille) in the southern sector of the study area in May and August 1982. Table 117 categorises the quadrants - each of which represents 100 km^2 of rangeland - of the map grid according to the number of houses they contain noting in each instance the month of the year and the tribal area in question.

The Gabra tend to be more evenly spread over their rangelands than the Rendille. The Gabra occupy between 35 and 45 100 km^2 units of range: the Rendille reside in between 22 and 24 100 km^2 units. Furthermore, the majority of the 100 km^2 units occupied by Gabra pastoralists have only 39 houses or less located in them. The opposite is true in the Rendille case:

Map 19. Distribution of Rendille houses, May 1982



Map 20. Distribution of Rendille houses August 1982

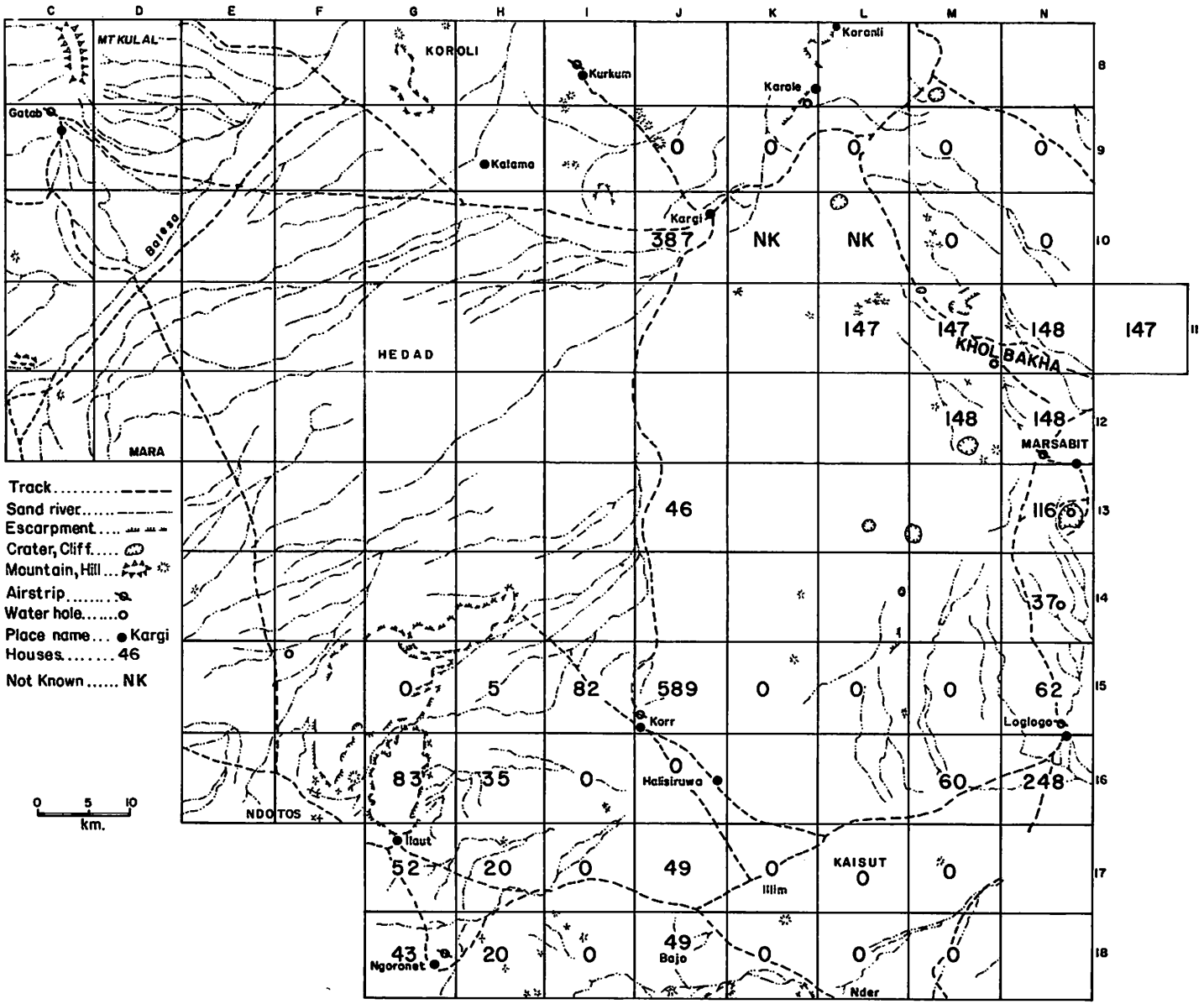


Table 117. Density of settlement per 100 km^2 unit of range.

	Rendille		Gabra			
No. houses per 00 km^2	May	August	January	March	May	August
0	31	29	29	54	47	45
1-19	4 (18.2%)	1 (4.2%)	18 (47.4%)	19 (51.4%)	21 (53.8%)	22 (48.9%)
20-39	3 (13.6%)	4 (16.7%)	14 (36.8%)	8 (21.6%)	9 (23.1%)	10 (22.2%)
40-99	7 (31.8%)	9 (37.5%)	5 (13.2%)	9 (24.3%)	8 (20.5%	10 (22.2%)
100-199	5 (22.7%)	7 (29.2%)	1 (2.6%)	- -	1 (2.6%)	3 (6.7%)
200-299	- -	1 (4.2%)	- -	1 (2.7%)	- -	- -
300-	3 (13.6%)	2 (8.3%)	- -	- -	- -	- -
NK	2	2	33	9	14	10
Total No. of 100m occupied	22 (41.5%)	24 (45.3%)	38 (56.7%)	37 (40.7%)	39 (45.3%)	45 (50%)
Total No. unoccupied	31 (58.5%)	29 (54.7%)	29 (43.3%)	54 (59.3%)	47 (54.7%)	45 (50%)

Occupied 100 km^2 units

the majority of 100 km^2 blocks settled in by the Rendille have 40 houses or more.

5. Population Estimates

The data from the previous section enable us to make estimates of the population of the study area. The statistics for August 1982 are used since these are the most comprehensive. In August 2,868 houses were counted in Rendille country and 1,366 houses among the Gabra. According to the 1979 population census the average size of household[3] in Laisamis Division, in which the Rendille reside, is 4.5 persons and in North Horr Division, the home of the Gabra, 4.74. Our data do not include the population of North Horr, Kalacha and Maikona trading centres. Their combined population according to the census is 2,327 persons. Hence the population estimate for the Rendille area surveyed is (2,868) x 4.5 = 12,906 and for the Gabra area surveyed is (1,366) x 4.74 + 2,327 = 8,802. These figures pertain strictly to population numbers of the study area. However, the population of the proposed management area is 20,983[4]. The population of the Rendille in 1919 was 5,474. In 1979 their population was 21,749, a figure which includes Rendille living on Mt. Marsabit and outside the district. This gives an annual increase of 2.3% between 1919 and 1979.

6. Nomadic Villages

An important finding from the study of the geographical distribution of rural pastoral camps is that the Rendille and Gabra pastoralists are not evenly distributed over the range. On the contrary, the majority of them tend to gather in conglomerations of 80 houses or more which form the basis of sizeable nomadic villages or communities. This finding has important policy implications for extending technical and social services to the nomads.

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[3] It seems for the most part the enumerators for the national population census regarded those occupying one nomadic tent or house as a household.

[4] This figure was obtained by substracting from the total population of Laisamis Division the population of Loyangalani. It includes the population of Mt. Kulal and all of the homelands of the Rendille.

The rural conglomerations of Rendille nomads are large. In May 1982 these were located at Kambini, North of Ilaut and west and south-west of Loglogo (Map 19). In August there were two major concentrations, at Kholbakha near Marsabit, and in the Ilaut/Ngurunit area (Map 20).

In May the largest rural concentration of Rendille pastoralists was at Kambini, some 25 kilometres from Marsabit town. Kambini is a regular site for camps when rain conditions there are sufficient. Pastoralists who frequent the vicinities of Ilaut and Loglogo move away from these trading centres in the rainy season to return to them or close to them when the dry season sets in (Maps 19 and 20). The concentration of camps at Kambini was also affected by the arrival of the dry season. Camps there moved to Kholbakha, which is relatively close to Marsabit. When questioned on this, pastoralists stated that a major factor in their decision was the better marketing and shopping facilities available to them in Marsabit town. There they believe that they can obtain much better prices for their stock and are charged modest prices for posho, sugar and tea. In addition, people at Kholbakha hire labour out to farmers: the return on a day's work is a *debe*[5] of maize. Others sell firewood for cash. Temperature is also a significant factor. Kambini, Kholobakha, and other places along the slopes of Marsabit mountains are regarded by the Rendille as favoured sites for camping because of the higher altitude and the corresponding lower temperature. This explains why pastoralists always opt for such places before sites in the Hedad desert, which can be extremely hot - even when forage and water conditions in both zones are similar.

7. Satellite (or *forr*) Camps

Both pastoral groups divide household stock into home-based herds, which are attached to the main camp, and satellite herds, which are based at outposts. Frequently the satellite camel, cattle and smallstock herds are separate. There are a number of reasons for these practices.

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[5] A *debe* is a four-gallon tin container

Firstly, by moving substantial numbers of stock away from the main camps the rate of use of the pastures surrounding the main camps is minimized. This enables the livestock at the main camps to stay in one place for longer periods and hence has the effect of reducing the frequency with which main camps move.

Secondly, the rangelands possess an inherent variation with respect to temperature, terrain, type of vegetation, availability of water, and the prevalence of disease vectors. Pastoralists avoid sending camels and smallstock on to the summits of mountains during wet seasons. Wet and cold conditions cause deaths among young animals and reduce the milk yield of camels. Gabra pastoralists distinguish between soft and hard ground. The lava fields, for example, on the slopes of the Hurri Hills and Asie mountains are unsuitable for cattle, which prefer to tread on soft ground such as that found in the dune country of Balesa Ildere. Camels and goats are more suited to hard ground. Pastoralists know which types of vegetation are most suitable for the different animals in their care and where these are located. Not all grazing sites possess the full range of vegetation species. Some may be more suited as camel pastures, others as cattle, goat or sheep pastures. Another aspect of range niches is their distance from water. Water is not a problem in wet seasons, when groundwater abounds. However, in dry seasons the availability of water is of prime importance. Camels are the least demanding; they can use rangeland niches located more than 50 kilometres from water and only need to be watered every 11-14 days. Smallstock, which are frequently grazed on their way to and from water, are watered every fourth day. Cattle, which are watered every second day, utilize pastures which are at most 15 kilometres from water. Certain areas, such as the territory which lies immediately east of lake Turkana, are considered unsuitable for camels because of the prevalence of tsetse and other flies which transmit the African trypanosomes. Pastoralists also know that the higher and colder regions contain ticks and avoid such places when possible.

The effort to match the needs and characteristics of the different animal species with appropriate range niches frequently necessitates the spatial division of herds, not only into home-based and satellite herds, but also into separate camel, cattle, and smallstock herding units. This practice facilitates the utilization of a variety of rangeland niches at any one time

and hence maximizes production. The extent to which any particular household divides its animals depends on the size of its herd and the amount of labour available to it.

Map 21 outlines the distribution of satellite camps among the Rendille in May and August 1982. A number of conclusions can be made about satellite camps.

Firstly the strategy of establishing satellite camps for all species of animals is more firmly ingrained in present-day Rendille herd management practices than is the case for the Gabra. There are a number of reasons for this:

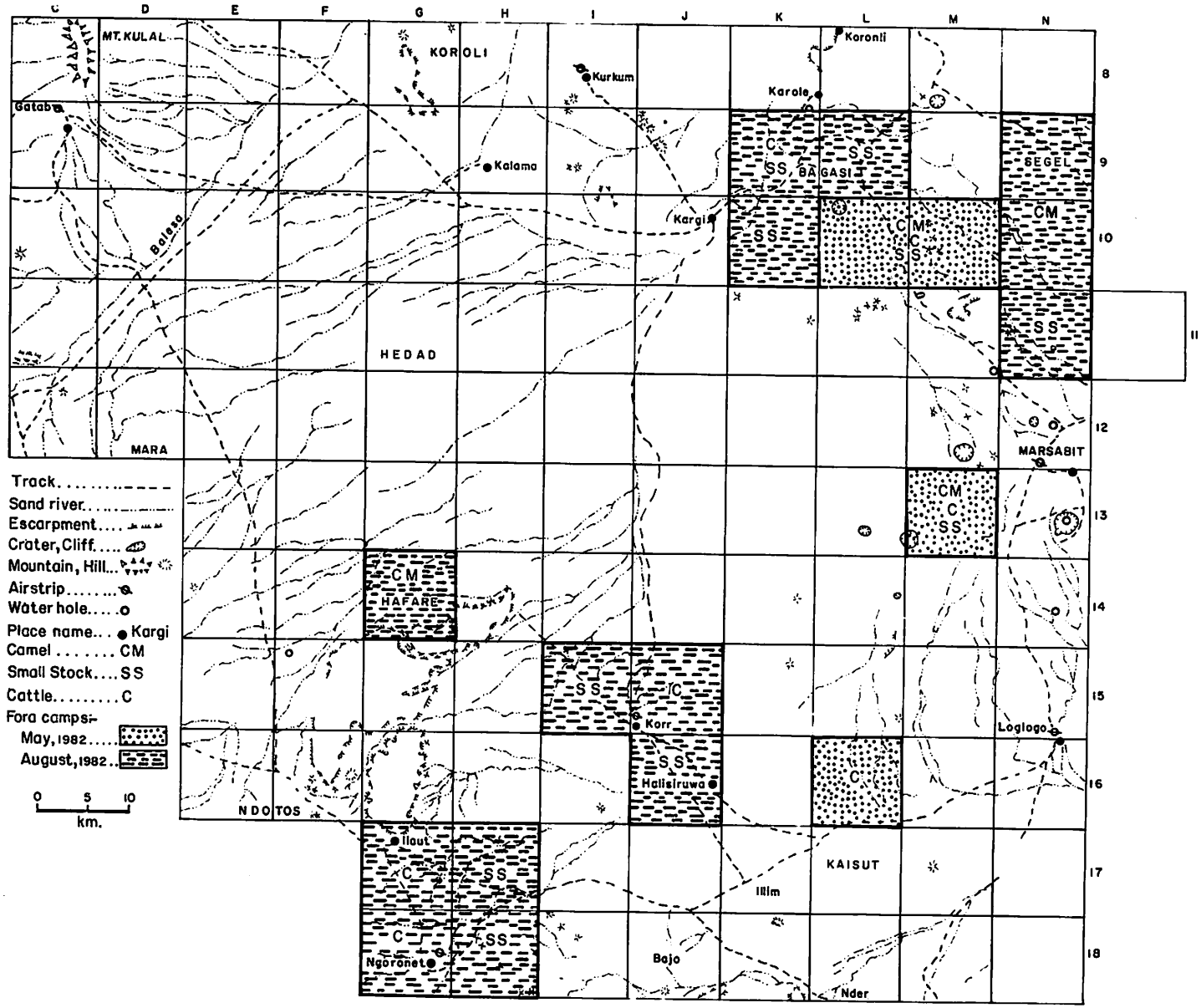
a. The institution of warriorhood divides Rendille society into two groups. One group, which consists of adult men, women and children, belongs naturally to the main camp. The second group, which consists of warriors (*moran*), belongs primarily to the satellite camps. The Rendille warrior is welcome at the main camp for family rituals and for short periods, when he is regarded as an honourable guest. However, he cannot overstay his welcome but must return to the satellite camp, which is his natural social habitat. In Gabra there is no such social division, and youths and young men feel equally at home in the main and satellite camps.

b. As already pointed out, the Rendille nomadic settlements are more concentrated than the Gabra settlements. It follows that Rendille nomads have a greater need to send stock to satellite camps because of the greater grazing pressure that can develop around their main camps.

c. The despatch of livestock to satellite camps increases household labour requirements. The Rendille households, who collaborate together on a much larger scale than Gabra households, are better organized socially to meet increased labour demands. Secondly, the aerial survey data indicate seasonal variations in the occurrence of satellite camps.

When the rains come the household head aims to bring all his personnel and stock together, particularly for the celebration of *sorio*. In both societies the eldest son must be present at the *sorio* rites and amongst the Rendille

Map 21. Location of Rendille forr camps in May and August 1982



camels cannot be absent from the main camp. The Gabra household - whose cattle are normally away in *fora* in dry seasons - relish the prospect of having them back in the main camp when the rains arrive so as to enjoy cow milk. Then it is frequent to hear it said that 'if we cannot enjoy the milk of our cows now we will never do so'. Nevertheless, male and dry cattle are sent away as soon as the *sorio* rites are completed, and some households may keep their cattle at *fora* for a number of years. In wet seasons cattle satellite camps are much in evidence both in Gabra and Rendille country. Wet seasons are the only times when cattle can use pastures some distance from permanent water. The upper reaches of the Hurri hills become in wet seasons the main target of Gabra cattle *fora*. In April and May 1982 the Hurri hills not only attracted cattle from within Kenya but also from across the Kenya/Ethiopia border. For the Rendille and the agro-pastoralists who reside in the mountain location of Marsabit, the slopes of Marsabit mountain and even the plains below where rain has fallen are appropriate places for wet-season cattle *fora* (Map 21). The Rendille, who own larger numbers of camels than the Gabra, maintain a number of camel *fora* even in the wet seasons (Map 21; none or very few Gabra camel *fora* occur then).

Both pastoral groups have very large numbers of smallstock and perforce continue to maintain a number of smallstock *forr* in the wet season. Another feature of wet-season *forr* camps is the tendency for *forr* stock of all species to intermingle.

As the dry season sets in, the demand for more *forr* of all species increases. The cattle *forr* settle closest to water, the smallstock *forr* further away, and the camel *forr* are located in pastures some distance from water (Map 21).

Among the Rendille, Hafare and areas close to Segel are suitable places for dry-season *forr* camels. Most of these animals water at Korole, which is approximately 60 kilometres from Hafare. Waterpoints at (a) Korole, Bagasi and Kargi, (b) Korr and Halisuruwa, and (c) Ilaut and Ngurunit attract in dry seasons *forr* cattle and smallstock which graze the surrounding pastures (Map 21). As the dry season proceeds camel *forr* use the Hedad more, and *forr* stock of Kargi Rendille move towards waterholes at Kurkum and Falam.

Thirdly, a comparison between the set of maps which deal with the distribution of main camps (Maps 19 and 20) with those which plot out the location of satellite camps (Map 21) is revealing.

In wet seasons among the Rendille there is little overlap between areas of satellite and main camps. The Rendille main camps do not 'follow the rain' with the same commitment as the Gabra. Instead they limit their choices of wet-season range to a number of well established sites such as Kambini. To compensate for this self-imposed truncated type of movement, the Rendille despatch their *forr* stock to search and utilize the other areas which received high rainfall (Maps 19 and 21). As the dry season sets in, smallstock and cattle *forr* camps come closer to permanent water, where they intermingle (Maps 19 and 21). The camel *forr* camps are the only exception, because they continue to use ranges long distances from water.

8. Individual Camp Itineraries

Much of this section has so far focused on the size and movement of camps at a macro-level. Here some attention is paid to movement at the level of the individual camp. In the course of research the itineraries of individual camps over a two-year period were collected. Both the Gabra and Rendille pastoralists distinguish between a major move from one locality to another and a minor move of 100 metres or so caused when sites become over-infested with flies and parasites due to an accumulation of dung. Here only major moves are considered.

In April/May 1980 the main camp of Rengumo moved a distance of about 23 kilometres from Korangagab to Kargi, where it has remained ever since. Table 118 and Map 22 illustrate the movement of *forr* camels attached to the Rengumo camp between April 1980 and March 1982. The general pattern consists of moving between the slopes of Marsabit mountain and the plains which lie to the west, and returning to the main camp at Kargi, usually during rainy seasons to celebrate the *sorio* rites.

Map 22. *Fora* camel movements from Rengumo camp, April 1980 to March 1982

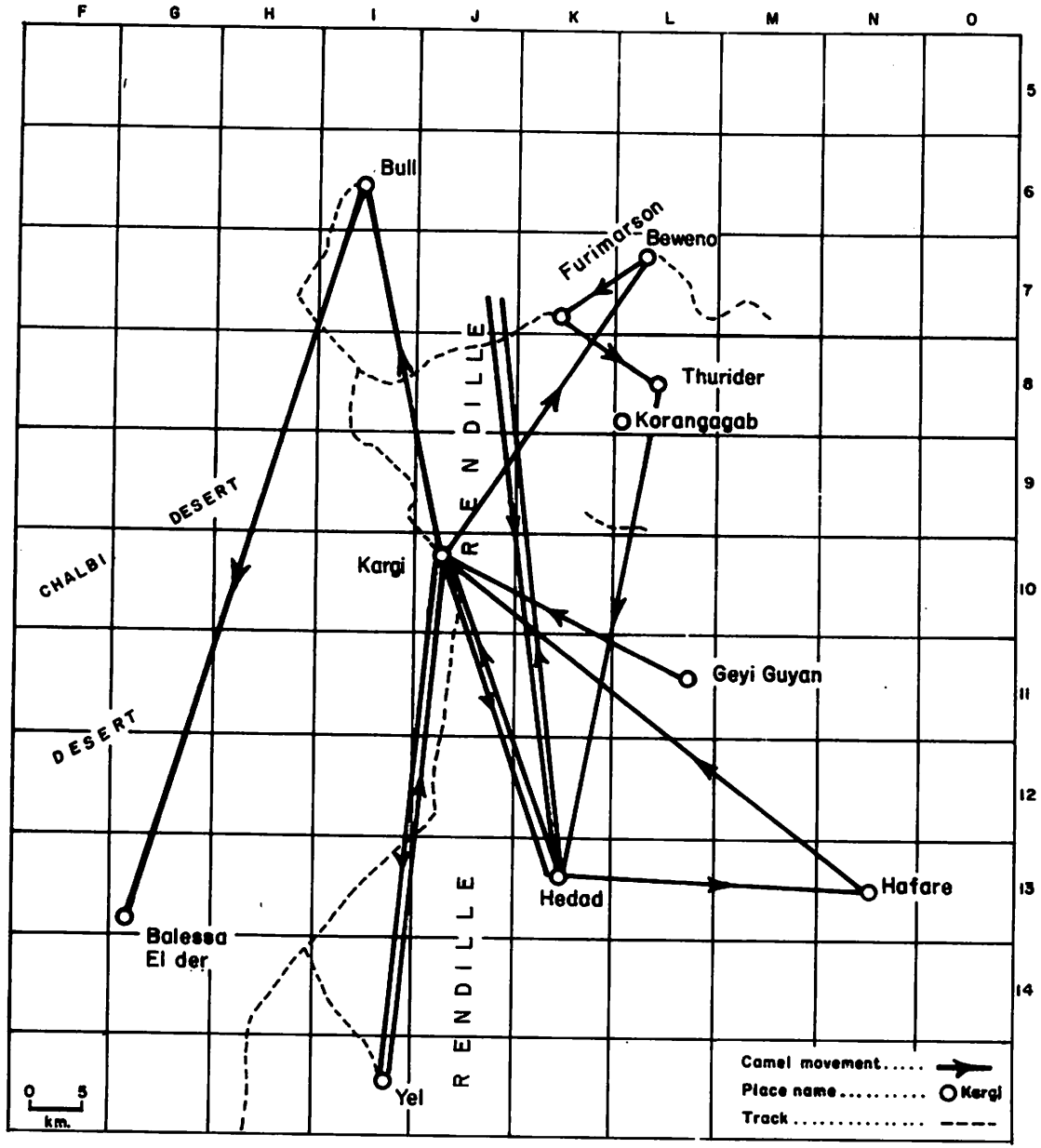


Table 118. *Forr* camel movement (Rengumo camp, April 1980-March 1982)[6]

From	To	Season	Distance (km)
Geyi Guyan	Kargi	Long rainy season 1980	27.5
Kargi	Yel	Long dry season 1980	53.0
Yel	Kargi	Long dry season 1980	53.0
Kargi	Beweno	Long dry season 1980	36.5
Bewebo	Furimarson	Long dry season 1980	11.25
Furimarson	Thurider	Long dry season 1980	12.5
Thurider	Hedad	Short rainy season 1980	50.0
Hedad	'on the lava'	Short dry season 1980/81	58.0
Hedad	'on the lava'	Long rainy season 1980/81	59.0
Hedad	Kargi	Long rainy season 1981	33.5
Kargi	Hedad	Long dry season 1981	33.5
Hedad	Hafare	Long dry season 1981	31.5
Hafare	Kargi	Short rainy season 1981	54.5
Kargi	Bull	Short dry season 1981/82	38.0
Bull	Balessa Ildere	Short dry season 1981/82	77.25

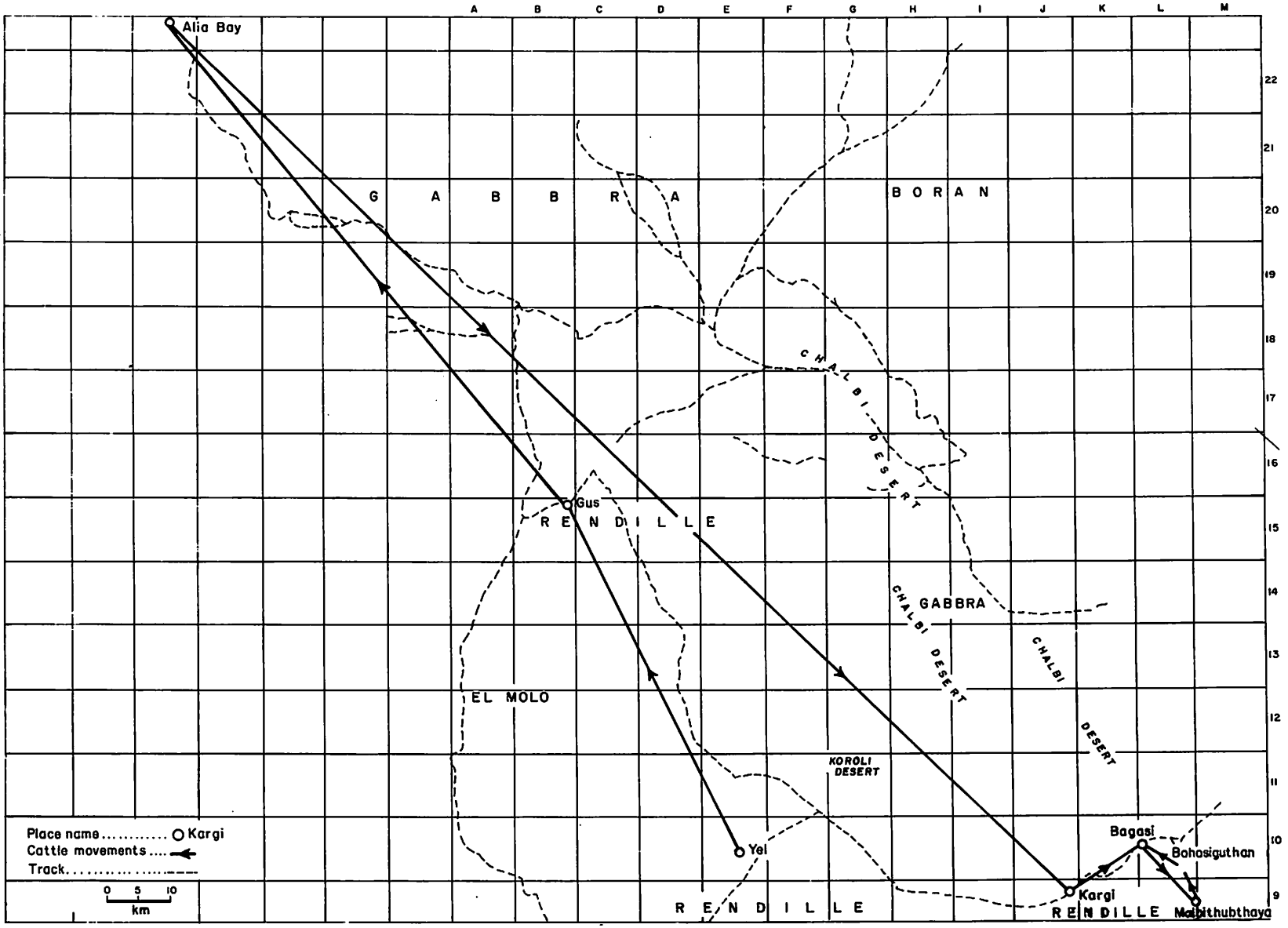
Distance travelled in the first year: 361.75 Km
Distance travelled in the second year: 268.25 Km

The long rains of 1980 failed and this led to a long drought which lasted until the long rains of 1981. At the beginning, the *forr* camels used the lower slopes of Marsabit mountains, but as the drought continued the tendency was to use the plains more and more. At all times the *forr* camels were watered at Korole, one of the major primary water sources of the Rendille.

During the same period the cattle *forr* moved towards Yel, Gus and Alia Bay, which is on the eastern shores of Lake Turkana and a fall-back area in drought periods, particularly for cattle and smallstock *forr* (Map 23 and Table 119).

[6]Distances between places are measured as the crow flies. Obviously, pastoralists when moving between camps may not necessarily follow the shortest route.

Map 23. *Forr* cattle movements from Rengumo camp, April 1980 - March 1982



8. Movement patterns

There are two distinct types of movement practised by pastoralists - *oscillineal* and *epicyclical* (Salzman, 1967). *Oscillineal* movement means regular migrations from one grazing zone to another on a seasonal basis. This type of migration prevails in certain parts of West Africa and the Middle East. *Epicyclical* movement follows no well defined pattern from one year to another. Movement decisions are situationally based within a context that provides few fixed parameters. The only fixed parameters in the Kenya IPAL environment are the primary water sources at Korole and Lake Turkana. The distribution of the rain which influences the state of the range is not fixed but varies from season to season.

Movement among the Rendille and Gabra follows in general an epicyclical pattern. The main clan sections of the Gabra - Algana, Gara and Galbo - have their own home ranges, whose boundaries are flexible, and all are permitted to use the home ranges of others. When rain fails to fall on any of these home ranges, the occupants move to the other home ranges. Movement between and within home ranges is usually unpredictable because of the uncertain nature of the climate. Nevertheless, since major mountain ranges such as the Hurri Hills usually catch some rain, movement towards those sections of the upper slopes which have received most rain is a regular occurrence in wet seasons. A similar pull towards mountain slopes during wet seasons was noted amongst the Kargi Rendille in 1982. When the rains come, the pastoralists who use the Kargi range - which stretches from the higher reaches of Marsabit Mountain westwards and north-westwards to Bagasi, Korole, Kurkum, Falam, the Hedad and beyond - moved their *forr* stock towards the mid-range levels of Marsabit mountain. Some pastoralists moved their camps there, but the greater number continued to reside at Kargi. As the dry season sets in, the cattle and smallstock *forr* were moved westwards and north-westwards to take advantage of water at Bagasi, Korole and Kurkum. Camel *forr* either migrated northwards towards Segel, or westwards to use pastures at Hafare or the Hedad. The pattern of movement of Kargi stock was different in the long rains of 1983 mainly because the plains received more rain in 1982 and consequently there was more use made of the plains and less use of the Marsabit slopes. In drought years smallstock and cattle *forr* are sent to Lake Turkana, or southwards towards Laisamis, Irrer and Ikerrai. Hedad is used mainly by camels in drought periods.

The cattle *forr* returned when the rains arrived in April/May 1981 to Kargi, and later they orbited around Bagasi, whose waterholes are important dry-season waterpoints for smallstock and cattle. The *forr* cattle moved slightly away from Bagasi during the short wet season of 1981. The smallstock *forr* of Rangumo camp followed a similar path, going to Alia Bay during the drought and returning to Kargi in the long wet season of 1981. However, on returning to the home range the *forr* smallstock moved over longer distances than the cattle *forr*.

Table 119. *Forr* movement (Rengumo camp) April 1980-March 1981

From	To	Season	Distance
			(Km)
Yel	Gus	Long rainy seasons 1980	61.75
Gus	Alia Bay	Long dry season 1980	100.5
Alia Bay	Kargi	Long rainy season 1981	201.0
Kargi	Bagasi	Long dry season 1981	14.0
Bagasi	Malbithubthaye	Short wet season 1981	13.25
Malbithubthaya	Bohosiguthan	Short wet season 1981	5.5
Bohosiguthan	Bagasi	Short dry season 1981/82	8.0

Distance travelled in the first year: 162.25 km
Distance travelled in the second year: 241.75 km

The camel *forr* which remained in the Kargi home range moved over longer distances than the cattle and smallstock *forr* during the drought year. In addition, the camel *forr* moved camp more frequently. Finally, this example illustrates clearly that although many Rendille main camps move little, their *forr* stock are quite mobile and cover long distances, particularly in years of drought.

Any effort to predict movement amongst the Rendille and Gabra precisely, beyond underlining the tendency of some to use mountain ranges in wet seasons, is doomed. It is not possible to establish ranges smaller than tribal units within which a particular group of pastoralists confines movement.

10. Pastoral Economy

The pastoral economy is based on an aggregation of individual households, their labour and herds. Heads of households, in conjunction with other heads, make decisions about herding and husbandry. In a situation of erratic and localized rainfall it is necessary that the household head has the freedom to make decisions about the care and movement of his stock.

Part of the response is the division of household stock into separate camel, cattle, and smallstock herding or grazing units, as well as dividing stock into home-based and *forr* animals. This diversification and specialization increases the labour demands of the households. The Rendille solve this in part by collaborating on a large scale with others, who are frequently co-residents of the same camp as well as being either agnates (close or distant), maternal kin, or affines. In other instances households short of labour but rich in livestock adopt children and teenagers from poorer but larger households.

Tables 120 and 121 give details of the allocation of labour in town and country camps respectively. In both country and town the majority of herders are involved in taking care of smallstock. Of the remainder more are herding camels than cattle. This reflects the composition of Rendille herds (Table 122) Sheep and goats are the mainstay of their economy. Although the camel is their prized beast many houses have few camels. Because of the better prices fetched for cattle many seek to acquire them. The young children are responsible for young kids and lambs, which use pastures close to the camp; older children and teenagers care for older kids and lambs, calves (cattle and camels) as well as the adult smallstock (sheep and goats); teenagers and adults herd cattle and camels. The statistics from Kargi relate mainly to herders who were at *forr* at the time of the research. It is worth noting the high percentage of females at *forr* particularly from the 15 - 19 age category.

Table 120. Occupational Structure of 4 camps at Kargi

	0-4 M	0-4 F	5-9 M	5-9 F	10-14 M	10-14 F	15-19 M	15-19 F	20-24 M	20-24 F	25-29 M	25-29 F	30-34 M	30-34 F	35-39 M	35-39 F	40-44 M	40-44 F	45-49 M	45-49 F	50-59 M	50-59 F	60-69 M	60-69 F	70+ M	70+ F	Total	% of Total
Total population	68	68	38	26	41	27	35	30	20	16	27	28	20	15	19	26	27	8	18	18	19	21	17	12	14	23	681	
Camel herding			2	1	11	6	13		5		6		6				1				1						52	7.6
Cattle herding			1		2			4	1		3				1		1										13	1.9
Small stock herding			6	4	9	12	13	23	8	4	5	2	8		3		7		5	1	2		1				113	16.6
Total No. herding			9	5	22	18	26	27	14	4	14	2	14		4		9		5	1	3		1				178	26.1
% Herding				19.2		66.6		90		25		7.1								5.6				8.3				
		23.7			53.7		74.2		70		51.9		70		21.1		33.3		27.8		15.8							
Number schooling	6	7	15	8	17	4	8		1	1	1			1													69	10.1
% schooling		10.3		30.8		14.8		0		6.3				6.7														
	8.8		39.5		41.5		22.9		5		3.7																	
Non-pastoral occupation						1			5		11		4		13		6		6		5		1				52	7.6
%						3.7																						
									25		40.7		20		68.4		22.2		33.3		26.3		5.9					

(O'Leary unpublished)

Table 121. Occupational structure of 4 country camps

	0-4 M F	5-9 M F	10-14 M F	15-19 M F	20-24 M F	25-29 M F	30-34 M F	35-39 M F	40-44 M F	45-49 M F	50-59 M F	60-69 M F	70+ M F	Total	% of Total
Total population	76 65	46 32	42 31	47 42	34 22	46 27	33 27	14 21	34 14	18 17	17 37	21 16	15 20	821*	
Camel herding		3 1	21 8	17 7	11	13	7			1				89	10.8
Cattle herding		1	3	4	5	7	4							24	2.9
Small stock herding		2 3	12 19	17 30	7 5	16	10	6	14	6 1		1		149	18.1
Total No. herding		6 4	36 27	38 37	23 5	36	21	6	14	7 1		1		262	31.9
% Herding		12.5 13	87.1 85.7	88.1 80.9	22.7 67.6	78.3	63.6	42.9	41.2	38.9		4.8			
Number schooling		2	1	3	1									7	9
% Schooling		4.3	2.4	6.4	2.9										
Non pastoral occupation				2	8	7 1	4	2	2				1	27	3.3
%				4.3	23.5	15.2 3.7	12.1	14.3	5.9						

(O'Leary unpublished)

* Ages of 6 males and 1 female unknown but included in total.

Table 122. Stock holdings of town and country households (57 town households at Kargi and 49 rural households).*

Camel holdings

	NK	0	1	2	3	4	5	6-10	11-15	16-20	21-25	26-30	31-40	41+
Town households	11	18	0	0	0	0	2	9	3	5	2	2	1	4
Rural households	1	3	1	0	1	3	1	11	16	5	2	3	2	0
Total	12	21	1	0	1	3	3	20	19	10	4	5	3	4

Cattle holdings **

Town	NK	0	1	2	3	4	5	6-10	11-15	16-20	21-25	26-30	31-40	41+
Town households	10	36	0	0	0	1	0	1	2	2	1	1	1	2
Rural households	0	31	0	1	2	1	2	5	2	3	0	1	0	1
Total	10	67	0	1	2	2	2	6	4	5	1	2	1	3

Small stock holdings

	NK	0	1-20	21-50	51-70	71-100	101-150	151-200	201-300	301-400	401+
Town households	6	6	1	10	5	7	6	3	7	3	3
Rural households	4	1	0	3	2	7	10	5	13	3	1
Total	10	7	1	13	7	14	16	8	20	6	4

(O'Leary unpublished)

* A household is defined as the smallest domestic group which owns its own independent small stock flock.

** One of the rural camps consisting of 18 households lost all its cattle to a raid in the 1970s and possessed no cattle at all at the time of enumeration.

In the town camps camps a higher percentage of the children are at school, the majority being boys. This in turn has meant a loss of their labour in herding.

Married men with young children herd smallstock and cattle but rarely *forr* camels. In general the main task of adult men is managerial (supervising the herding operation and advising young herders where the most suitable grazing is to be found) and frequently they also dig and maintain wells. Women are the principal milkers of cows, sheep and goats when at the main camp. The ideal milkers of camels are boys, and married men are only allowed to milk camels in the early stages of lactation when celibate.

Data collection and analysis continue with regard to research into the number of stock of each species (camel, cattle, sheep/goats) owned by households[7]. However, Table 122 illustrates the animal wealth of 57 town households (at Kargi) and 49 rural households.

There is a complex set of unwritten rules governing when the different species of animals ought to be milked and suckled, when they ought to leave for pasture, when they ought to return to camp, the frequency of watering animals, etc. The routines change between wet and dry seasons. In wet seasons, for example, animals are brought home during the early part of the day to be milked and returned again to the pastures. In the dry season, labour requirements increase, particularly if there is need to dig, maintain, and lift water from deep waterholes. When smallstock are up to 30 kilometres from water the round trip for water takes three days. Depending on their distance from water, camels can be away from 1-3 days. Households heads try to ensure that all the different animal species are not away from the camp at the same time, otherwise its residents would be without a continuous supply of milk. Women are primarily responsible for fetching water for domestic use, a task which proves burdensome and tiring and involves walking long distances with pack animals every three days if the camp is situated far from water.

The pastoralists bring to their tasks skills and knowledge about the characteristics and needs of the different animal species, the vegetation types most

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[7] A household is defined as the smallest domestic group which owns its own independent smallstock flock.

suitable for them, and a map of the rangelands consisting of the vegetation and water inventories of particular grazing sites. Pastoral craft is acquired through a long apprenticeship.

In wet seasons the diet of rural pastoralists who have sufficient animals in milk consists of milk and tea only. Surplus milk is processed and made into yoghurt and ghee[9].

As the dry season sets in, maize becomes a necessary supplement to the diet of the older children and adults. Adults then drink tea with less milk but with generous amounts of sugar. Pastoral households slaughter a number of animals in a year for meat. The preferred animals are male sheep, male goats, female sheep, and female goats, in that order. Cattle and camels are rarely slaughtered and only then by rich households and in times of drought. A variety of events are occasions for slaughter - hunger during dry seasons and droughts, hospitality towards visitors, post-natal sustenance, nourishment for the sick, family rituals such as the *sorio*, etc. The richer households slaughter up to twenty smallstock in a year.

The exchange of different types of rights over animals between households is common. One such practice consists in lending and borrowing milk animals. Another involves lending and borrowing female animals, the male progeny of which belong to the beneficiary. The female animal and its female progeny can be recalled at any time. Outright gifts of animals also occur. Most transfers of rights over stock occur between close kin and friends.

In conclusion, pastoral households are joined in a network through which rights over stock and labour, and information on the state of the rangelands, circulate. It is a network which is based on kinship, affinity, and friendship; celebrated in ritual; strengthened by inter-visiting and essential for the smooth running of the pastoral economy. It is a network which is controlled by the old, and this gerontocracy creates tension between adjacent generations. The old control the stock and make the major decisions in herding and husbandry; the young have to wait long for their own ascendancy and control over viable herds.

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[9]The Rendille rarely make ghee.

11. Change among the Pastoralists

The Rendille are gradually moving out of their isolation and are very slowly becoming integrated with the national economy and policy, in which they still possess marginal status. This trend is motivated by a growing awareness that total reliance on pastoral nomadism will not provide all with sufficient insurance against drought nor the economic base necessary for the improvement of living standards. (Table 120 and 121 outline the number involved in non-pastoral activities in camps studied.)

The severe droughts in the 1960s and early 1970s were turning points. The losses of livestock incurred then pushed many households out of the nomadic way of life because they no longer possessed minimum subsistence herds. These destitute households flocked to trading centres such as Kargi, Korr (which was established in the early 1970s), Loglogo, Laisamis, where church and state provided famine relief as well as schools, clinics, and water. The drop in livestock numbers displaced a number of livestock owners and herders and some consequently went to Nairobi and other urban centres to obtain low-paid jobs while leaving their wives and children, more often than not residing at the trading centres back at home. According to the 1979 population census 1,938 Rendille lived outside the district. Households with few livestock send children to school in the hope that eventually they will obtain better-paid jobs and thereby increase the household income.

Sending children to school and labour migration are part of the strategy to diversify the economic base of the household. Another form is to open up gardens on Marsabit mountain. More and more Rendille are engaging in cultivation. In addition, residents of Ulanula keep cattle in order to sell milk in Marsabit town. Rendille also sell firewood in Marsabit and their labour in the gardens of others for cash or food. A small number of pastoralists engage in trade as a means of increasing household income.

However, not all pastoralists have turned to non-pastoral sources of income. A number of destitute pastoralists living in trading centres were assisted by the missionaries with gifts of animals to enable them to return to a nomadic way of life. In North Horr alone about 70 households were helped in this way.

The drive to diversify the economic base of the household has drawn the Rendille into a variety of activities: sending children to school, labour migration, cultivation, marketing milk and firewood, local employment, etc. Although pastoral nomadism is still seen as the main occupation and a major focus of investment, even by Rendille wage earners, it has lost its status as being the only means of livelihood.

In the new frame of things trading centres assume added importance because they provide services which are in demand: schools for children, minimum health services, some job opportunities, marketing and shopping facilities, opportunities to trade, water and security. Women who live at trading centres need no longer walk long distances to fetch water. In North Horr and Kalacha, women use this newly found freedom to manufacture handicraft items, an industry which has been organized by missionaries. This provides a supplementary source of income, particularly for destitute households. In addition, in most trading centres some of the women attend adult-literacy classes and organize women's development groups.

The desire to improve the standard of living of the households, the search to diversify its economic base, and sedentarization are three inter-related processes. Drought in the late 1969s and early 1970s was a major factor in causing Rendille nomads to settle at trading centres. During this period many households lost a high proportion of their stock and no longer possessed minimum subsistence herds. Consequently they were forced out of the pastoral economy. At the trading centres church and state provided famine relief. The churches also, as already noted, provided schools, clinics and, in some instances, water.

The Rendille began to appreciate these services and the higher living standards they afforded. Destitute households no longer required the labour of all their children, and so began to send some of them to school in order to obtain a foothold in the wider economy. Women appreciated having waterpoints close to their camps and were reluctant to return to the nomadic way of life, which involves walking long distances in dry seasons to fetch water for domestic use. Nowadays, young Rendille women long to marry men who have low-paid jobs in Nairobi, because of the financial security it

promises, and usually, but not always, wives of labour migrants reside at trading centres. Fewer and fewer young women are being trained in loading and handling pack camels, crafts essential for nomadic women.

Overall, a noticeable trend amongst the pastoralists of the study area is the tendency for main camps to limit their movement or become totally sedentarized. The trend is more in evidence amongst the Rendille. Nonetheless more and more Gabra pastoralists are confining their migratory orbits within easy reach of primary and secondary water sources[10]. The increase in the number of secondary water sources enables the Gabra pastoralists to open up occasionally-used rangelands, while allowing them at the same time to limit the distance they cover in a year. Reduced movement of the main camp is usually compensated for by keeping *fora* stock mobile. This seems to be a generalised adaptation of pastoralists to a modern and changing situation.

12. Water Management (Rendille)

The person who initiates the digging is regarded as the owner of the well (*et wor leh*). As he digs deeper he will usually acquire the assistance of others (*thothi wor islekhuto*). Two to six people may collaborate in establishing a well, and these frequently reside in one and the same camp. Wells provide water mainly for human consumption, cattle, smallstock and camel calves too weak to travel long distances. A four-day cycle is established for the watering of smallstock and a two-day cycle for cattle. In instances where four people collaborate to build a well, each pair will be assigned one day in every two days for watering cattle and in addition each person will be given one day in every four days for watering smallstock.

When the original owner of the well temporarily abandons it and it becomes silted, any person who needs to use it can clean out the well. He is obliged to inform the owner of his actions and as a reward for his labour he will be granted rights to use the well to water his stock on a regular basis for the rest of the dry season.

Public water systems such as the Kargi water system (which consists of a borehole with water pump, storage tanks, water taps and water trough) are administered primarily by the chief.

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[10] A primary water source is defined as one from which large numbers of livestock can be watered without much labour, e.g. the large springs at the edge of the Chalbi desert A secondary water source is one from which a limited number of animals can be watered and usually much labour is involved, e.g. dug waterholes.

with the assistance of his committee and employees of the Ministry of Water development. To enlighten his work load the chief may decide to delegate his authority to regulate access to the taps and water trough to the Government water technicians.

When the diesel to run the water pump comes to an end frequently Rendille pastoralists co-operate to buy fuel which is used to water their own animals. Five litres are sufficient to keep the engine running for a day's watering.

13. Leadership Amongst the Rendille

In pre-colonial years two categories of secular leaders (*karnath*) were recognised - tribal and clan leaders. Only members of the Sale and Dubsahi clans became tribal leaders. This probably was due to the fact that these clans were the largest of the tribe. "People had respect (*inkanyit*) for tribal leaders and heeded their summons to attend tribal meetings." Within clans only members of particular lineages assumed leadership roles. These lineages were termed *yaf hi karnath delo* (groups which give birth to leaders). Table 123 gives a list of some of these lineages.

Table 123. Rendille ruling lineages

Clan	Section of the clan which produced leaders
Dubsahi	Wambile
Rengumo	Orbelle
Nahagan	Machan, Leba
Matarbah	-
Uyam	Basele
Sale	Kimogol, Fofen, Sanget, Hase, Bullo, Lito, Idhe, Orre, Orkhobesle
Urawen	Ogom, Ikimire
Galtheilan	Eisimfecha
Tubcha	Nayaba, Eisimgabana, Galale

The position of *karnath* was not hereditary. Candidates for the post had to be married and judged to possess leadership qualities. On occasions the implementation of decisions by these leaders was reinforced by a curse. The indigenous administration of the tribe was made all the easier since the Rendille moved all together *en bloc* over their range. In 1919, for example,

all the Rendille tribe occupied only 18 localised camps.

At the beginning of colonial rule the authorities identified headmen (who were unpaid) from all the pastoral camps of the Rendille. This multi-focused . system of government quickly gave way to a more streamlined approach with the appointment of a small number of paid headmen and sub-headmen whose authority rested ultimately on the mandate of Government of which the District Commissioner (D.C.) was the local representative. The worth of these headmen was assessed by their ability to do what they were told and to collect tax. It was an authoritarian administrative structure unlike the indigenous ruling system. Rendille clan and tribal leaders (*karnath*) were leaders amongst equals. The *karnath* could occasionally go against the will of the majority if he thought it fit to do so but there were certain limits to actions and decisions which constantly went against the consensus of the group. The headman system of rule was imposed on the indigenous system of government and it eventually sapped the latter of vital functions in judicial and welfare affairs. However, traditional leaders continued to regulate the ritual life of the tribe.

With the establishment of a more secure border the Rendille no longer moved en masse. Clans were no longer localised. The members of any one clan resided in a number of camps which were scattered widely. This weakened to a certain extent the clan leaders' control over their subjects. It also strengthened the power of the camp leader (*jaldab*) who had more direct contact with his subjects. In addition the number of camp leaders increased.

The headman (or chief) occupied an interfacing role between Government and the people. The role was not without internal conflict. In order to affect efficient administration the headman had to rely on the co-operation of Rendille elders and leaders. However when the D.C.'s orders were unpopular - as was the case with some of the grazing control regulations - headmen did everything to circumvent them with the connivance of the elders. This on occasions lead to the dismissal of the headman.

Since Independence the Government has increased the number of posts for chiefs and assistant chiefs, and thereby strengthened its control. Rendille look to Government chiefs to solve serious disputes, to maintain law and order, to seek famine relief in drought periods, etc. Chiefs form committees

to assist them in implementing Government policy. In Kargi, for example, each camp selected a representative to sit on the chief's committee. However, it seems that in other areas not all camps are equally represented.

In most instances clan members continue to recognise leaders who have influence throughout the clan and some clan leaders claim extensive authority within the tribe which reaches beyond their own clan. Any aspiring politician courts their support.

In everyday camp affairs - such as decisions relating to camp movement, who ought to be admitted to the camp, etc. - the camp leader (*jaldəb*) has the final say. Nevertheless he usually uses his power to veto with discretion. The movement of *forr* stock is primarily the responsibility of the *moran* herders. Elders only intervene when these stock have moved into areas of extremely high insecurity. Women play an important role in the distribution of livestock products (Beaman, 1983).

14. Administrative Structures for Development

The present district governmental structure consists of administrators and technical officers of a wide range of ministries. The administrative arm is central and consists of the District Commissioner (D.C.), District Officers (D.O.s), Chiefs and Assistant Chiefs.

The D.C. is responsible to the Provincial Commissioner (P.C.) of the Eastern Province and, through him, the President for the overall administration of The district. Marsabit District is divided into five divisions, North Horr division (occupied mainly by the Gabra), Laisamis division (resided in principally by the Rendille), and the Marsabit Mountain, Moyale, and Sololo divisions. D.O.s administer divisions and are assisted by Chiefs, who govern locations. Chiefs are assisted by Assistant Chiefs, who are responsible for sublocations. At district level there are technical officers of a variety of ministries involved in such activities as water development, livestock development, education, agriculture, forestry, co-operatives, commerce, health and social services, management of natural resources, etc. Some of these ministries also have officers at divisional level and junior personnel at locational level.

The key planning body of the district is the District Development Committee (D.D.C.). The D.C. is its chairman and the District Development Officer (D.D.O.) its secretary. The following are members: D.O.s, district technical officers, M.P.s, a representative of the Marsabit County Council, and representatives of traders, churches, and other interested bodies, such as IPAL. The D.D.C. operates within the guidelines of the district development plan, which forms part of the Kenya Government National Development Plan. The current plan runs between 1979 and 1983. Recently D.D.C.s have been given more autonomy *vis-a-vis* the allocation and use of funds received from Central Government.

While the D.D.C. can lay claim to worthwhile achievements in development, it is not without flaws. A reading of past minutes of the D.D.C. (Marsabit), reveals inefficiency in the administration of projects. Frequently officers are requested to implement certain decisions of the D.D.C. and at later meetings they either fail to turn up to report or produce lame excuses for inaction. In other districts, where public opinion is more vocal, M.P.s are under pressure to see to it that officers perform their duties more efficiently. Where funds which are allocated to particular projects are not spent within a specified time, they are returned to the Treasury. This has happened a number of times with the Marsabit D.D.C.

There are other problems. Many of the officers (district and divisional) are very far from their homes. Some come from the Coast Province, 1,000 km away. Many leave their wives and children in their home places. Frequently a posting in Marsabit district is regarded as a punishment for misconduct on duty elsewhere. Most officers do not know any of the local languages and have very little direct contact with the local nomadic communities. They tend to base their operations in and from trading centres. Frequently officers lack transport and/or fuel to move around the district. This is a major constraint on their efficiency.

When officers are appointed to divisional headquarters such as North Horr and Laisamis, they frequently fail to take up permanent residence at these posts, preferring to live in Marsabit town instead.

A major flaw in the district's development process is the total exclusion of leaders of the nomadic communities from Government development structures. Indigenous leaders - who have power in their communities - have no part to play in identifying, formulating or implementing development projects. This demoralizes them and makes impotent their local political structures. It also generates and maintains a communication gap between the majority of Government officers and the local nomadic communities. The committees of chiefs in some instances consist of residents of trading centres and the majority of the committee members are traders. The local trading community, because of its formal and informal contacts with Government officers and its representation on development committees, has influence in the development process. The locally elected politicians - many of whom are in business - are frequently caught in a conflict of interests between the nomadic and trading communities.

The fact that the Marsabit County Council - a body dominated by the trading community - rarely organizes auctions which would raise the price of livestock is a typical example of this conflict of interests. In summary, commercial and bureaucratic interests dominate the development processes, sometimes at the expense of the local nomadic pastoralists, who remain powerless.

The following quotation has some relevance in the Marsabit context:

"Successful desertification control, like all successful rural development, often involves giving those who are presently powerless the means to solve their problems, and this in turn is often threatening to commercial and bureaucratic interests" (Eckholm, 1982, p. 154).

V

MARKETING AND INFRASTRUCTURE

The study of the economic problems of pastoral nomads in the Rendille area of Marsabit started in January 1980 and continued until April 1982, when field work stopped.

1. Objectives of the Study

Broadly, the aims of the study were:

- to describe the economic relationships that exist within modern Rendille society and to check whether there are economic reasons for the trend towards overgrazing and degradation of rangelands;
- to make recommendations on the best strategy for maximizing sales of livestock from range areas under the control of the Rendille;
- to contribute towards the formulation of a management plan for the study area.

2. Methods of Data Collection

Various types of data were collected and a brief description of methods follows.

2.1 Literature review, participant observation, and informal interviews

Most of the literature by people who have studied the Rendille, Gabra, Boran, Samburu and other pastoral peoples of Northern Kenya and the Sahelian Zone was reviewed. At the same time the Rendille were observed in their *manyattas*, at animal sales, at shopping centres, and while grazing their animals. Informal discussions have been held whenever possible with individuals and groups of pastoralists, and their explanations sought for certain attitudes, beliefs and behavioural patterns. The views of missionaries, politicians, local administrators and researchers working among the Rendille were also obtained through interviews in the field or at seminars, and as opportunity arose.

2.2 Questionnaires

After about eight months in the field, the workings of the Rendille system were clear enough to warrant some quantification, and interview schedules were designed and administered as follows.

a. Traders

Thirty-three of a total of 37 traders operating at Laisamis, Korr, Kargi,

Ilaut, Ngurunit, Loglogo, Mt. Kulal, Loiengalani and South Horr were interviewed on their livestock and retail-trading activities during the 1979-80 and 1980-81 periods. Each interview related to a period from August of one year to July of the next.

The information sought included the following:

Livestock trade

(i) numbers of livestock bought and sold for the previous twelve months;
(ii) source of animals and supply situation;
(iii) distances and forms of transportation used to take livestock to the market;
(iv) losses from disease, theft and predators;
(v) buying and selling prices;
(vi) all costs associated with livestock sales.

Retail trade

(i) goods dealt in and their sources;
(ii) supply and transportation costs;
(iii) sales during dry and wet seasons;
(iv) buying and selling prices;
(v) all costs associated with the buying and selling of these goods.

Other information

(i) sources of working capital;
(ii) credit facilities available and used;
(iii) sources of marketing information;
(iv) other business interests;
(v) formal and informal business and academic training;
(vi) age and business experience;
(vii) main problems experienced in running business.

b. Livestock Marketing Divisions (LMD) activities in Marsabit District

These were monitored by attending all their auctions between July 1979 and March 1983. The information sought included:

(i) number, sex and weights of animals brought for sale and bought by the LMD;

(ii) number sold by traders and pastoralists;
(iii) distribution of sellers by place of origin;
(iv) age, weight and other conditions at sale;
(v) organization of the actual sales and purchasing activities;
(vi) views of traders, pastoralists and LMD officers about these activities.

c. Pastoralists

One hundred and nineteen pastoralists from all parts of the Rendille country were visited and interviewed in January and February 1982. The sampling procedure was non-random and included one or two households from each of the *manyattas* visited. The survey covered over 50 per cent of all Rendille *manyattas*. The following information was gathered:

(i) clan, age group of household head, age and sex of all family members;
(ii) distance of *manyatta* from the nearest trading centre;
(iii) income from sales of livestock and other sources for a period of 12 months;
(iv) attitudes to sales of livestock and the purchase of goods from shops;
(v) monthly money requirements during the wet and dry seasons;
(vi) ownership of items purchased from shops;
(vii) contacts with modern institutions such as hospitals, schools, veterinary officers and facilities, and visits to large towns;
(viii) attitudes to money and to the LMD traders, Government officials, politicians and missionaries.

d. Employed pastoralists

A one-year income and expenditure survey of most IPAL employees who were pastoralists or pastoralists' sons was conducted. The information sought included:

(i) age, educational background, family size and ownership of livestock;
(ii) sources of income every month;
(iii) savings and where held;

(iv) gifts of money to relatives and friends;
(v) items purchased and where;
(vi) purchases of livestock;
(vii) participation in traditional exchange.

2.3 Official records

Government and LMD reports on livestock sales and purchases from Marsabit District were reviewed. These, together with direct observation and information from questionnaires, gave the necessary statistical materials for describing the structure and efficiency of trade in the area.

3. Descriptive Analysis

3.1 Livestock as the main resource of the pastoralists

Except for occasional gathering of wild fruits and the hunting of wild animals, such as giraffes, for food, the Rendille rely on domestic livestock to provide direct subsistence and money for the purchase of products such as grain, cloth, and other goods which they do not produce. Animals have therefore a central role in the whole production process. They are a form of capital goods which are combined with water and forage to produce milk, blood, meat, and hides and skins for domestic use and occasionally for sale.

3.2 Acquisition of livestock

There are many ways of acquiring livestock, of which the most important are:

a. gifts;
b. inheritance;
c. contract - in exchange for labour, as compensation, or for bride price;
d. theft;
e. exchange.

a. Gifts

Most of the Rendille pastoralists acquire their animals as gifts. At birth, at circumcision, and at marriage, all Rendille men receive gifts of animals from relatives and friends. At marriage, women are assigned specific animals from their husbands' herds on a permanent or temporary basis. They also receive gifts from relatives and friends from both their parents' and the husband's side.

The nature and size of these gifts is determined by:

(i) custom, (ii) the character of the person receiving the gift, and (iii) the wealth of the giver, or by a combination of these factors. In some cases, as at circumcision, the receiver can apply pressure to increase the size of the gift - in this case by refusing to "wake up" from the circumcision position - until satisfied with the amount.

b. Inheritance

At the death of a household head, all the animals in his herd which have not been promised or given to some other person are inherited by his first-born son, subject to the condition that he should take care of his younger brothers and allow them to use the products of the herds.

c. Contract

If a pastoralist lends his bull to somebody without one, or agrees to look after another person's animals for a specified period, or borrows a milk animal from a friend, he receives payment in the form of livestock. The sex and type are fixed by custom, but there is room for negotiation about quality. At marriage, approximately eight camels and some smallstock are paid by the groom's family to the bride's family.

People who perform special duties, like blacksmiths, medicine men, midwives, and leaders in certain ceremonies, are paid for their goods and services in livestock. Lastly, in recent times money is increasingly being accepted as a means of acquiring animals by Rendille with non-pastoral sources of cash.

d. Theft

One of the quickest, if riskiest, ways of acquiring livestock is by theft. It is very uncommon for Rendille to steal from each other, but stealing from other tribes, especially in times of intertribal tension, is looked upon as a courageous and fully legitimate way of acquiring animals.

With the advent of modern government, raiding is actively discouraged but is still common in the study area. The risk of being caught and jailed is, however, discouraging all but the most daring warriors from exercising this option.

e. Exchange

Finally, it is possible to buy livestock by exchanging different types and species at traditionally determined rates. Tradition, for example, fixes the number of goats that can be exchanged for a male or female camel. It is not clear whether these rates are universal and permanently fixed or vary from place to place and over time.

3.3 Household implements

Table 124 shows some of the implements that are necessary to a Rendille household for the purposes specified. Some of these, like jerrycans, are bought from shops, but most are made locally within each household.

Table 124. Implements generally found in modern Rendille households

Item	Functions
1. Knives	Slaughtering animals, cleaning hides, eating meat, making leather straps
2. Assorted plastic, leather, wooden and metal tins, pots, bowls, and other containers	For carrying and storing water, milking, cooking, storage of meat, fat, milk, ghee, yoghurt, drawing water from wells for animals
3. Panga (matchet)	Making fences for livestock night enclosures, cutting thin branches for hut rafters and herding sticks, making saddles, lopping branches for livestock
4. Various tools (e.g. chisels, axes)	Digging wells, making troughs, livestock bells and wooden domestic utensils
5. Saddles	For harnessing camels and donkeys for various types of work
6. Ropes	For making houses, tying bells to stock, lashing loads onto and controlling load camels and donkeys
7. Spears and swords	For scaring off wild animals and helping in defence and herding; swords extensively used in eating of meat

In the past, metal implements and items of decoration which needed special skills, materials which were not available locally, or large capital investments which made it uneconomic for every household to purchase for itself, were bought either from other tribes or from specialists within the

tribe. In modern times this has been extended to the purchase of some of these items from shops.

4. Changes in Human and Livestock Numbers

4.1 Rise in human and livestock population

Change in the pastoral economy has traditionally been slow. Livestock and human population growth rates remained low because of constant disease, droughts and famines. Improvements in human and veterinary medicine and security brought about by modern government and missionary activities have changed this situation in most of the pastoral areas of Africa (ILCA, 1980). Taking the whole tribal group of the Rendille, large increases in numbers of people have been recorded since the beginning of this century, as shown in Table 125.

Table 125. Rendille population, 1909-1979

Year	Population
1909	1,687 (males only; total 3,500)
1919	5,414
1929	3,750
1939	6,713
1949	8,000
1959	15,628
1979	19,856

Source: Sobania (1979) and 1979 census data.

Figures for livestock population, are not available for comparison, but given that more people must have more animals to feed them and that the last 50 years have witnessed the control of large disease epidemics and some water development, it is reasonable to assume that the number of livestock has also increased.

It can only be observed here that area of land already overstocked and degraded is increasing, even though the level of veterinary activities in pastoral herds and their productivity is still very low (see discussion in the livestock resources section, above). Fortunately for us, the calculated carrying capacity of the area is slightly higher than the present livestock population.

Experiments carried out within IPAL indicate that the productivity of livestock with improved veterinary activity raises milk yield, growth rates, and calving rates and reduces mortality. It has also been shown that one of the main constraints on productivity is lack of enough fodder (see the livestock section). Improvements in range management should lead to fuller utilization of the production potential of the Rendille range. Coupled with an improved veterinary service, this is likely to lead to large increases in herd size.

4.2 The need to raise offtake rates

Using a simple herd-development model, it can be shown that the carrying capacity of the range will soon be passed unless a higher level of offtake from these herds maintains herd numbers at levels consistent with long-term carrying capacity (Njiru, unpublished). Failing this, such improvements will lead to an acceleration of the trend towards deterioration which is already evident around trading centres. A high level of offtake can be maintained if the Rendille eat more of their animals and/or can be persuaded to sell them. The first alternative is not very attractive and is unlikely to be successful. The Rendille diet of milk, blood, meat and some cereals is even now in excess of their requirements for protein (Field, 1979; FAO, 1971). In fact, one of the main problems with the Rendille diet is that they are getting a large proportion of their energy from proteins - a very inefficient process. Efforts to increase meat consumption are therefore not likely to result in significantly higher levels of offtake and may not even be desirable.

4.3 Advantages of raised sales

The alternative, increasing the level of sales, is more attractive, both to the Rendille and to Kenya as a whole, for the following reasons.

(i) Sale of animals outside the area relieves pressure on the land.

If sales are properly organized they can be increased or lowered as need arise.

(ii) Proceeds from the sale of these animals can be used to raise the standard of living of pastoralists through the purchase of goods from outside the pastoral economy. They can also be used to fund development projects aimed at making the livestock or the range more productive. By raising the incomes of pastoralists, such sales would reduce the level of, or even the need for, constant famine relief in the area. This would lead to the reduction of famine-relief expenditure by Government and allow funds to be deployed in more productive activities.

(iii) Sales raise the level of integration of the people into the national economy and lead to a greater level of commercialization. This is necessary if the Rendille are to make use of the many other goods and services which could improve their well-being but cannot be produced locally.

(iv) Animals go to other areas of Kenya where supplies of animal proteins are at present lower than the demand.

5. Sale of Livestock by the Rendille

The following section discusses the level of involvement of the Rendille in the selling of livestock. Potential for raising sales and present constraints on the realization of this potential are also discussed.

5.1 Outlets

Njiru (1982) has shown that sales of livestock by the Rendille are made through the following outlets:

(i) small traders operating shops in the centres of Laisamis, Kargi, Korr, Loglogo, Ngurunit, Ilaut, South Horr, Mr. Kulal and Loiengalani;

(ii) itinerant traders from Baragoi, Maralal, Wamba, Isiolo and other centres down country who come to the study area, buy livestock and trek or truck them out of the district;

(iii) traders and butchers at Marsabit Market who buy animals at the main market for transmission to centres down country or for slaughter in Marsabit.

Table 126 shows the total number of livestock and quantities of hides and skin estimated from a survey as having been sold by Rendille between August 1979 and July 1980.

Table 126. Estimates of total sales of livestock and skins by Rendille, August 1979 - July 1980

Item	Numbers	Price per item (KShs.)	Amount earned (KShs.)
Camels	0	501.90	0
Cattle	1,871	501.90	939,119
Goats	6,996	96.50	654,389
Sheep	2,588	96.20	248,964
Sheep skins	28,828	7.67	221,004
Goat skins	18,068	9.52	172,096
Hides	0		0
Total			2,235,572

Table 127 shows these as a percentage of total livestock population estimated for the whole Rendille area.

Table 127 Commercial offtake from Rendille livestock, August 1979 - July 1980[1]

Item	Numbers sold	Total population	% sales
Camels	0	18,976	0
Cows	1,871	36,104	5.2
Smallstock	9,584	126,623	7.6

[1]Two traders from Loiengalani and four from South Horr were also included. Since these areas are not covered in the total livestock population estimates given above, the % sales from the study area are likely to be less than this.

The total population of livestock is that for the management plan area, the Laisamis area, and the drought reserve (see livestock section). This is because these surveys covered all traders working among the Rendille. Table 128 shows that the commercial offtake from the Rendille area is quite reasonable. It is above the FAO 1971 estimate of 3% (FAO, 1971) and consistent with that achieved by pastoral nomads elsewhere.[1] Meadows and White (1971) found that commercial offtake for cattle ranged from 5.4% to 12.5% and averaged 8% between 1973 and 1977 for the Maasai pastoralists at Kajiado.

Table 128 shows the percentage of sales of female animals. Sales to itinerant traders and at Marsabit where sex composition was not determined are excluded.

Table 128. Sex composition of livestock sold by pastoralists to the LMD and traders interviewed, 1979/80

Item	Total sold	Males sold	%	Females sold	%
Cattle	1428	1355	94.9	73	5.1
Goats	5489	5348	97.0	141	2.6
Sheep	2030	1928	95.0	102	5.0

The proportion of females sold was very small, despite the fact that there must have been many females of culling age from Rendille herds, which have a very high proportion of females.

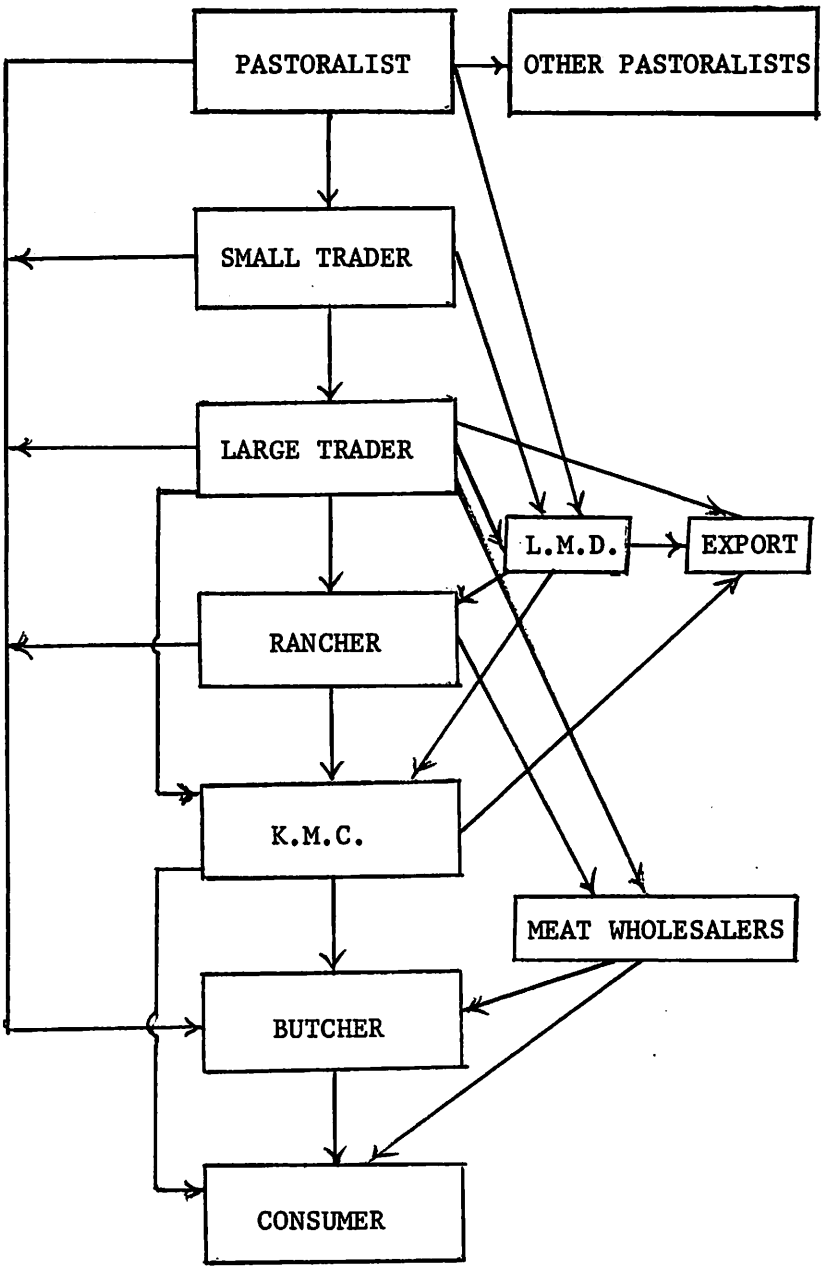
5.2 Organization of livestock marketing

The channels used for the sale of these animals and skins are discussed below.

a. Cattle-marketing channels

Figure 27 is a simplified representation of the various channels through which cattle and smallstock are marketed from the study area.

Figure 27. Marketing channels for cattle and smallstock from Rendille territory, 1983



KMC - Kenya Meat Commission

LMD - Livestock Marketing Division

Pastoral nomads sell their cattle to small traders in the trading centres near them or to itinerant traders who come to their *mantatta* looking for them. These small traders buy slowly over periods ranging from a few months to two years. When they have a satisfactory number of animals or when they hear of good prices they take animals to the larger towns, where they are sold to larger traders, the LMD or to slaughterhouse owners. The larger traders and the LMD sell their immature animals to ranches for fattening in the high-potential areas of the country. Mature animals are immediately sold to butcheries for slaughter. The meat is then sold to butcheries for sale to final consumers. Some of the large traders export live animals, while the Kenya Meat Commission (KMC) is the main exporter of meat from Kenya.

In Marsabit District, where the LMD actively buys livestock at least once every year, pastoralists may be able to bypass the smaller trader to sell direct to it. A few pastoralists also manage to sell their animals to Marsabit butchers for local consumption and even directly to the large traders at Marsabit market.

b. Sheep-and-goat-marketing channels

Until February 1983 the Government, through the LMD, was not involved in the marketing of sheep and goats. It was only involved in the slaughter of any sold to the KMC. However, in February and March 1983, the LMD bought smallstock from North Horr and Marsabit Division at very good prices. It is understood that these were for the export market. Due to the absence of fattening ranches for sheep and goats, there is little trade in immature stock.

As in the case of cattle, the small sheep/goat trader buys from pastoralists over a long period. However, when it comes to selling he has more options than the cattle trader. This is because transportation of smallstock to Nairobi or even further is quite easy and does not require trekking to Isiolo, and then trucking to Nanyuki by lorry and to Nairobi by rail, as is the case with cattle. Ample sheep and goat space is available on the many lorries going to Isiolo, Nairobi, or other towns down country for supplies or returning to them from a delivery trip to Marsabit. For charges ranging from as little as Shs. 30/- to Shs. 35/- per animal it is possible to

transport sheep to Isiolo or Nairobi. As a lorry takes between 100 and 200 sheep/goats, even a small trader can manage to take his animals to the markets of Dandora, Dagoretti, or Kariobangi and sell directly to butchers, thus bypassing the large traders.[2] On the other hand, he can trek the animals to Marsabit, Isiolo, Maralal or Baragoi and sell to large traders and butchers there. Pastoralists who live near Marsabit or even as far as Kargi and Loglogo also take their animals to the town and sell them to butchers and large traders directly. The large traders sell to the KMC and slaughterhouses. A few export smallstock to the Middle East.

c. Sheep-and-goat-skin marketing channels

Trade in sheep and goat skins has the simplest channels, as shown in Figure 28. Pastoralists sell to small traders at the nearest trading centre, who in turn sell to larger traders in larger towns. The skins are then sold to tanners or to exporters. The former sell some of the tanned leather to local shoes manufacturers and export the rest. Some large traders in Nairobi export unprocessed hides and skins.

Since the value of skins is very small per unit of sale, very few pastoralists undertake journeys to Marsabit or other large towns to sell a skin, and even if they are near the town they sell to the smaller hides-and-skin traders. On their part, large hides-and-skin traders prefer to buy in large quantities from small traders, and discourage retail purchases from individual pastoralists. It should be noted that among the Rendille the number of hides sold is very small. This is because hides have a very high value as bedding. The price offered by traders is often unattractive because the hides are often of low commercial value due to excessive branding.

5.3 Organization of retail-goods marketing

Livestock sales are made for the purpose of obtaining money, which is then used to purchase goods and services that pastoralists cannot provide or that they would rather buy. In the Rendille area the main items purchased are posho (maize-meal), sugar, tea, clothes, tobacco, shoes,

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[2]The size of the load depends on whether the lorry has one or two decks.

cooking pots, water containers, beads and other decorative items, veterinary and human medicines, pangas and knives. Ownership of these items is quite widespread in Rendille households. Some of the money is also used to pay school fees.

Figure 28. Marketing channels for sheep and goat skins from Rendille territory, 1979/80

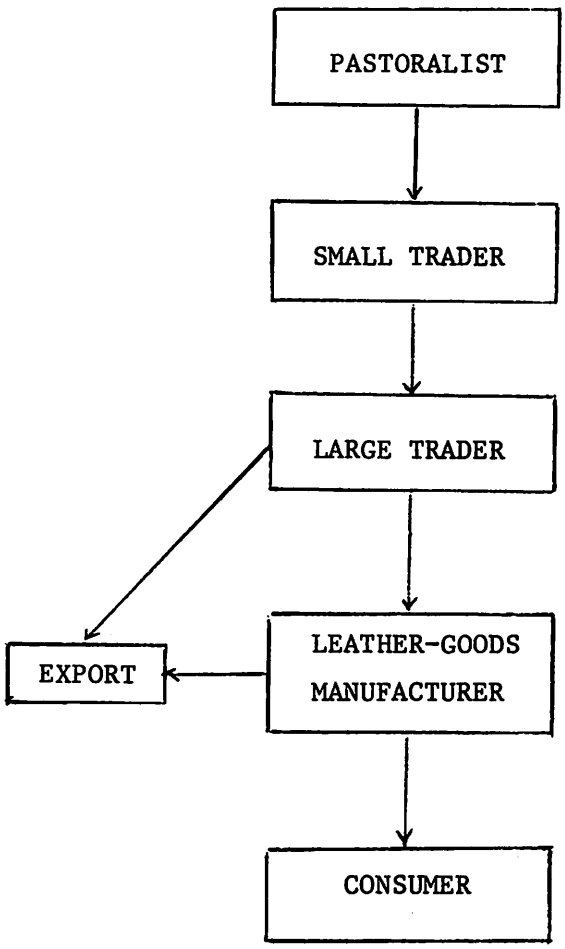

Table 129 gives an idea of the ownership.

Table 129. Ownership of selected purchased items by a sample of 119 Rendille households, 1981

Item	% owning
Cups	99.2
Plates	86.6
Spoons	94.1
Jerrycans	80.7
Cooking pots	97.5
Drinking glasses	20.2
Bowls	39.9
Mattresses	5.8
Clocks	5.3
Torches	72.6

Cups are most popular, followed by other domestic utensils like cooking pots, spoons, and plates. Jerrycans and torches are also quite popular.

As trading centres are few and far between, most pastoralists can only buy what is on the shelves of the few shops in the centre nearest to them. If these are not well stocked, as during a shortage, things to buy will be few. Since pastoralists sell animals in order to buy shop items, one would expect low sales of livestock during a period of shortage and higher sales when the shops are well stocked. Indeed, 78.8% of the traders answered in the affirmative when asked whether the willingness of pastoralists to sell animals is related to the availability of well stocked shops in their area.

Following this logic one would expect a close correspondence between the values of retail goods sold and proceeds from livestock sales in the area. For the sake of brevity this analysis will focus on the six most important commodities bought by pastoralists: posho, sugar, tea, clothes, tobacco, shoes. Together they account for over 90% of the value of items sold in some of these shops.

a. Posho

From the point of view of both the trader and the pastoralist, posho is the most important of these commodities. It is used to supplement supplies of livestock-based foods, which are very often insufficient in the dry season when livestock produce little milk, the pastoralists' staple food. At the height of a drought posho is the main food in practically every household that has access to it. Contrary to suggestions that pastoralists eat posho only in times of stress, a study of the expenditure patterns of employed Rendille shows that families with enough camels, cattle, and smallstock to provide all their protein and energy requirements still buy posho even during the rainy season (Njiru, 1982b). Posho mixed with milk to form porridge is becoming increasingly popular among salary earners. However, when the money to buy posho has to be generated by sale of the more highly valued livestock, ordinary pastoralists may prefer to forego this luxury during the rainy season. Table 130 shows that average consumption for the 119 households sampled in 1982 fell from 4.5 kg in the dry season to 1.2 kg in the wet season per week.

During the periods February to April and July to October, when grazing is poor, posho is so important to business that some traders actually close their shops and go to look for it as soon as supplies run out. During these periods, which are also the periods when the bulk of livestock and skins sales are made, the main preoccupation of the pastoralist is with food.[3] If traders in a particular centre do not bring in any posho, pastoralists may actually migrate to places where it is available. As stated above, this results in fewer animals and skins being available for purchase by the traders concerned. All traders therefore try their best to maintain their stock of posho at these times. A dramatic example of this was seen in 1982 when because of a bumper crop the price of posho in Marsabit fell drastically while supplies to Kargi were very poor because the road between Kargi and Marsabit was bad. The result was that most of the Kargi Rendille moved to Hogichu near Marsabit.

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[3] Skin sales are higher during the dry season because this is the time when animals are eaten and when many die.

During the survey period (August 1979 to July 1980) traders indicated that when supplies were available they could sell (together) a total of 2,258 bags of posho in any one of the dry months. This is equivalent to about 2½ bags every day for the 29 traders who sold it.

b. Sugar

Sugar is another commodity in great demand. It is used in tea and for sweetening posho porridge. Studies on food consumption in these areas indicate that families near trading centres consume as much as half a kilo of sugar a day.[4] Average consumption figures for 1981 on a weekly basis are presented in Table 130.

Table 130. Average consumption of posho and sugar by 119 Rendille households, 1981

	Dry season		Wet season		*Dhube* season[5]	
	% of sample	Average per week (kg)	% of sample	Average per week (kg)	% of sample	Average per week (kg)
Posho	82	4.5	63	1.2	97.4	2.9
Sugar	100	2.5	100	2.4	100	2.3

Due to the fact that monthly sales are not high enough to justify the hiring of transport by individual traders, sugar is never bought on its own. Another explanation is that a full lorryload of sugar would require over Shs. 36,000/- and is beyond the reach of most traders interviewed. The usual practice is therefore to load a 7½ ton lorry with a capacity of 80 bags with 70 bags of posho and 10 of sugar.

[4] From unpublished data collected by Sabina Schwartz at Korr in 1979/80.

[5] In relation to food supplies the Rendille divide their year into three seasons. The *dhube* season is the period between the wet-season surplus and the dry-season deficit in food. In this season some families are quite comfortable but most are beginning to feel the effects of shortages.

As a result, although sugar is in great demand throughout the year, supplies in all centres are best during the dry season when the high demand for posho justifies constant trips to the bigger town for replenishments. Pastoralists have learned to drink their tea without sugar during the wet season. The 29 traders who sold sugar stated that they were able to sell a total of 407 bags of sugar or 14.1 kg per trader per day during the months when supplies were available.

c. The 1980 posho shortage

In the years of the survey there was a national shortage of posho. The study area is far from the main maize-producing areas of the Rift Valley and western Kenya. Distribution problems due to the large distances involved make posho shortages at Isiolo, Nanyuki and Meru, the main supply centres for northern Kenya, common even in good years. When there is a national shortage as in the survey period, the Government, through the National Cereals Board, a parastatal organization charged with the marketing of cereals, intervenes to ensure that remote areas of the country receive some supplies. In 1980 the shortage was so serious that massive imports of maize had to be made from outside Kenya. To ensure fairer distribution of imports and the little posho available from local sources, the provincial administration, through District Commissioners, District Officers, and Chiefs, were requested to clear applications for posho by any traders in their area before it could be sold to them by the Board and to ensure that there was no hoarding or overcharging.

Despite this Government intervention, sales of posho in the study area were very low and traders estimated that they were only able to sell the equivalent of two months' supplies under normal circumstances. The price of posho also rose fron an average of sh 1.50 a kilo in 1979 to an average of sh 2.57 a kilo in the study period.

Sugar supplies, which are influenced by the availability of posho, were estimated as being equal to four months' supplies. This is because, due to the scarcity of posho, traders loaded larger quantities of sugar per trip than they did when posho was plentiful.

d. Tea

Tea is another commodity that is very popular with pastoralists. Supplies in this period were again limited by Government rationing, as there was a national shortage of tea. Each trader could only purchase a maximum of 10 packets of 10 kg each per month. The 29 traders who sold the commodity indicated that they sold 273 such packets every month. Tea is so popular that on the many occasions when sugar is not available pastoralists will drink sugarless tea.

e. Tobacco

A large percentage of adult men and women in this area chew tobacco, which, as it does not grow in the area, has to be imported. In pre-colonial times supplies were acquired through camel caravans to Meru, where skins and livestock were exchanged for tobacco, millet, maize, and other agricultural foodstuffs (Sobania, 1979). In recent years traders have taken over this function.

Frequent trips to Meru are unnecessary, since a trader can buy up to one year's supply on one trip. The 30 traders who sold it estimated that their total monthly sales were 1.246 kg.

Traders in this area close their shops very often. This is usual when supplies of the main commodities are not available, when traders go to sell livestock in Marsabit or outside the district, or when they go for major supplies trips. As a result it is unlikely that these traders actually sold more than ten months' supplies of tobacco, posho and tea in the year.

f. Tyre shoes

Another popular item is tyre shoes. The many thorn trees in the study area make protection of the feet essential for herdsmen. Although traditional skin sandals exist and are worn by some people, sandals made of the remains of tubes and tyres are becoming increasingly popular. They last longer than the skin sandals and give more protection, as the sole is quite thick. The 26 traders who sold them indicated that pastoralists purchased a total of 536 pairs of shoes every month.

g. Clothes and items of decoration

Sales of decorative and non-essential items like beads, red ochre, trinkets, cloth, and clothes are highest during the rainy season.[6] This is the period when food purchases go down as grazing improves and livestock satisfy more of the pastoralists' food requirements. *Forr* herds also move nearer to main camps. Herding at this time can be done by young boys and girls, since animals do not go far from the night enclosure at *forr* or in the main camp, and surface water is abundant, making the tedious watering of animals unnecessary. People fall into a festive mood and day and night dances for young and old alike become common. They begin to concentrate on adornment and it is at this time that most men, especially morans, buy a blanket or several metres of material to use as a loose covering for the body. It is also at this time that the few women who wear manufactured cloth buy it.

During the four months of the wet season each of the 26 traders who stocked cloth and clothing sold approximately 70 metres of material per month.

[6]Only women and girls wear skin clothes and even among these, skins are increasingly being replaced by manufactured cloth. Despite this, few people have more than a pair of sheets. These are wrapped around the body, one for the lower body and the other for the upper parts at night, when visiting distant places, or when it is very cold. Replacements are usually made when the pair being used is torn, so that few people have more than one pair at a time. In addition, most elders, women, and girls also own blankets for use at night.

Table 131 summarizes the principal information on sales of retail goods.

Table 131. Quantities and values of commodities bought by Rendille, August 1979 - July 1980.

Commodity	Unit	Quantities	Values(Shs.)	No. of months when sold
Posho	90 kg bags	2,258	1,044,758	2
Sugar	100 kg bags	407	719,000	4
Tea	10 kg packet	273	444,500	10
Tobacco	kg	1,246	406,300	10
Shoes	pair	536	88,065	10
Cloth	metres	1,826	102,088	4
Total		-	2,804,711	-

Source of data: 33 traders

5.4 Marketing channels for retail goods

Figure 29 shows the marketing channels used for most retail goods. It involves small traders buying from a wholesaler, usually at Isiolo, Meru, Nanyuki or Maralal. These wholesalers in turn get their supplies from manufacturers in Nairobi and other towns, or even from abroad. Trade in a number of retail goods is under the control of the Cereals Board and the Kenya National Trading Corporation. These are parastatal organizations charged with the distribution of certain items such as maize meal, sugar, rice, soap, cooking fats, etc. at prices fixed by Government. They establish wholesale depots or appoint agents to act on their behalf in most large towns in Kenya. The lack of such depots in Marsabit District is partly responsible for the long distances travelled by traders on their purchases.

Figure 29. Marketing channels for retail goods among the Rendille 1979/80

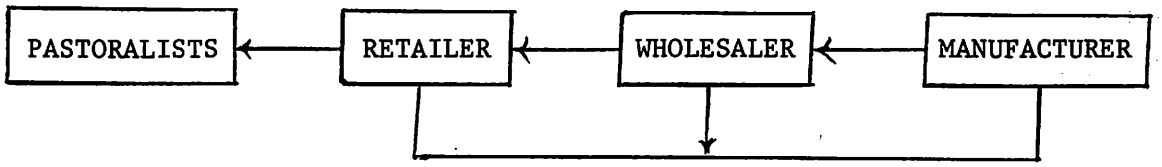

Table 132 shows that the maximum distances travelled are considerable. The minimum distances represent Laisamis and Loglogo traders, where local Marsabit wholesalers sometimes deliver posho and tea to the shops.

Table 132. Average distances travelled by survey traders to get supplies of retail goods, 1979-1980

Item	Average distance (return) (km)	Range (km)
Posho	462	36-1,022
Sugar	374	0- 732
Tea	200	0- 492
Tobacco	395	86- 492
Cloth	691	160-1,236
Shoes	780	124-1,236

Table 133 shows the amount of the main consumer items supplied expressed on a per capita basis.

Table 133. Per capita consumption of the five major retail items bought by Rendille, 1979-1980

Item	Amount purchased	Per capita consumption	National	Unit
Posho	406,440	16.8	118	kg
Sugar	162,800	6.7	14.1	kg
Tea	27,300	1.13	-	kg
Tobacco	12,460	0.52	-	kg
Cloth	7,304	0.52	-	metres
Shoes	5,360	0.22	-	pairs

It is immediately obvious that the per capita level of consumption of posho was indeed extremely low. This is partly explained by the fact that there was a shortage of posho in the country within this period and that most shops were able to supply these items for only a few months within the year, as shown under the column "No. of months when sold" in Table 131.

5.5 Food consumption and livestock sales in 1981

A sample of 119 pastoralists from households in trading centres and in *manyattas* easily accessible from these centres, interviewed in January-February 1982, indicated that 1981 was a much better year in terms of consumption.

Consumption of posho and sugar by the average pastoral household was as shown in Table 130 above. If this is expressed on a per capita basis each individual then consumed 30.7 kg of posho and 21.9 kg of sugar. This is less than the national figure for posho and higher for sugar. It also shows a marked increase in consumption of these two items over a period of only one year. The same group indicated that they sold livestock as shown in Table 134.

Table 134. Average sales of livestock per household by a sample of 119 Rendille pastoralists, 1981

	Dry season		Wet season		Dhube season	
	% of sample	Average number of animals	% of sample	Average number of animals	% of sample	Average number of animals
Camels	6.7	0.13				
Cattle	63.9	2.0	6.7	0.1	17.6	0.2
Goats	68.1	2.8	16.8	0.3		0.9
Sheep	34.5	2.0	6.7	0.1	8.4	0.2

When extrapolated to the total population, these average sales of livestock are seen to indicate higher levels of sales than in 1979-1980 (Table 135). Using the figure of 6 persons per household found in that survey (Njiru, unpublished) and taking the 1979 population census figure of 19,856 for all Rendille in Laisamis Division, the area covered by the original 1979-1980 survey, the number of households is 3,309. Extrapolating figures from Table 133 to the whole population, we get the total livestock-sales figures shown in Table 135.[7]

Table 135. Estimated total sales from Rendille territory using sample average for 1981

Item	No. sold	% offtake	% 1979/80 figures
Camels	430	2.3	
Cattle	7,611	21.1	407
Goats	13,237		189
Sheep	7,611	16.5	294

These sales of livestock are so much higher than for 1979-1980 that some explanation is called for. First, it should be noted that the first part of 1981 was much drier than 1980 and many animals died. The IPAL experimental cattle herd in fact recorded mortalities of over 28% (Field, 1981). This will have led to greater willingness on the part of pastoralists to sell animals. The higher figure for cattle sales would tend to support this, since cattle are affected more than other animals by drought. Secondly, cattle purchases by itinerant traders from the south and sales by pastoralists to Marsabit may have been underestimated. Thirdly, it may be that sales of livestock among the Rendille themselves are very high. Only sales to traders were recorded in 1979/80. To the extent that these animals are kept on the same range they do not represent offtake, but such sales are nevertheless important indicators of the level of commercialization of the people.

[7] A household was defined as a family including a man, his wives, unmarried children and dependents all of whom are dependent on his herds for subsistence.

6. Potential Offtake

Herd-structure figures quoted in the livestock-ecology section indicate that the proportion of castrated males in nomadic herds ranges between 10 and 30% for smallstock, is approximately 25% for cattle, and ranges between 9.3 and 14.5% for camels. It is well known that together with cull and barren females, castrated animals and excess bulls (both immature and mature) are kept for consumption, for ceremonial purpose, and for sale (Oba, 1982). In the absence of any estimates of consumption and ceremonial requirements, it is difficult to know how much is available for sale. However, assuming that consumption requirements are met by death, cull cows, and bulls, and that 50% of all castrates are too young or are necessary for ceremonial purposes in the case of smallstock and cattle, and that 60% are required in the case of camels, which are also used for transport, crude estimates of total potential offtake from Rendille herds can be attempted.[8] Taking the mean of the range of castrated males, we calculated potential percentage offtakes. These are presented in Table 136. Derivation of estimated prices is shown in section 7.1 for cattle and smallstock. Camel prices are from observation at Isiolo and in the study area.

Table 136. Estimated potential offtake from total Rendille herd and management-plan herd

	% offtake	Total Rendille herd	Potential offtake	Price per head	Estimated value
Smallstock	7.5	126523	9489	130/=	1,233,570
Cattle	12.5	36104	4513	730/=	3,294,490
Camels	4.8	18976	911	1000/=	911,000
					5,439,060

If it is assumed that sales in 1979-80 were the normal yearly sales and that the potential sales above would come on top of this, total potential offtake can be as in Table 137.

[8] Since camels last longer than cattle and smallstock the figure of 60% is high enough to take care of transport animals.

Table 137. Total potential offtake for the whole of the Rendille area

	% offtake[a]	Numbers	Estimated value
Smallstock	15.1	19,073	2,479,490
Cattle	17.7	6,384	4,660,320
Camels	4.8	911	911,000
			8,050,810

a. This was obtained by adding % offtake on Table 127 and Table 136. For cattle and smallstock this total potential commercial offtake is less than what seems to have been achieved in 1981 (see Table 135) and less than what is achieved by Kenyan commercial ranchers (Meyn, 1970). It is, however, unlikely that such a high offtake rate can be sustained under existing management. The more likely offtake figures probably lie between those on Table 127 and Table 137.

7. Constraints on Improved Commercial Offtake

The Rendille have traditionally been dependent on the livestock products milk, meat, and blood for food. Various scholars have shown that pastoralists must fulfil all the food and social requirements of their families and have some surplus to insure against the high risks of the pastoral way of life (Monod, 1975). The number of animals required to do this is quite high. Studies in the human ecology section have not yet reached a point where the requirements among the Rendille are accurately known. However, results from the 1979-1980 study of all Rendille sales and from the 1982 study of a sample of Rendille from nearby trading centres indicate that it is probably possible to raise the sales of a certain proportion of the herds, especially in the castrated mature and immature categories, quite substantially (Njiru, unpublished). It was suggested in the previous section that commercial offtake could go as high as 15.1% for smallstock, 17.7% for cattle, and 4.8% for camels.

This section examines some of the factors which militate against sale of livestock by the Rendille. All these factors negatively influence the desire to sell livestock, but it is not possible to quantify the specific impact of each of them at the moment.

7.1 Prices for pastoral products

The average price of the cattle sold by Rendille in 1979-1980 was KShs. 502, while that of sheep and goats was KShs. 93.50 and 96.20 respectively. Assuming an average liveweight of 250 kg for cattle, 35 kg for goats, and 33 kg for sheep sold, this translates to approximately KShs. 2.00, 2.65, and 2.90 per kg liveweight. The price of meat in a butchery in Marsabit Town was KShs. 10.40 for cattle meat-with bone and KShs. 13.70 for smallstock meat. Assuming a killing-out percentage of 50% and that sale of head, offal, hides and/or skins is enough to offset the butcher's costs, butchers could afford to pay KShs. 5.20 per kg liveweight for cattle (or 1,300/- per animal) and KShs. 6.85 per kg liveweight for goats and sheep (or 239/- for goats and 226/- for sheep).

Even assuming that butchers would want more profit than what they get from offal and the hide/skin sales, it would still be possible for them to offer at least 975/- and get 25% profit on the CDW value of a 250-kg cow and 179/- and 170/- for sheep and goats respectively. Allowing another 25% for the trader's gross margin, the pastoralist could still get 730/-, 134/-, and 127/50 for cattle, sheep and goats respectively. This would represent an increase of 45.6%, 39.3% and 36.4% on the prices for cattle, sheep and goats, then current. Recent retail price increases have further raised the potential product prices that could be offered.

On the retail side, the pastoralists paid a price of approximately KShs. 2.57 per kg of posho. The price of posho was therefore much higher than the price per kg. liveweight which the pastoralist received for his cattle and only slightly lower than the price for sheep and goats. As most of their income was spent on posho purchases this gave them very poor terms of trade. Most pastoralists know that meat is more valuable than posho and feel very bitter about these prices, which they consider unfair.

7.2 Few goods in shops

One of the most conspicuous characteristics of shops in the study area is the paucity of goods they offer for sale. Most shops stock posho, sugar, tea, cooking fat, tobacco, some pieces of cloth and clothing, a few domestic utensils, some shoes and ornaments and little else. Very few offer more than 30 different items, and the five items in Table 131 account for over 90% of the turnover in most of them.

When asked to give reasons why the number of goods they offered was so low, traders identified the problems shown in Table 138.

Table 138. Major problems faced by traders, 1979-1980

Problems	% of traders[a]
Lack of capital	42.5
Shortage of goods at wholesale sources	24.2
Transport problems	36.4
Lack of business knowledge	21.2
Giving too much credit	12.1
Price control	12.1
Lack of customers	3.0
Lack of skins licences	3.0

a. These percentages do not add up to 100 since some traders identified as many as 3 problems and some only one. However the table shows quite clearly that lack of capital, transport problems, and lack of supplies were the major problems.

7.3 Irregularity of supplies

These problems not only resulted in a small selection of goods being offered but in a very unreliable service. Large numbers of traders (97% and 66.7% respectively) indicated that they could only provide posho and sugar irregularly to their customers, and 89.9% of the sample of 119 Rendille pastoralists interviewed complained that they were never sure that they would get posho and sugar at the shops when they went there. Indeed, it is common for posho

or sugar to be out of stock in a trading centre for more than a month.

This irregularity in the supply of goods reduces the willingness of pastoralists to sell livestock, a fact already observed by 98.8% of the traders.

7.4 Lack of buyers for pastoralists' livestock

Even when pastoralists were willing to sell their animals they did not always get buyers; 74.8% of all pastoralists interviewed in 1982 indicated that in the course of 1981 there were occasions when they had wanted to sell livestock but could not get a buyer. They ended up eating the animal or, in the case of larger stock, exchanging it for livestock which are more convenient to consume over a long period. On the other hand none of the traders indicated that he ever wanted to buy animals and could not get supplies.

Although buyers for cattle, smallstock, hides and skins do exist, there are no markets for camels. Considering that the Rendille are traditionally camel keepers and that some families do not own cattle at all, this is a major drawback to camel owners. The few families who claimed to have sold camels did so to other Rendille who wanted them for some special purpose or took them to Kargi, Korr, Marsabit, or Laisamis, where they sold them to butchers or slaughtered them and sold the meat. In the dry season this happens occasionally in these places, but the numbers involved are not more than a few a month. There are few buyers for the meat and one pastoralist at Loiengalani got only 180/= from slaughtering a castrate camel. The rest of the meat had to be given away.

7.5 Poor demand for female animals

Table 128 shows that the number of females actually sold was very low. It is difficult to understand why this is so, as quite a number of females exist which could be sold, either because they are past their productive age or because they are barren, or poor mothers or milkers.

Four possible explanations for this are:

(i) that there is low demand for females among buyers. This is definitely true of the LMD, which does not buy any females because of management problems on the trek to Isiolo.

The LMD claims that females are too few to form a separate mob and when a few are trekked in a mob of several thousand males the males start mounting them, creating disturbance and even hurting them, at times fatally;

(ii) that the animals sold must be strong enough to brave the several-hundred-kilometre trek to the main markets at Isiolo, Maralal or Nanyuki, or even to the Athi River Meat Factory. Pastoralists cull females at such an advanced age that most are too old to make this journey;

(iii) that pastoralists have not yet accepted the fact that females of any description should be sold;

(iv) finally, it may be that the internal exchange values for females are higher than the prices offered in the market by traders. This is definitely true of fertile females. The position with respect to old culls and barren females is not clear.

It is possible that all the above factors contribute to the low sales of females. Although 61.3% of all pastoralists interviewed in 1982 indicated that they will sell any category of animals when in need of money, 23.5% indicated a reluctance to sell lactating and pregnant females. The proportion of those who will not sell females is, however, too small to be the sole explanation for the low sales of this category of animals.

7.6 High risks in the livestock trade

Because of lack of market news, traders are never sure that when they take their animals to a market they will find a buyer. The distances involved are usually so high that once the costs of trucking or trekking have been incurred the trader has to sell the animals at any price. It would not be profitable for them to return the animals. Another complication is the fact that, due to low capitalization levels, a large proportion of a trader's working capital is tied up in livestock and he has to keep up a high turnover to make any profits.

Because of the fact that most traders in northern Kenya buy their livestock in the dry season and try to sell them at the end of the wet season when they have improved in weight, it often happens that the main markets of Isiolo and Nairobi are flooded with animals at the same time. This depresses

prices. At such periods traders may have to hold their animals for long periods around these markets. The high incidence of disease due to the varying origins of the different animals and the lack of good grazing at such places leads to high weight losses and disease and/or high preventive drug costs. All this lowers the profitability of trading by reducing the prices actually received and/or raising the costs. This in turn makes traders unable and unwilling to offer high prices. Some traders actually go bankrupt for such reasons.[9]

7.7 Poor organization of the LMD at Marsabit despite their good prices to pastoralists.

The LMD purchases cattle about once every year at Marsabit. It offers prices which are very good for the small pastoralist but which a trader could get from ranches and butchers at Isiolo, etc. Table 139 shows the results of such purchases held in July 1980. Note that total purchases were over 4,000 head, but these are only Rendille animals.

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[9]One trader from Ngurunit lost 40% of his animals at Isiolo on a sales trip. Another Rendille trader lost all the money he had obtained by a loan when his goats died at Nyeri. This ruined him, since he still had to repay the loan.

Table 139. Origins of cattle sold to the LMD from the Rendille areas by traders and pastoralists in July 1980

Traders

Centre	No. of traders	%	No. of animals	%
Laisamis	5	38.5	109	43.6
Merille	1	7.7	13	5.2
Karare	2	15.4	13	5.2
Loglogo	2	15.4	93	37.2
Ilaut	2	15.4	12	4.8
Songa	1	7.7	10	4.0
Total	13	100.1	250	100

Pastoralists

Laisamis	71	32.7	107	30.4
Merille	9	4.1	14	4.0
Karare	66	30.4	113	32.1
Loglogo	21	9.7	29	8.2
Ilaut	7	3.2	18	5.1
Songa	11	5.1	17	4.8
Ngurunit	5	2.3	6	1.7
Kargi	11	5.1	13	3.7
Korr	6	2.8	2.8	7
Ilaut	3	1.4	8	2.3
Marsabit	7	3.2	20	5.7
Total	217	100	352	100

Note: Total cattle sales by Rendille were 602 head, of which 41.5% were sold by traders and 58.5% by pastoralists.

It is worth noting that of the 602 cattle from Rendille areas sold to the LMD, 41.5% were sold by traders. The price paid by the LMD per kg live-weight was Shs. 3/15. Though not as high as the price that traders could get at Isiolo, this is quite competitive, considering that trekking costs to Marsabit are much less. For pastoralists who only got Shs. 2.00 from traders, this was a fantastic price. Unfortunately, not many pastoralists or traders utilize the LMD purchases at Marsabit for various reasons. Among these are:

(i) They are very erratic in their requirements, making it difficult for sellers to know exactly what they want in advance so as to bring the right animals. In three consecutive purchases which have been observed the LMD have changed their requirements from buying both males and females to not buying any females;from buying males weighing no less than 120 kg to buying those only between 180 kg and 300 kg. Some pastoralists who had brought the wrong type of animals (which had been right in the previous auction) were very bitter when they were rejected. The LMD insist that animals purchased must be healthy and free from disease. If a notifiable disease is discovered during the auction, as happened in July 1981, the auction is closed. As the risk of discovery of such a disease is quite high, given that the cattle come from all over the district or even from neighbouring areas, traders can never be sure that, even if they buy just those animals which the LMD wants, they will be able to sell them.

(ii) There is no fixed time at which the LMD comes to Marsabit for the event; in 1980 they came in July, in 1981 in July and October, in 1982 not at all, and in 1983 in February. When they do finally come the notice given is usually about two to three weeks. Although the district administration publicizes the dates adequately, the notice given is too short for traders and pastoralists to be able to organize the trekking of animals from places far from the main road. Table 139 shows practically all the animals sold, with the exception of a few from Ngurunit, Kargi, Korr and Ilaut, come from centres on the main

Marsabit-Isiolo road or from near Marsabit. This reflects the short notice and the inability of people from places far from the main road to organize themselves in time.

(iii) The LMD takes periods of from two weeks to several months before paying for the animals purchased. For the small trader who has an empty shop waiting to be supplied from this money, this delay is extremely frustrating. For the pastoralist who may have travelled some hundreds of kilometres to sell animals, the long wait in Marsabit for payment may be disastrous to his herd, which may be mismanaged in his absence and the expenses incurred lower the desirability of such a sale in his eyes.

(iv) The LMD buys only cattle.[10] For the small trader who also trades in smallstock it would be more convenient if he could take all his animals to one point for sale. Now he has to send the smallstock down country, and if he is walking them it may be cheaper to send the cattle along than to send smallstock to Isiolo and cattle to Marsabit. The new trend of purchasing both cattle and smallstock is very encouraging in this respect.

(v) The LMD buys animals only once a year at Marsabit. While this is a central place for the district as a whole it is far from most actual places in the district. The once-a-year auction also means that there is only one opportunity for sale in 12 months, and this is likely to be too long for pastoralists or the small trader who needs a high turnover of his small working capital if he is to make a living. The recent purchases in North Horr and Laisamis should be continued.

7.8 Lack of capital among traders

Table 60 shows the starting capital of the traders interviewed. It shows that 84.4% of all traders started with less than 15,000 shillings. When this is compared with the Shs. 18,250/= required to organize a lorry trip of 70 bags of posho and 10 bags of sugar from Isiolo, Meru or Nanyuki, it is clear that few of the traders can afford to hire a lorry on their own.

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[10] In February 1983 the LMD for the first time bought both cattle and smallstock in Marsabit district. They also deviated from the pattern of only buying at Marsabit by going to North Horr, Dukana and Laisamis.

This forces them to organize joint supply trips and raises expenses, as all of them have to accompany the lorry and incur travelling and accommodation expenses.[11] No wonder then that 42.5% of them identified capital as their major problem (see Table 138).

The possibility of raising money through loans is not very high. Table 141 shows that indeed only 24.2% of the traders had ever received a loan in the 20 years between 1960 and 1980.

Table 140. Initial capital with which traders interviewed started business, 1979-1980

Amount (shillings)	% traders
1,001-5,000	34.4
5,001-10,000	34.4
10,001-15,000	15.6
15,001-20,000	9.4
20,001-25,000	3.1
50,000	3.1

Table 141. Loans to traders in the Rendille area since 1960

Year	60	67	70	73	74	75	80	Total
% traders who received loans	3.0	3.0	3.0	3.0	3.0	6.1	?	24.2

Even those who received loans did not benefit very much, as the amounts received were very small.

[11] Traders hire vehicles after acquiring enough goods because purchasing can take a long time, due to shortages. Discounts from regular suppliers and the fact that additional lighter commodities like household goods can also be transported with the posho and sugar at no extra cost make the presence of each trader essential.

Table 142. Amount of loans received by traders in Rendille territory since 1960

Amount (shillings)	2,000	4,500	6,500	8,500	10,000	20,000
% receiving	3.1	9.1	3.1	3.1	3.1	3.1

Table 142 shows that the amounts received were usually less than Shs. 10,000/- and did not improve the financial position of the recipient to any great extent. One of the main reasons why these loans were so few and so small is that almost all of them were given by the District Joint Loans Board. This Board has to spread a small grant given to it by Government over as many traders as possible. There were at the time of survey no financial institutions like banks in Marsabit.[12] These are able to give larger loans and indeed the only sizeable loan (20,000) reported by a trader was given by a commercial bank from Nanyuki.

7.9 Inadequate business training

The educational level of the traders in the study area is quite low. Table 143 shows that although 12.1% did not answer the question on education, 45.4% had never been to school and only 6.1% had secondary school education. Most of the traders therefore are people who can only increase their business knowledge from the extension service, since it can be assumed that they are not literate enough to study books on business management. In fact the standard of business management in the area is very low. Few traders keep books and many do not know what amount each item contributes to their profits, since their costing system is very arbitrary. As a result the business-failure rate, especially among Rendille businessmen, is very high. The Somali, who have a firmer business tradition, do slightly better. Despite this, there has been very little contact between the traders and the Ministry of Commerce and Industry's extension services. Over the 20 years between 1960 and 1980, only 21.2% of the traders had ever attended a business course

[12] Again it is noted that the subsequent opening of the Kenya Commercial Bank branch will hopefully remove this constraint.

organized by this ministry. These courses usually last from one to two weeks and teach basic accounting, pricing and business methods. Those who attended such courses found them useful.

Table 143. Number of years of formal schooling by traders in the study area, 1979-1980

No. of years	%
0	45.4
1 - 4	9.1
5 - 7	27.3
12 +	6.1
No answer	12.1

7.10 Lack of market places

At Marsabit Town and in Isiolo, Wamba, Maralal and Baragoi, certain places in the town are designated as market places for livestock. Any trader or pastoralist wishing to sell or buy livestock therefore knows where to take them or where to go in search of them. This ensures that sellers and buyers meet.

In the study area no such places exist in the trading centres and it is not uncommon to find a pastoralist trying to sell a goat at one end of the village while someone else at the other end is searching for one in vain. This also make it difficult for traders who are not familiar with this area to trade, since they do not know where to get sellers. It also raises the costs of looking for animals and lowers profitability.

7.11 Poor trekking facilities on the routes to markets

At present, trekking routes to the main markets have not been developed. Facilities for watering and keeping the animals overnight do not exist. As a result, animals can be trekked to Isiolo only during the wet season when there are many surface pools of water along the route. The area between

Merille and Archers Post is particularly difficult, as there is little water and animals have to spend at least three days of continuous travel without it. In dry periods, weight loss on the trek can be drastic, leading to a loss of condition by the animals and to the lowering of prices and marketability. In the wet season this is less than 5% of the total weight of the animals before starting the trek.

Development of water and rest places on these routes would be very useful and could reduce the risk of weight loss and allow trekking at all times of the year. As it is now, animals can only be trekked after the rains. At other times trucking, which is much more expensive, is the only alternative.

7.12 Financial institutions

Studies of Rendille pastoralists who work for IPAL, the Government, and missions and of those who only earn money from the sale of livestock indicate that few pastoralists have cash savings (Njiru, 1982b). Most prefer to save 'on the hoof' because livestock on average give better returns than money savings, which, because of lack of banks (there is only one Post Office bank in Marsabit), would have to be kept in the house and would earn no interest. The cost of operating a savings account at Marsabit would also be prohibitive for most pastoralists, who live far from Marsabit and would have to incur transport and accommodation costs for every transaction. On the other hand, lack of reliable transport links with Marsabit means that one would not be able to withdraw money on demand and would be unable to respond to emergencies. Savings in livestock, on the other hand, do not have this disadvantage. Livestock can be used to pay for many goods and services directly or can easily be sold, albeit at low prices, to raise cash in an emergency.

It is also possible to borrow money on the security of livestock. In addition to this, investing in female or young animals gives high returns from offspring or increases in weight and/or value with time. An animal bought at the height of the dry season can usually be sold at one and a half to twice the buying price at the end of the next wet season. Many Rendille employee salary earners are increasingly investing in livestock either for sale or as a form of wealth.

Another form of monetary investment is giving gifts of money to relations and friends. These create friendship bonds and result in reciprocal gifts of livestock, often worth much more than the original money gift. They also perform the function of strengthening an individual's network of friends. This ensures that if he gets into difficulties he has friends on whom he can rely for help.

To the extent that there is an overstocking problem, saving in livestock can be said to be disadvantageous to society, since by creating a local demand for cattle it reduces the number of animals that would otherwise have been sold outside the system. Where some animals are imported, this compounds the overstocking problem. Alternative forms of savings would in such a situation help in getting the number of animals on the range reduced or in preventing growth in numbers from imports.

7.13 Poor road network

A road map of the Rendille area like Map 24 below shows that except for the Marsabit-Isiolo highway, which is supposed to be an all-weather road but is occasionally impassable during very wet periods, all trading centres are connected by tracks motorable in the dry season only. These are usually made by removing topsoil from the surface and they have no bridges or culverts to take care of the many laggas and streams that cross them. As a result most of these tracks are washed out during the rains and it becomes impossible for lorries or other non-four-wheel vehicles to reach the centres in the wet season.[13] As the tracks are repaired very irregularly, they are also in very bad shape in the dry seasons. Lorries using them often break down and this raises the cost of transportation.

In some cases, lorry owners who come here without prior knowledge of the conditions subsequently refuse to hire their lorries to traders in these centres because of their initial experience. Those who agree to hire often overrate the risk of a breakdown and charge very high rates for transport.

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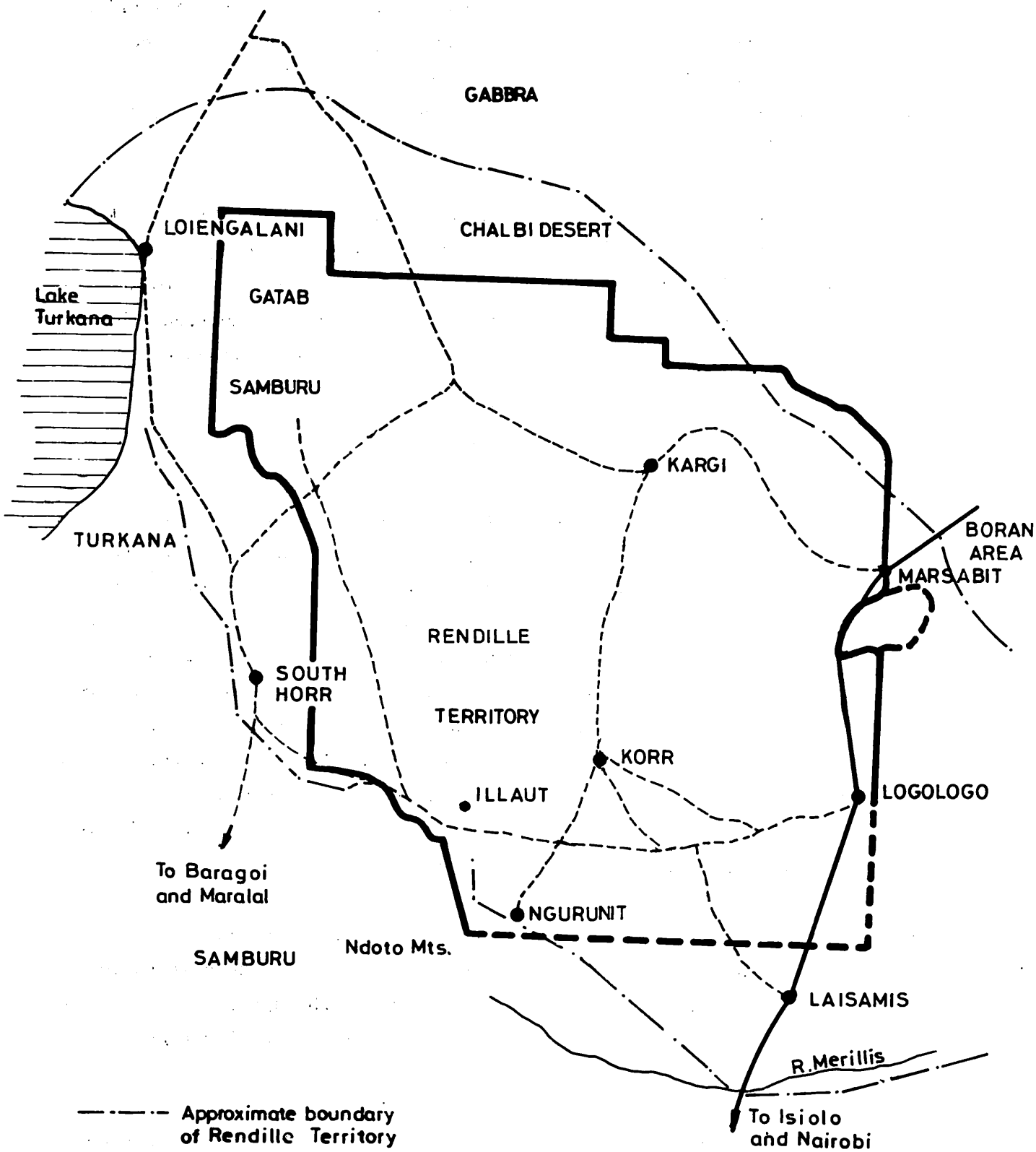
[13] For example the two traders at Mt. Kulal are only able to function because of help from the missionaries and IPAL with transportation. Most lorry owners will not go to Mt. Kulal because of the state of the road.

Map 24. Road map of the Rendille area



This raises the costs of importing goods and lowers the return from the sale of any livestock products transported in vehicles. Lack of willing transporters sometimes causes long delays on supply trips, again raising costs.

7.14 Lack of alternative insurance systems

Pastoral life is very risky, since disease, severe drought, or theft can easily reduce a rich man to poverty in a matter of days. As a result pastoralists have developed insurance systems which ensure that in case of such an eventuality they are able to recover. These insurance systems are based on the giving of livestock to various friends, splitting of herds so that they graze in different areas, having multispecies herds, and having very large herds (Dahl, 1979). All this raises the livestock holding necessary per household to a number much above its requirements purely for the provision of an assured food supply over the year. Again, in overstocked areas this form of insurance helps to raise the pressure on the range.

Provision of acceptable alternative livestock-based insurance systems (e.g. saving money in an account) could, we believe, drastically reduce livestock requirements per family.

8. Alternative Industries

8.1 Small rural businesses

In Rendille country there are few means of earning an income other than pastoralism. Exceptions to this are trading in livestock or opening a shop. Unfortunately, the capital and skills required are often beyond the capacity of those who need alternatives most, e.g. destitute pastoralists or primary-school leavers. The few who manage to venture into trade have to surmount enormous problems and very few manage to last for long.

8.2 Rural handicrafts

The potential for selling locally-made mats and Rendille artifacts to tourists has not been explored anywhere in Rendille, to the best of our knowledge. A market for these exists in Nairobi and areas frequented by tourists and this has been demonstrated by the successful marketing of artifacts produced by Gabra people with the help of the Catholic mission.

8.3 Honey production

Bee keeping on the mountain slopes is an alternative which is only now being investigated. Some District Development Committee funds have been used to buy modern hives. The hives have been placed on Mt. Kulal and in the Ngurunit area, and they indicate a good potential. A cautionary remark is that the potential exists only in the mountains, because of lack elsewhere of water which bees need to produce honey. The main problem with modern hives is that they are hung very low and stealing the honey is easy. At the moment pastoralists have not shown much interest, but a few hives have already been placed among the larger farmers of Marsabit Mountain. At Ngurunit, honey gathering using traditional methods is quite extensive. In some seasons it is possible to buy very good honey.

8.4 Metal work

The Rendille traditionally have the craft of the blacksmith and the technology for making spears, knives and swords. Unfortunately, there is a great deal of ritual and tradition involved in the practice of blacksmithing. This profession also has very little prestige and practitioners do not command much respect. Something should be done to train a few people per village in metal work so that they can make or maintain pots and other metal goods that are becoming increasingly popular. Efforts to remove the stigma attached to the craft should be made.

8.5 Fishing

Most of Lake Turkana is in Marsabit District. The results of multi-disciplinary surveys conducted between 1972 and 1975 have given an inventory of the fish species, their ecology, and potential yields. Recommendations for the management of the Lake Turkana fishery have also been made. Out of a total of 46 species occurring in the lake, 34 of them regularly, the species commercially important now and in future are; *Lates*, *Tilapia*, *Labeo*, *Bagrus*, *Synodontis*, *Schilbe*, *Alestes*, *Citharinus* and *Hydrocymus*. A possible annual yield of 60,000 tons of fish from the lake was estimated as compared with the present average yield of 13,700 tons worth about KShs. 12 million (Government of Kenya, 1983).

Since the 1970s attempts have been made to help the local people exploit this fishing potential. Fishing equipment was provided by the Catholic

mission, the European Economic Community Microproject Scheme, and the Government of Kenya to the Loiengalani Fishermen's Co-operative Society, started in 1976 with 64 members but which remained dormant until 1982. The society now has an active management of 9 and a membership of 179 people, with a technical advisory committee composed of Fisheries, Co-operative and Health officers, the area Chief, a councillor, the Kanu chairman and the Catholic mission. In 1982 it handled 70,352 kg of fish and earned Shs. 61,239/= from commissions and rent of its boats and personnel for tourist sport fishing.

It experiences problems in the marketing of fish because of poor access roads and poor storage facilities leading to large storage losses. However, these problems are slowly being overcome with Government help.

The whole membership, however, consists of people from the El Molo tribe who live on the shores of the lake. To the best of our knowledge no Rendille have shown an interest in exploiting this vast natural resource.

8.6 Abattoirs

As shown in Tables 136 and 137 in this section, the total commercial offtake of cattle from the Rendille area is not likely to be more than about 7,000 head of cattle, 1,000 camels, and 20,000 smallstock. Only a small proportion of this would be available for an abattoir, and, given the capital costs involved in setting up a large one, it is not surprising that no one has ever tried to do so here. A small unit for processing animal by-products may be successful and proposals for such a unit are made in the livestock section.

8.7 Leather industries

A cottage leather industry could be encouraged in each of the trading centres. A large tanning factory is unlikely to succeed for the same reasons as a large abattoir, but a tanning shed has been proposed as a part of the livestock by-production unit proposed in this report.

9. Service Centres

The following is a physical-facilities table of all the centres in the management-plan area.

Table 144. Service centres: infrastructure and services

Centre	Chief	Police Station	A.P Post	Mission	Water supply	Dis-pensary	Health centre	School
Kargi	x		x		x	x		x
Korr	x		x	x	x	x		x
Loglogo	x		x	x	x	x		x
Mt. Kulal	x	x	x	x	x		x	x
Ilaut	x		x					x
Ngurunit	x			x	x			x
South Horr	x		x	x	x	x		x
Laisamis	x	x	x	x	x		x	x

The water-supply systems at Kargi, Korr and Ngurunit do not provide a regular supply of clean water for all the residents of these centres. At the same time, adequately staffed and supplied health centres with well trained personnel are only available on the fringes of the area at Laisamis and Mt. Kulal, where also the only two police stations are situated.

Land in these centres has not been adjudicated as plots. The allocations made to shop owners are only temporary, while the pastoralists locate themselves wherever they wish. The result is that individuals cannot develop their own plots and this is holding back the development of these centres.

10. Land Reform

The borders of Rendille land, especially on Marsabit Mountain, need to be demarcated and protected from being encroached on by expanding farmers or by the individual ranches that are likely to be sought after soon.

It should be emphasized that extending agriculture into marginal lands is bad for catchment areas and wasteful of otherwise good rangeland which is, however, only marginal for crops. The Rendille should be assured of their land and the possibility of ever having individual holdings on Rendille land should be clearly spelt out as undesirable because of ecological constraints, which dictate that such units would have to be so large as to be inequitable.

Those Rendille who may want to farm should be allocated land in the Marsabit farming area along with other people. This has already happened in the Karare and Songa schemes, where the Rendille are doing much better than the other settlers.

If a dairy industry based on some form of high-yielding exotic cattle does indeed develop on Marsabit Mountain, the Rendille should be encouraged to have a share in it. In the future, milk from such an industry could substitute for the milk they now get from their own animals and enable them to become more efficient meat producers through allowing their calves all the milk and hence a higher chance of survival. Traders in the area have already discovered this effect, and many do not milk their breeders, with the result that calf mortality is lower than in the nomads' herds (personal communication from Otte Soke and Hassan Turkana).

11. Summary

In this section trade in livestock and livestock products and consumption of imported goods by the Rendille is analysed. It is found that the Rendille earned Shs. 2,235,572/=, or approximately Shs. 112.5 per head, from the sale of livestock and livestock products over a 12-month period in 1979-80. This represented an offtake rate of 5.2 and 7.6 for cattle and smallstock. Camels were not marketed at all. This is found to be much below the potential offtake, estimated at 17.7% for cattle, 15.1% for smallstock, and 4.8% for camels. These figures are based on the proportion of castrates in the herds and are high because they may have been accumulated over time. It is however noted that current offtake rates can be improved on.

Although a marketing system for cattle and smallstock does exist, it provides an irregular, poorly organized service at very low prices for pastoral products. This discourages pastoralists from relying too much on the market.

In the same period pastoralists consumed Shs. 2,804,711/= or Shs. 141.2 per head worth of posho, sugar, tea, tobacco, shoes and cloth. These were provided by a network of shops in the trading centres in the Rendille area. Eighty-two per cent of these shopkeepers were also livestock traders. Analysis of the whole economy showed that some of the major constraints on the improvement of trade were:

(i) lack of capital among traders;
(ii) poor roads and consequent transport problems;
(iii) lack of alternative investment opportunities for pastoralists;
(iv) poor terms of trade for pastoralists, lowering their incentive to participate in the market.

It was, however, noted that, given a proper opportunity, pastoralists are willing to sell animals and use the money to improve their standard of living.

VI

OTHER LAND USES

A. FORESTRY

The following section is based on research done by Synott (1979 a and b) and Herlocker (1979) and some personal observations and interviews with the District Forester, Marsabit. It is not exhaustive and is presented to emphasize the important relationship between the montane forests in the district and the rangelands which are the main focus of interest of the present management plan.

1. Present State of the Forests

1.1 Extent and legal status

Synott describes the existing montane forests and their legal status. The following summarizes his main observations.

a. Marsabit

The Marsabit National Reserve was established by Government Notice in 1948 and originally extended from Lake Turkana down to Isiolo and included the Marsabit and the Mathews Ranges. It was reduced to its present size of 780 square miles on 22 December 1960. Although the authorities were aware of the wood needs of the people, the objective in planting trees had been largely conservation, increasing forest area rather than maximizing wood production.

b. Kulal

Mt. Kulal has been much less visited by forestry and administration officers from Marsabit. The forest was demarcated in 1956 and a boundary line completed. This boundary (plan No. 180/1970) enclosed a total of 45,729 ha but was never gazetted due to shortage of funds and staff.

Recently, however, the mountain area has been declared a MAB Biosphere Reserve, but no forest guards have been deployed.

c. Hurri Hills

These have had a long and complex history of human use as valuable grazing land, but have had no special conservation status. The Forest Department would like to reserve about 30,000 ha to improve water supplies and the forest reserve area in Marsabit.

d. Nyiru Forest

The Nyiru and the neighbouring Ol'Doinyo Mara hills surrounding the South Horr Valley are used for dry-season grazing by the Samburu. Demarcation of 45,400 ha of Nyiru was completed in 1951 and gazetted in 1956 as forest reserve. The demarcated area is in Samburu District, though it is important for the southern Rendille and Ariaal. Ol'Doinyo Mara has never been reserved or protected by the Forest Department, presumably because it carried only a small closed forest. The forest station at South Horr looks after this forest.

e. Ndotos Range

A forest reserve boundary line was completed in 1950 and gazetted in 1956. Use of this forest by Samburu and Ariaal Rendille declined during the 1960s because of shifta activities. This was, however, followed by over-use in the 1972-76 period. More control from Wamba is envisaged.

1.2 Forest types

In an appendix, Synott (1979a) gives a list of all the forest trees and shrubs known to occur in the mountains of this area. He also discusses the ecology and status of each of the forests mentioned above. Most of this discussion will not be repeated here. The following is a summary of his main observations.

a. Marsabit

This mountain has more rain at any given altitude than any of the other mountains in the area. This is because of its larger bulk and its position as the first substantial high ground in the line of the monsoon winds from the Indian ocean. Its forest differs from others in both structure and composition.

The commonest large trees on Marsabit are *Caseria, Croton, Megalocarpus strombosia, Diospyros abyssinica, Olea africana, Olea capensis, Cassipourea* and *Apodytes*. Among the commoner shrubs and small understorey trees are *Canthium* spp., *Ochna* spp., *Techlea nobilis, Ritchiea,* and *Rinorea*. In general, the forest appears to be stable, well developed and of considerable antiquity, although not particularly rich in species even by East African standards.

b. Kulal

Kulal has been better described than all the other forests in the area and it is possible to describe both the composition and successional status of the different communities. The main vegetation types are:

1. Mature mixed hardwood forest

Mainly composed of *Xymalos, Ocotea casearia, Clausena,* large *Ficus, Brucea, Epidotrichilia, Oxyanthus* and *Juniperus.*

2. *Juniperus communities*

Juniperus is a pioneer species, typically intolerant of shade, but more susceptible to fire damage than many other colonizers. *Juniperus* is found in a wide variety of communities, e.g.:

(i) young trees with shrubs and small trees of *Diospyros, Maytenus, Rhamnus, Turraea, Allophylus, Rhus, Cussonia, Heteromorphia, Euclea myrsine, Olea africana, Schrebera, Pavetta psychotria, Vengueria,* etc.;

(ii) trees with an understorey as above and with a few forest tree species such as *Diospyros* and *Teclea* spp.;

(iii) large, old individuals (sometimes dead or dying) standing in minute thickets or isolated in grasslands;

(iv) large old trees, scattered in a more or less mature broadleaved forest stand.

3. Colonizing forest edges

10-metre-wide strips of woody species invading the grassland surrounding many of the thickets and main forest edges. The species involved include all those associated with young *Juniperus* communities with *Aspilia* conspicuous on Mt. Kulal.

By replacing grasses and other herbs with perennial woody plants, the colonizing fringe is more resistant to fire and grazing; it will continue to expand when conditions are favourable, and may remain stable when conditions reach an equilibrium. It may be destroyed by particularly heavy fires or very heavy browsing by livestock or elephants, followed by invasion of grasses and retreat of the forest edge.

4. Bushlands

These occur at lower elevations and in drier situations than the closed forest areas. In some cases they are capable of developing into forests with lowered grazing pressure, while in others they appear to be in equilibrium with the effects of rainfall, altitude, and soil depth,

They include many of the shrubs typical of the colonizing forest but also include several other species like *Grewia, Cadia, Erythrina, Osyria, Pappea,* and *Ruttya* and an increasing admixture of succulent plants such as *Aloe, Euphorbia* and *Dracaena ellenbeckiana. Lippia, Derodendrum, Ocimum* and several composites are among the shrubs and subshrubs also included. Larger shrubs include *Carussa, Euclea, Rhus* and some *Olea africana.*

5. Grassland

Open grassy glades partly or completely surrounded by forest. These were probably initiated by fires, and maintained by grazing by wild and domestic livestock. With the removal of grazing pressure, many of the grass glades would develop into closed forest. The complete elimination of all grassland areas above 1,600 or 1,700 m would perhaps produce some modest improvement in water catchment and conservation, but would also constitute a loss of biological and habitat diversity, of scientifically interesting communities, and of valuable drought emergency grazing resources of great importance for sustaining the local pastoral economy.

c. Nyiru with Ol'Doinyo Mara and the Ndotos

Much less is known of these forest ranges than of Mt. Kulal and Marsabit. The mountains are substantially taller and of a quite different geological formation, and these factors affect the composition and the status or vulnerability of the forests.

Both ranges have substantial (but not accurately measured) forest areas. The main forest tree and shrub species which are certainly (or probably) common to both ranges are *Juniperus, Podocarpus milanjianis, Croton megalocarpus, Sapium, Pkunus, Rhamnus* spp., *Brucea, Trichilia, Cussonia holstii, Diospyros, Maesa, Nuxia and Olea* spp.

There are small patches of forest on Ol'Doinyo Mara, but since the ridge is small and narrow, and the soils are vulnerable, the forests have probably suffered particularly severely from the effects of grazing. Soil erosion has increased but recovery is possible if they can be protected.

The soils of these mountains are relatively infertile and there are strong indications that they are more easily eroded by water and more damaged by trampling then the volcanic soils of Kulal, Marsabit, and many other mountains.

d. Hurri Hills

There are no extensive areas of closed forest on these hills, but many valleys, gulleys, and steep hillsides at higher elevations carry dense thickets and in some areas small trees form a closed canopy, resulting in a low forest. Among the tree and large shrub species growing in such forest communities are *Croton macrostachyus, Euphorbia* (or a similar species), *Bauhinia tomentosa, Pistacia, Olea africana, Quttya fruticosa* and many other shrub species which are also found in small thickets, such as *Croton dichogamus, Osyria, and Rhus* spp., with several Rubiaceae, Labiatae and Verbenaceae.

These communities have much in common with the evergreen bushland found on Kulal and elsewhere, with the notable absence of *Juniperus*. The vigour of the colonizing edge of many of these valley and gulley forests, often including *Croton macrostachyus,* strongly suggest that closed forest and bushland could significantly extend its range and could probably maintain itself over large areas even during dry periods. Present distribution is closely limited by fire.

The open hills and gentle slopes of the Hurri Hills also carry open woodland or savanna of two types; one in the wetter western slopes, including *Combretum malle, Lannea* and *Ozoroa (Sieria),* while in most of the accessible areas the most conspicuous tree is *Erythrina burtii* (often very large) with *Acacia* spp., *Fagara chalybea, Pappea, Cordia sinensis, Dichrostachys, Ormocarpum, Zizyphus* and *Fias*. Many shrubs such as various *Grewia* spp. can be found in almost all communities.

The grasslands seem old and do not appear to have been derived from woodland in the recent past.

2. Economic Importance

2.1 Introduction

With the exception of the forest on Marsabit Mountain, all the forests discussed are mainly used by nomadic pastoralists as dry-season grazing for their livestock. They are also used by Ndorobo honey-gatherers and by pastoralists to obtain various types of wood for making domestic appliances. In all these forests, however, only use by domestic stock significantly affects them.

They also constitute a valuable resource for the lowland areas, which without them could probably not support as many animals as they do now.

They are also the main water catchment areas for springs in the lowlands below. These uses are, however, not quantifiable at present. The following discussion is based on the Marsabit forest, which is utilized for firewood, pole cutting and furniture wood and where some data are available from the Marsabit District Forester's reports and an interview held with him.

2.2 Forestry on Marsabit Mountain

Marsabit District has 14,914 hectares of gazetted forest, all of it on Marsabit Mountain. In addition to this, another 22,791 ha receive protection as a high forest productivity area, 4,228 ha as bushland, and 200 ha as grassland within the forests. The forest is composed of large evergreen trees and covers the eastern part of the mountain. Heavy mists help to maintain it, as rainfall alone would be inadequate.

The Marsabit forest forms the main source of building and furniture timber for the whole of the district. (Mt. Kulal forest is not heavily used because of distance.) It is also the main source of firewood for people in Marsabit town and others living near the mountain. In the dry lowlands the people are dependent on lowland vegetation for these purposes.

a. Furniture

The prison and the Technical School are the only furniture manufacturers in the district. They used about 20 m^3 of fallen and dead wood in 1980 and 1981. The price per m^3 of wood is 78/-.

b. Fuel wood

There are two main licences for fuelwood within the district. These provide the schools, hospital and other institutions in Marsabit with their fuel requirements. Tractors and trailers are used to collect fallen and dead wood from the forest for this purpose.

In addition to this, local woman are given monthly fuel collection licences at a cost of 4/- a month by the Forest Department. This enables them to collect one headload of firewood for every working day within the month.

The average number of such licences per month in 1981 was given by the Forest Department as 70. The Forester estimates that one headload weighs approximately 30 kg. This means that the forest provides approximately 655.2 metric tonnes of firewood to Marsabit town residents per annum. As unlicensed fuelwood collection is rampant, the true figure is likely to be double this or around 1,300 metric tonnes. This has a market value of approximately 1,300,000/- at 1/- per kg.

c. Building poles

In Marsabit town and other settlements in the district a large proportion of the local Borana, Burji, Rendille and Gabra people no longer build their dwellings in the traditional way. A traditional dwelling requires only thick sticks and branches on which mats and skins are hung and is very light; it is transported every time a manyatta moves. The townspeople build more permanent structures made of thin pole walls and having a thatched or, occasionally, an iron roof. All the poles for walling and roofing these houses and shops (including trading centres in the lowlands) are currently being supplied from Marsabit Mountain. The Forester estimates that at the moment 30,000 running metres of poles per annum are being supplied from the forest.

d. The danger to forest viability caused by pole cutting

As no felling of large trees is allowed and the poles required must be thin (5-30 cm), people have to cut young trees. In most of the forest the only young trees available are those of species which are not suitable for construction purposes. This is threatening the future viability of the forest because there will be no replacements for the trees which fall. The Forester has tried to limit the number of building poles cut from the forest, but as there are no alternative building materials, pressure from politicians and the people is forcing him to continue this very dangerous practice. It is felt that unless urgent measures to find alternative sources of building materials are instituted, the Marsabit forest will deteriorate into bushland within the next few decades.

3 Potential Development

3.1 Importance of forests and trees

Forests are extremely important in an arid area like Marsabit District. They provide firewood, materials for construction of houses, and more importantly a water-catchment area. They also prevent soil erosion and provide a habitat where wild animals can live, and in extreme cases could be used as drought reserves.

In the dry lowlands, trees provide firewood, materials for the construction of domestic implements and livestock enclosures, browse for livestock, shade, fruits which can be eaten by both human beings and livestock, fibre for the making of ropes and mats, and gum which could be used for the establishment of a gum-arabic industry.

The Ministry of Environment and Natural Resources recognizes this and in Marsabit District the District Forester has a very ambitious development programme.

3.2 Gazettement of forests

The only gazetted forest in Marsabit is on Marsabit Mountain. The Forestry Department has identified other ideal forests and afforestation sites and proposes to raise the gazetted area from 15,000 to 250,000 ha. Proposed sites include Mt. Kulal, the Hurri Hills, Manyatta Jilo (Orondille), the Karare Hills, the Bubisa Hills, Turbi, some hills in Sololo Division, Moyale, Godoma and Dabelle. Although the major function of forests in the district should be the protection of water-catchment areas, re-afforestation includes the planting of commercially useful tress. More forests will therefore supply the needs of the population, which are likely to rise as sedentarization raises the need for permanent housing and furniture.

3.3. Planting programme

In the past the goal has been to plant 40 ha of new forest every year. This has been raised to over 60 ha in the last two years. The Forester would like to increase this even more, but lack of labour, vehicles and water for nurseries is a big constraint.

Currently he is using indigenous trees and has developed very cost-effective nursery procedures. The cost of producing 1,000 seedlings is on average only Kshs. 50.00. The germination rates are as follows:

Germination rates per kg of seed:

Grevillea robusta	8,800
C. simea	10,000
Eucalyptus saligna	20,000
Eucalyptus camaldulensis	40,000
Croton megalocarpus	1,000
Dadacha	10,000

In 1981, help from the District Development Committee in the form of labour and funds enabled the Forest Department to plant 1,910 ha of trees. This was helped by very good rainfall, which totalled 1,331 mm in Marsabit forest and ensured that many seedlings survived. In poor sites (with deep rooted plants) the survival rate is usually 50%, while in good sites (shallow-rooted plants) the survival rate is 75%.

4. Links with Lowlands

At present, scarcity of funds, personnel and vehicles limits the Forest Department's extension activities to providing seedlings and extension advice to farmers near the forest stations at Marsabit and Sololo. Efforts to encourage the planting of trees have been very successful at Sagante, Songa, Karare and parts of Moyale and Sololo. The Forest Department is no longer able to meet the demand for seedlings. In 1981 alone over 400 ha of trees were planted. Seedling production is being increased to meet this demand.

In the drier and more remote centres like Laisamis, Korr, Loglogo, and Kargi the Forest Department has carried out little tree planting. There is an acute shortage of water in these places and seedlings have to be watered very frequently to survive. Since the department does not have facilities to ensure constant supervision and encouragement, its efforts have been limited in scope and not very effective. The Forester, however, feels that if funds were available more extension effort could drastically reduce or stop misuse of existing woodlands in the lowland areas.

Research into dry-land afforestation could also help the rehabilitation of treeless centres, by providing information on the most appropriate species and methods of re-establishing trees on degraded lands.

5. Main Constraints

As mentioned above, the Forest Department suffers from shortage of funds, personnel, and equipment. To man the largest district in Kenya there is only one Forester, one Forest Assistant, one Clerical Officer, one Copy Typist, five Forest guards and 129 manual helpers. They are provided with one landrover, one lorry, one tractor with no plough and one bonded tractor.

The shortage of transport and technical staff limits the amount of extension work that can be done. It also greatly limits the amount of re-afforestation work and the effectiveness of forest guards.

The Forester feels that to achieve the ambitious developments proposed above, every division should be provided with a Forester and the same equipment and personnel now provided for the Marsabit station.

B. AGRICULTURE

1. Introduction

1.1 Present extent

In Marsabit District rainfed cultivable land (in zones II and IV) forms only 3-5% of the land, estimated at 269,003 ha. Of this 80% is either under forest, game reserve, or grazing. This leaves 53,800 ha for farming. Currently, only 13,000 ha are actually cultivated, the rest being used as grazing land (*District Development Plan 1979-83,* Marsabit).[1]

The areas cultivated at present are on Marsabit Mountain, and in small parts of the Sololo-Moyale region. Parts of Mt. Kulal, the Hurri Hills and the South Horr Valley are also suitable. Development here has been slow and is not being fully encouraged because these areas serve as important water-catchments and it is feared that agricultural development would reduce their usefulness in this respect.

On Marsabit Mountain, however, a large number of Burji, Borana, and Rendille have established farms with the help and encouragement of the colonial and post-independence Governments and missionaries. The area being farmed is very good agricultural land. To the extent that farming is not allowed to encroach on the more marginal areas, which are important for the rational utilization of the rangelands below, this agricultural activity is very useful for the following reasons.

1.2 Advantages of agriculture in Marsabit

- Since animal production in this area is extensive and of low productivity, the use of high-potential land for the production of low-grade meat does not represent optimal use of resources. Under these circumstances agricultural activity produces more value added per unit of land than livestock production.
- The population of Marsabit Town and District will always require large quantities of agricultural products. The larger the proportion of these that can be produced within the district the better, because this reduces transport costs and the export of money outside the district. This releases such money to be used for development and at the same time creates incomes for farmers. It also facilitates the importation of more high-value goods, which are less bulky than agricultural products, and raises the actual

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1. The following discussion relies heavily on this document, which is very comprehensive.

use value per shilling of imported products.

- It protects the local community from irregular supplies caused by shortages in the maize-producing areas in western Kenya and creates a local base for famine-relief activities in this drought-prone district.
- If properly developed, agriculture can provide alternative income-earning opportunities for those pastoralists who cannot be absorbed into the pastoral economy.
- The agriculturalists also provide a market for livestock and livestock products like meat, milk, hides and skins.
- The potential for milk production discussed elsewhere in this report can supplement the diets of the settled people's children who, according to recent research (Eva Mubia,1981), were undernourished and showed signs of protein deficiency.

1.3 Disadvantages of agriculture on Marsabit Mountain

The main disadvantages of agricultural activity are as follows:

- There is a tendency for agriculturalists to extend into areas necessary for the proper exploitation of the rangelands. Although these areas are only occasionally used, their use is critical to livestock production and their removal makes large areas unusable.
- If proper methods are not used, agriculture can lead to erosion, loss of soil, and degradation. This is particularly the case in areas where farming is a new practice and there is no farming culture, as in Marsabit. On certain places in Sangate Location in Marsabit this is already a major problem.
- Agriculture removes the plant cover which was previously provided by grassland or forest. This may reduce the water-catchment potential of an area and affect the supply of water to wells in the lowlands.

Agriculture on Marsabit Mountain must be aware of this risk, since the main crops grown are cereals, which leave the ground bare for long periods after the harvest.

2. Production

2.1 General overview

Agricultural production in Marsabit is mainly practised by Burji and Borana tribesmen in Sagante and around the town. Several missionary and Government rehabilitation schemes have established farming schemes among destitute Gabra, Rendille and Samburu tribesmen.

The main crops grown are maize, beans, taffi and wheat. These are grown in farms ranging in size from one or two hectares in the settlement schemes to large holdings of over 50 hectares in the Badasa area.

The settlement schemes established to resettle people impoverished by calamities like drought, cattle raids and shifta attacks are briefly described below.

Songa: initially 20 families, but now over eighty, were given 1-2 ha irrigated plots. They grow vegetables and fruit in addition to the major crops.

Nasikakwe: initially 83 families on 1-2 ha plots. They grow sunflower, chillies, and sorghum.

Kituruni: initially 68 families settled on 1-2 ha.

Manyatta: with 20 families on 1-2 ha of land. Neither have irrigation, and they grow only maize and beans.

Gabra schemes: with 55 families growing maize and beans.

Marsabit Refugee Rehabilitation Centre: 24 refugee families on 1½ acres each, growing maize and various horticultural crops.

The original farming area of Sagante is subdivided into plots ranging from 1-2 ha to about 10 ha. On the outskirts of the farmed areas some traders have now established large farms operated by gangs of labourers and at times by tractors. Some of these are over 50 ha in size.

Table 145. Production of main agricultural crops in Marsabit, 1976-81.

Year	1976	1977	1978	1979	1980	1981
Maize						
Hectarage	5,060	5,660	3,500	500	2,500	2,950
Tonnage	4,560	5,100	3,150	-	2,700	2,655
Beans						
Hectarage	199	300	300	-	776	1,016
Tonnage	143	217	288	-	279	731
Taffi						
Hectarage	200	300	350	-	90	116
Onnage	30	210	210	-	-	52
Wheat						
Hectarage	30	30	50	-	88	-
Tonnage	30	30	50	-	40	-

Source: Various annual reports and *District Development Plan 1979-83*, Marsabit.

In 1973 about 4,247 ha were under cultivation in the whole of Marsabit District, compared with 6,375 and 13,000 ha in 1977 and 1978 respectively. The number of farmers in the district has increased from 4,200 in 1973 to about 9,000-10,000 in 1978. On average the farm-holding size is 5-6 acres per household (*District Development Plan 1979-83*, Marsabit).

2.2 Cash crops

Beans and maize are the main cash crops. Until 1980 the D.C. was the main purchaser of these items for famine-relief activities. This no longer happens, but the Cereals Board have opened an agency in Marsabit Town and it is hoped that this will provide a major outlet for these two crops.

Coffee, of which there is at present about 20 ha, seems to be a potential cash crop but at the moment is only used for subsistence and the husbandry practices are very poor. The trees look in general very unhealthy, and it seems that there is scope for improvement.

2.3 Horticultural crops

Where irrigation water is available, especially in the Songa, Badasa and Kituruni schemes, the following crops are grown: cabbages, kale, tomatoes, onions and chillies. In other unirrigated areas the emphasis is now on cereals and beans, whose water requirements are not so high.

2.4 Fruit

This includes mangoes, avocadoes, rough lemons, oranges, passion fruit and pawpaws. They thrive best in well watered areas, especially the schemes of Songa and Badasa. The Government has a nursery at Songa and is helping to provide seedlings. The Government extension service advises on how to plant. At present the Ministry of Agriculture complains that funds available are not enough to supply the number of seedlings wanted.

There are other demonstration plots in Sagante and Moyale, where new methods of agriculture are demonstrated.

3. Constraints on Production

In a district like Marsabit, where rainfall is highly variable, agriculture is very insecure and the risk of crop failure without irrigation is very high. Some of the problems of farming encountered and requiring solution if future development is to succeed are:

3.1 Soil erosion

The soils of Marsabit Mountain are erodable. Farming is concentrated on the foothills of the mountain and in some places the slope is very steep. Farmers are, however, not sensitive to this and do not practise soil-conservation techniques. In some areas steep gullies have been formed.

The Ministry of Agriculture has realized this and is now carrying out a soil-conservation campaign. Its extension staff have already put in some gabions in the worst places and 18 kilometres of cut-off drain were measured in 1981. But farmers are not very enthusiastic and want the Government to employ labourers to make and maintain the cut-off drain for them. This effort by the Government is commendable and should be continued.

3.2 Research

Very little is known of the district's soils or their quality, erodability, and fertilizer requirements. The types of crops which can grow here and the best methods of growing them are not known. In fact the Ministry knows very little about how to improve the production of taffi, one of the main food crops grown.

On the other hand, since water stress is such a powerful constraint, the possibilities of irrigation using wells, dams etc. should be investigated.

It is also unknown how much of the cultivable land should be cultivated and what effect expansion will have on the production of livestock in the lowland. A study of the relationship between montane areas and livestock production in the lowlands should be a prerequisite to future expansion of agriculture into new areas.

3.3 Land tenure

At the moment all the cultivated area on Marsabit Mountain falls in the forest reserves and is owned by the County Council. Anybody willing to farm gets an allocation from the County Council on payment of a small registration fee. The tenure is not permanent and there is no incentive to invest in long-term structures and improvements. It is recommended that agricultural land should be legally designated as such, adjudicated, and people issued with title deeds. This will promote a more responsible agriculture and allow people to use the land as security and collateral for loans.

3.4 Wild animals

Destruction of land and crops by wild animals is rampant. At the moment nothing can be done, since people are farming on the forest reserve and animals have priority. When agricultural land is adjudicated it is recommended that measures to prevent wild animals from getting into shambas or a compensation programme should be instituted.

3.5 Extension services

The agriculture extension service is currently staffed by technical personnel from other parts of Kenya. The farms, on the other hand, are run by people who hardly understand any Swahili. There thus exists a communication gap and giving advice is extremely difficult for the extension workers who, in most cases, do not understand the farmers' language and vice versa. It is recommended very strongly that in future local people be trained to perform this task. Only in this way will it be possible to explain new farming methods to the farmers in a language they understand and to have it done by people who know where to lay emphasis and what points are sensitive in relation to the culture of the farmers.

The facilities that exist for extension workers are very poor and they are forced to live in substandard houses, as the Government houses available are few and the standard of housing in Marsabit is very poor.

3.6 Farm inputs

The farm implements like ploughs and hoes in use are few and not very efficient. The plough, especially, is simply a wooden branch with a sharpened motor-vehicle-brake spring as the coulter. In the past it was difficult to get better farm implements, but it is now hoped that with the opening of a new co-operative store this problem has been solved.

The same applies to the use of chemical inputs like fertilizers, fungicides, insecticides and herbicides. So far little use has been made of these and it is felt that higher yields of practically every crop could be attained by more crop protection from diseases and weeds and by the application of fertilizers. Use of manure is not common, although large quantities are available from the nomadic herds which are at times coralled near Marsabit. Manure is now usually burned. The usefulness of manure applications should be demonstrated and actively encouraged.

3.7 Marketing

Most of the goods produced by the farmers are for domestic consumption. However, as farming has become more intensified the need for a good market is becoming increasingly obvious. In November 1982 there were approximately 3,000 bags of maize in the stores of the Cereals Board agent, traders and farmers. At the same time traders were importing large quantities of maize meal.

The problem was that there was no milling machine which could produce maize meal of the quality people want. Something should be done to license such a mill here. It is the agricultural department's opinion that, if properly developed, Marsabit could support itself with maize meal in good years.[1]

On the other hand, the marketing of horticultural products from Songa and Badasa is being hindered by lack of a good road through the forest. This road should be improved and help given to farmers to acquire donkeys or ox carts for transporting their produce.

3.8 Shortage of labour at peak periods

Most of the farmers in Marsabit have businesses or paid jobs and rely on relatives or employees to look after their farms. At harvest time there is great shortage of labour. At the same time many pastoralists in the lowlands are idle, especially since agricultural peak periods usually occur during the rains, when pastoral work demands are lowest. It is recommended that the extension service explore the possibility of getting some pastoralists to come and help relieve the labour shortage on farms during these peak periods. This would not only help them earn an income but would help raise the production of food. The fact that some pastoralists may not like the idea of farming should not discourage such efforts. Rendille and Gabra pastoralists are known to be coming to settle near the mountains during the rains (Michael O'Leary, personal communication). Some traders with large farms and large holdings of cattle do already deploy some of their herders for farm work during peak periods (personal communication from Mohamed Wario).

Such a symbiotic relationship, if properly organized, could both solve Marsabit labour problems and help in raising the incomes of pastoralists. Some may also like the idea of more permanent work or settlement. This is a desirable trait, since sooner or later some people will have to start moving out of pastoralism if a decent standard of living is to be assured to those who remain.

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1. This point came up again and again in discussions with the District Agricultural Officer and several of his technical officers who took the author of this section for a tour of farming areas in Marsabit.

4. Conclusion

If the problems identified above are addressed properly there is no reason why the areas with agricultural potential should not be able to produce a major proportion of the food requirements of the district. At the moment, however, productivity is low and soil erosion threatens large parts of the farmed areas. The problems of marketing, inadequate extension work due to lack of research to base recommendations on and to agents who do not understand local languages, and a land-tenure system which does not encourage a responsible attitude to farming are probably the main stumbling blocks to future developments.

C. DAIRY FARMING

1. Introduction

Dairy farming using exotic breeds of cattle is not new on Mt. Marsabit. It was first attempted in the late 1950s by the colonial Ministry of Agriculture. One Guernsey cow, one Friesian cow and one Friesian/Ayrshire crossbreed bull were introduced. These animals were kept on the agriculture research farm which at the time was situated between the Post Office and the Girls' Secondary School. The animals performed well for about two years, until the bull died after being bitten by a rabid dog. The incident coincided with independence and the cows with their offspring were sold to Mr. Godana Galgalo and Mr. Ote Soke. The agricultural research farm was dismantled and the two men moved the animals to their farms in the Sagante area. It is of interest to note the background of these two men: Mr. Godana Galgalo was an influential politician at the time, while Mr. Ote Soke was an Agricultural instructor who had received his training in animal production and extension work at Nyeri, Wambugu and Embu. Mr. Galgalo's animals died during the drought of 1961, while the stock of Mr. Ote Soke, whose owner supplemented grazing with feeds from down country, survived the drought. However, after four years these cattle also died, due to inadequate management. No veterinarian confirmed the cause(s) of the deaths. By then Mr. Ote Soke had already acquired some crossbreeds. He herded those crossbreeds in the same way as the local breeds, the major exceptions being:

(a) weekly washing with acaricide throughout the year;
(b) supplementing grazing with feeds from down country during dry seasons at milking time;
(c) deworming of calves of about 6-24 months, using Nilzan;
(d) treating coccidiosis (as detected by diarrhoea) with Zoaquin;
(e) use of antibiotics such as Terramycin, which he gives as need arises (e.g. in case of a wound inflicted by stones).

With these basic inputs the economic parameters have been as follows:

(a) The Friesian cows at the agricultural research farm on Mt. Marsabit produced 20 litres.
(b) Crossbreeds developed at Marsabit produce 5-6 bottles of 700 ml each.

(c) The Boran breed on Mt. Marsabit produce 1-2 bottles of 700 ml each.
(d) Crossbreed bulls weigh 450 kg and are very desirable to butchers down country.
(e) Age at first calving is 3-4 years.
(f) The calving interval is 1-1½ years and the owner introduces the element of controlled breeding, depending on weather.
(g) Mothering ability: there is a lot of milk from dam - he speeds up the growth of calves by leaving 3 teats for calves and only milking one for human consumption. This ensures fast growth.

The history of dairy farming thus far suggests that the improvement of such farming through the introduction of exotic breeds of cattle is possible on Mt. Marsabit, but also warns us that such a development must be accompanied by fodder development to supplement grazing during dry seasons and drought, and also by the improvement of veterinary facilities.

2. Recommended breeds

The history of dairy farming on Mt. Marsabit suggests that the following exotic breeds would be ideal:

(a) Guernsey
(b) Friesian
(c) Ayrshire

3. Disease risks and strategies for their control

(a) *Ticks,* especially *Rhipicephalus pulchelus,* are rampant on Mt. Marsabit (Omara-Opyene, 1982). Dips should therefore be constructed before the introduction of exotic breeds of cattle. Although no tick-borne disease has been confirmed on Mt. Marsabit, *Boophilus decoloratus,* a known vector of anaplasmosis and babesiosis, and *Amblyoma gemma,* a known vector of heartwater, do exist there. Exotic breeds of cattle should be screened to avoid the importation of these diseases, which might otherwise easily gain a foothold on Mt. Marsabit, since the vectors are there.

(b) Moulton (1978) and Omara-Opyene (1981) have reported that Ayrshire cattle are prone to squamous cell carcinoma of the vulva. In Kenya, the incidence of the malignancy in the recommended breeds according to Omara-Opyene (1981) is:

Guernsey	0.00%
Friesian	1.26%
Ayrshire	6.37%

This work suggests that the Ayrshire breed should not be introduced.

(c) Omara-Opyene (1982) reported some blood parasites on Mt. Marsabit and the report has been supported by Prof. Mugera (1982), who has suggested that the parasites are different stages of binary fission of trypanosomes. More work is needed to clarify the epidemiology of these parasites before the introduction of exotic breeds of cattle as it is suspected that the parasites were the cause of death of the first exotic breeds introduced here.

(d) *Helminthiasis* and *coccidiosis:* Omara-Opyene (1982) states that helminths are abundant on Mt. Marsabit and that coccidiosis is sporadic in calves. These diseases can be handled by the farmer; all that is needed is education and provision of the appropriate drugs, e.g. Panacur for helminths and Sulfadime for coccidiosis.

(e) Biting flies are a nuisance to exotic cattle during rainy seasons. The important aspects of this observation is that exotic cattle should not be herded with local breeds to avoid mechanical transmission of trypanosomiasis.

(f) Exotic cattle should be vaccinated against diseases such as anthrax, blackquarter and foot-and-mouth disease.

4. Fodder and hay development

(a) Alfalfa (lucerne) is a likely plant to serve as fodder. The plant could be maintained during dry seasons or drought by irrigation, e.g. at Songa. The plant has been shown to perform well under irrigation at Naivasha in Kenya and at Khartoum in the Sudan. Other alternatives include:

(i) sweet-potato vines - the tubers are used by man and the vines could be used by exotic cattle;

(ii) napier grass.

(b) Stems of maize are at the moment not being well utilized after harvest. Experience gained at the A.D.C. farm at Kitale shows that the maize stems are very valuable feeds if treated well.

The farmers should be taught how to convert the maize stems to hay, which could be fed to exotic cattle during dry season or drought.

5. Dairy farming potential

There are at the moment about a dozen farmers who are capable of conducting dairy farming using exotic cattle. Each could afford 10-20 exotic cattle to start with. The number could be increased considerably as they see the advantage.

6. Marketing structure

There is a ready market for milk and its products in Marsabit District. The farmers will need to form a dairy co-operative which could then purchase a cooling plant for milk. As milk production increases, some could be transported and sold to places like Kargi, Korr etc. just as is done in other parts of Kenya.

D. MINERAL RESOURCES

There are only a few minerals available in Marsabit District. An exact determination is not possible in the absence, to date, of any general or specific geological survey.

For some time a mine was worked in the mountains of the South Horr Valley. The main products were aquamarines, garnets and some other gemstones of minor value. Due to the low output, economic constraints, and security problems the work has long been stopped.

Today only a few people in the South Horr region are gathering some gemstones from the surface but the economic output is almost zero. Amethyst and agate are also found in the Lake Turkana area.

Another mineral is salt, which can be found widely spread over the Chalbi desert. It can be gathered easily and used for salting livestock. Transport can be done by camel.

It must be said that probably no other minerals, especially of higher value, are present in this part of northern Kenya. This includes oil, gas, etc. The geological structures as we know them at the moment offer no chance here. A survey for mining purposes would be very expensive, and probably the cost-benefit ratio would be unfavourable.

VII

EDUCATION, TRAINING AND EXTENSION PROGRAMMES

1. Introduction

Two approaches will have to be adopted in solving the problems of degradation of the arid lands of northern Kenya: an immediate and a long-term approach.

Immediate approaches will involve adults since it is their responsibility to remedy the situation. Long-term solutions will, however, be the responsibility of the younger generation. Unless the younger people are prepared for this role, the problems of land degradation will remain far from solution and the future of nomadism will be in jeopardy.

The school curriculum followed in the area is the common curriculum for all primary and secondary schools in Kenya, which was developed at the Kenya Institute of Education. This curriculum, though within the science and geography sections it does include studies of the environment at various levels, treats these topics in a rather general way, specifically making little mention of arid environments.

Students in the arid areas of the country therefore often remain ignorant of the problems of their local environments while becoming quite familiar with examples from the humid areas, which are covered in greater detail. This anomaly is partly attributable to lack of relevant textbooks on arid areas.

The Kenya Institute of Education is, however, making an effort to develop a relevant curriculum that puts emphasis on the study of the local environment, as is indicated by the advanced-level biology and geography syllabus. The study of ecology and of local landforms and related land use are now popular. IPAL research results can be used to patch up the deficits in these subjects, where the syllabus is limited on the ecology and geography of arid environments.

The nomadic pastoral population, on the other hand, having had limited contact with either formal or non-formal education, will have little use for written educational materials. Education and training programmes for this group should, therefore, be organized through intensive mobile extension services, equipped with audio-visual aids and also relying on the traditional forms of communication for disseminating information.

Short but frequent seminars should also be organized for the various target groups.

2. Broad Educational Objectives

- to identify the existing target groups that need to be reached by the education and training programmes;
- to identify the educational needs of these target groups;
- to explore the possibilities of using the existing formal-education facilities for non-formal educational and training programmes for the Rendille nomads in the IPAL study area;
- based on these findings, to recommend an educational system and infrastructure that will be appropriate for such education, and to suggest various teaching methods that could be adopted.

3. General description of Education, Training and Extension Programmes in Marsabit District

3.1 Formal education

In Marsabit District, even by the time of independence (1963), there were only three primary schools. Nineteen years after independence, the picture has changed. Education has now expanded and thirty primary schools, with a total enrolment of over 7,000 students, have been built. Three secondary schools, with a total enrolment of 400 students, have also been built.

Missionaries have made important contributions to the growth of education in the district after independence. Twenty three of the thirty primary schools mentioned were built and sponsored by missionaries. Before independence, except for the Bible Churchmen's Missionary Society, which had a base in the Marsabit area, the district was virtually closed to other missionaries.

For the future development of education in the district, missionaries can now be seen to have a very important role to play, particularly in the more remote areas.

Educational development in the district has encountered a number of problems. First, poor enrolment, due to poverty and the unwillingness of the parents to send children to school, has led to some schools operating at half capacity. Some schools, such as Dabel and Godoma in Moyale Division, are under-utilized.

Second, the nomadic way of life contributes essentially to poor enrolment, since children form part of the family labour force and cannot be spared.

Third, inadequate transport for the District Education Office has caused administrative and inspection problems, as schools are scattered over the vast area of a district served by very poor roads.

Fourth, the distances involved often result in teachers being delayed in reaching their schools at the beginning of term, and the opening of schools is often help up.

Fifth, the problem of school leavers and unemployment is becoming very noticeable in the area. This factor has also contributed to poor enrolment, since parents feel there is no point in sending more children to school while those who have already finished their schooling are still without jobs.

Nearly all the primary schools have boarding facilities. These facilities at the Government-sponsored boarding schools are not fully utilized, because there is a minimum fee of Kenya shillings twenty per term to be paid by the parents, whereas the missionary boarding schools are fully utilized because they are free or almost so (Table 146).

The Government started a school feeding programme throughout the district in 1981. Pupils who do not utilize the boarding facilities are fed under this programme, and the District Education Officer has reported that attendance rates have improved tremendously since it was initiated.

Table 146. Boarding schools and level of utilization

	Name of the boarding school	Approximate Number of places for boarders	Present level of utilization	Utilization (%)
1.	Marsabit Full Primary school (Government)	230	180	78.3
2.	Moyale Primary School (Government)	50	30	60.0
3.	Sololo Primary School (Government)	100	70	70.0
4.	Loglogo Primary School (Government)	80	60	75.0
5.	St. Teresa Girls' Primary School (Mission)	250	250	100
6.	Laisamis Primary School (mission)	290	290	100
7.	Loiengalani Primary School (fed by famine-relief food)	126	126	100
8.	North Horr Primary School (mission)	290	290	100
9.	Gatab Primary School (mission)	50	50	100
10.	Maikona Primary School (mission)	100	100	100
11.	Kargi Primary School (mission)	90	90	100
12.	St. Mary's Primary School (mission) (Moyale)	120	120	100
13.	S.K.M.Primary School(mission)	222	222	100
14.	Illeret Primary School (fed by famine-relief food)	16	16	100
15.	Kargi Primary School (mission)	120	120	100

Source: Education Office, Marsabit, Marsabit District Development Plan, 1979-1983.

Another important observation that can be made about the influence of education in the District is the resettling of some nomadic families. In areas where either boarding facilities are not adequate or families cannot afford the fees, families are making their own arrangements to resettle some households in trading centres closer to schools, so that their children can attend school from home.

But these households also keep livestock for subsistence, and this has become a contributory factor in the degradation of areas around such centres. Any recommendation made for the exclusion of livestock from some of these areas would, therefore, require educational solutions to be found for the children of such families.

3.2 Non-formal education and extension

Non-formal education programmes were negligible until the launching of the National Literacy Programme in 1978. The literacy survey carried out by Gufu Oba (1981) has shown that participation rates were very low. For instance, during the Literacy Day celebrated on 9th September 1982 only 800 students were reported to be attending adult literacy classes from all the centres in the district.

The survey also noted that 82% of the literacy classes were restricted to trading centres. The campaign has, therefore, had limited impact on the nomadic population.

Extension programmes in the district are similarly poorly developed. There are only a few extension officers posted to the remote areas of the district. Some departments do not even have extension workers in the field at all. By and large, extension services in the district are inefficient and inadequate for the following reasons:

- First, as already pointed out, there are very few extension workers among the pastoral nomads. Those posted to "remote areas" often remain in isolation from the people they are meant to serve, as they are confined to their stations.
- Second, the extension programmes have been in the hands of a few technical experts, each of whom was concerned only with his own area of expertise. This unco-ordinated operation has made the extension services largely ineffective.
- Third, a major constraint on extension services among the pastoral communities has been lack of trust and mutual understanding between extension officers and the pastoralists. The pastoralists know their way of life and trust it; then comes an outsider who does not understand this way of life and starts advocating change. There is bound to be a period of learning for both parties before they can start to build mutual confidence and understanding.
- Fourth, communication has been a major problem between the pastoralists and extension workers. This has arisen from the shortage of local people trained for extension work. Extension workers have therefore mostly been people from other ethnic groups, who did not understand local dialects and, having come from different environmental and social backgrounds, had difficulty in understanding the nomads' way of life.

IPAL has developed, on the job, a large work force of research assistants, trained in all aspects of the vegetation, hydrology, livestock and human ecology programmes. These are local school leavers of Form four standard of education. These assistants will be an asset for future extension programmes in their home areas.

- Fifth, the mobility of the pastoralists and the lack of transport facilities for the extension workers have also limited the services offered. In order to offer more effective educational services to the nomads, extension workers need to be as nomadic as the nomads themselves.

4. Environmental Education and Training

4.1 Curriculum

The primary and secondary school curricula are, as we have seen, the same as those followed throughout Kenya, developed by the Kenya Institute of Education in conjunction with the National Examinations Council. At the end of seven years of primary education and four years of secondary, students write examinations for the Certificate of Primary Education, and the Kenya Certificate of Education respectively. From 1984 they will participate in the 8:4:4 system.

The major criticism that can be offered of the curriculum as it now exists is that it does not prepare the pupils for a nomadic pastoralist lifestyle. The parents claim that children develop different values and no longer want to care for animals. Going to school makes them aspire to jobs in towns and choose a different lifestyle from that of their parent.

4.2 Target groups

Environmental education and training should be introduced in all educational fields. The most important area, however, is that of public education. For any attempt to combat desertification will fail if the population concerned is not involved and is left ignorant of the causes and consequences of environmental deterioration and the methods of protection, conservation, and rehabilitation.

Environmental education introduced into the educational main-stream can also systematically promote environmental awareness in the younger generation, while specific training can facilitate the tasks of those engaged in the work of environmental assessment and management.

In order to identify deficiencies in the present primary and secondary syllabi, books and syllabi used at these two levels were examined and recommendations on the input of environmental education with reference to arid environments have been made. Details of these can be found in *IPAL Technical Report No. F-1,* November 1981.

4.3 Non-formal education

The very fact that nomadic societies have survived in such a hostile environment as northern Kenya for so long indicates that they are well adapted to these conditions.

Knowledge of the environment is gained from parents, elders, personal experience during migrations, herding, hunting, etc. and these have formed the nomads' environmental perceptions. Such knowledge should be the basis of the education that is offered to them. The education offered should equip them with the skills and attitudes necessary for their successful involvement in the management of their environment.

Environmental education is founded on the premise that we will only be able to solve our environmental problems when we have developed in our citizens an awareness and understanding of and concern for the environment with all its problems, and the knowledge, skill, commitment and motivation to work towards solving them.

4.4 Existing adult-literacy programmes

One of the investigations that was carried out by IPAL (1981) was a survey to identify the existing non-formal programmes and to see if these programmes met real needs. The study was specifically designed to find out:
- the proportion of men and women attending adult literacy classes;
- what factors influence attendance and what subjects were taught.

The results of the survey revealed that 82% of literacy classes were held in institutions such as schools and missions situated in trading centres, while 18% of the classes were run in sedentary manyattas and none in mobile pastoral camps. The results indicated that the literacy programme has had limited or no impact on the nomadic populations.
The attendance composition also showed that 59% of the attendants were women, while only 41% were men.

This disparity can be explained by the distribution of labour within the nomadic pastoral families. Generally speaking, men have livestock and resource-management responsibilities. They also have obligations to the rest of the community. When there are discussions of water and pasture use, men gather to make decisions on the options and solutions. Women on their part are mainly charged with household management, fetching firewood, and drawing water.

The labour distribution between men and women, therefore, allowed women to remain closer to their home camps, while men were away for much of the day or even for weeks. This meant that if women were interested it was relatively easier for them to attend literacy classes.

Other factors also affected the attendance of men at literacy classes. Their attitude to the quality of education offered at these centres had an influence, for example. The men interviewed argued that instead of making them attend literacy classes, which they claimed made no contribution to their economic well-being, the Government should think of solving their water problems. This was a reflection upon the subjects taught in these centres: reading, writing, and arithmetic formed 94% of the subjects taught, while conservation education formed only 6%.

For the purpose of environmental management the literacy programme has, therefore, made little or no contribution. It has been deficient in two ways. First, it has never involved the people in deciding what they should be taught; second, it has given minimal attention to the subject of conservation, which should have had top priority in such an area as northern Kenya, where environmental deterioration is on the increase (Gufu Oba, 1981).

4.5 Survey on environmental perception, knowledge and management

a. Objectives

- to find out people's general perception of their environment and practices;
- to identify their educational needs based on their perception of their environment and practices;
- to establish people's knowledge of the environment, together with their existing land-management practices, should be the key points of entry for development.

b. Methodology

The results of this investigation were based on interviews and discussions held with 167 Rendille elders sampled from the study area by means of a scheduled questionnaire. The elders were asked to give factors that influenced their selection of manyatta sites, range preferences, perception of climatic changes, reasons for their increasing dependence on famine relief, soils, tree resources, preferences for water resources, and their perceptions of livestock marketing and diseases (Gufu Oba, 1982).

Elders were selected because of their knowledge of the environment, and the important roles they could play in the management of their environment.

c. The findings

(i) Siting of manyattas

As shown in Table 147 the nomads have various factors to assess before siting a manyatta.

Table 147. Factors to be assessed before siting a manyatta

Factors to be assessed	Importance as a percentage of total
Distance to pasture	24.9
Distance to water	24.6
Surface topography and soils	11.3
Availability of kraal materials	21.9
Disease vectors (e.g. ticks)	17.3

The destructive impact on vegetation by the Rendille, Gabra and Boran nomads is largely attributable to their need to construct livestock kraals everywhere they camp. This has led to serious wood shortages around sedentarized settlements such as Kargi and Korr. In these areas tree felling is taking place at a faster rate than replacement by young trees.

The answer to tree destruction by the nomads depends on two factors. First, a change of the nomads' attitude towards utilizing natural resources such as trees. This will help them to realize that trees are resources that, if misused, can be destroyed and that, as a resource, trees require constant care,

just as they care for their livestock. Further, that although they must satisfy their immediate needs, they should use tree resources so as to avoid cutting down whole trees, by cutting only a few branches from each tree. They should be convinced that if they do this they will continue to have a continuous supply of kraal materials produced through tree regeneration.

Second, they should be helped to realize why they should be prepared to utilize alternative kraal building materials such as bamboo, stone, lava, dead wood, *Euphorbia,* etc. particularly in sedentarized centres.

(ii) Range preferences, a basis of traditional land use

The pastoral nomads have their own rationale for using the range. This is seen in their ability to use various areas of the range at different times of year, often developing transhumance in some areas and cyclic movements in others. These movements are all based on the nature and distribution of water and pasture and to some extent on the soil types and disease vectors prevalent in the areas, as shown by Table 148.

Table 148. Range preference and parameters used for range selection

Parameters used for range selection	Importance as a percentage of the total
Water availability	32.9
Vegetation types	32.7
Disease vectors prevalent	22.7
Soil types	11.6

The pastoral Rendille, Gabra and Borana associate a range area with a particular land use. This can be shown by the distribution of their livestock over the areas of the range. Certain areas are predominantly settled by camel-keeping families, while others are used by smallstock *fora* and still others by cattle-owning families. Some areas support all types of livestock.

They also have a mystical belief that certain areas of the range are preferred by livestock to others. The Rendille say that such areas have *fuur* - a factor in the range which is not clearly statable, but is claimed to make livestock fat even in the absence of pasture! Other areas of the range, on the other

hand, are claimed to be "not preferred" by livestock, even when they have adequate pasture, because they lack *fuur*! Livestock grazed in such areas, it is claimed, grow thin.

The concept of *fuur* does not imply total rejection of these areas. For example an area that is claimed to have *fuur* for camels will not have *fuur* for cattle and vice versa.

The concept of *fuur* is, however, often misused, because the areas which are claimed to have *fuur* are the most degraded today. There is therefore a need to help the Rendille nomads to come to terms with this problem, if the conservation of their environment is to succeed.

There are also other factors such as disease prevalence which may help them to understand why some areas are not suitable. For example, in mountain areas, such as Marsabit and Mt. Kulal, high incidences of intestinal worms in livestock have been reported. The incidence of these worms is not often noticed by the pastoralists, except for the loss in weight by their livestock and certain other symptoms such as diarrhoea.

The use of drenching drugs and other veterinary inputs may help people to realize that loss of condition by their livestock is not necessarily attributed to an area's lack of *fuur*, but to disease infections.

(iii) Climate

Table 149. Responses to questions on climate changes

a. Factors causing 'localized droughts'	Importance as a percentage of the total
Rainfall failures	46.3
Overgrazing	16.0
God	37.7

b. Frequency of droughts now as compared to many years ago	%
More frequent	80.4
Less frequent	4.8
Neutral	14.9

c. Number of people depending on famine relief now, as compared to ten years ago	%
Increasing	99.4
Decreasing	0.6
Neutral	0.0

The pastoralists have their own ways of predicting rainfall failures and successes. These are done by men who study cloud patterns, the intestines of slaughtered animals, movements of stars, etc. Whatever the limitations of these methods, they do help the pastoralists to determine their future movements.

They claim that 'localized' droughts are caused by rainfall failures, overgrazing, and God, as shown in Table 149 Part A.

The responses on overgrazing and God as factors causing localized droughts are certainly important. The response that God is behind the occurrence of droughts is part of a deep-rooted belief that any happenings, be they wars, diseases, rainfall or hunger, are brought by God.

While country-wide droughts can be accepted as natural phenomena, it must suffice to say that environmental degradation has contributed to localized droughts. Overgrazing is a factor that all the pastoralists are very familiar with. The Gabra, Borana and Rendille nomads have expressions for it in their own languages. For example, if a Rendille wants to say that the land has been seriously overgrazed, he would say, *'hara abarbathwate'*, by which he means that the land has been so severely overgrazed that not a single piece of grass is to be seen. A Gabra would say 'barbadha diluuni uuba infuune', the land has been so much overgrazed that even when the after-birth of a cow is dragged on the ground it will not pick up a piece of grass! Using such local perceptions, the problem of overgrazing and what steps are to be taken to stop it can be appreciated by the nomadic Rendille and Gabra.

They should also be helped to realise their role in the deterioration of their environment and that they have no cause to blame God but themselves. Many of the nomads who have lost their livestock through droughts (48.0%) and tribal raids (23.8%) are now dropping out of nomadism and settling in trading centres. The immediate future of these families does not lie with nomadism, but in becoming adapted to a life of begging or selling their labour to farming communities and town folk, doing such chores as water fetching, baby sitting and watchmen's work.

Education for such people must meet their needs in their present environment. For those who farm, agriculture and soil rehabilitation and conservation could possibly form the core of the curriculum. Others, who have some capital, may prefer to join the traders, and these groups could be taught the principles of trade and marketing, etc.

The children of such families might be helped to join village polytechnic or apprenticeship classes in such crafts as woodwork, or learn other forms of trade, or be rehabilitated through boarding schools. Their future employment may perhaps provide an opportunity of restocking the herds of their families.

(iv) Soils

The pastoral Rendille, Gabra and Borana are very familiar with soil types found in their areas of the range for which there are local names. They equate the goodness of a range with the type of soil present. For example, the Rendille elders interviewed pointed out that soil baths or *gangelimo* are a pre-requisite for camels to inhabit any area of the range. Areas with lava are not preferred because there are no soil baths, while chalky soil types are claimed to be most preferred, particularly if saline. Such soil baths are claimed to help camels against mange.

The Rendille nomads do not, however, believe that soil can be degraded or that loss of the vegetation cover can lead to loss of soil (Table 150).

Table 150. Perceptions on degradation of soil

Can soil be degraded?	% of total responses
Yes	15.6
No	84.4
Would overgrazing and excessive tree felling cause loss of soil?	
Yes	32.9
No	76.1

These findings have important educational implications: unless the inhabitants of these areas understand the relationship between overgrazing, excessive tree felling and soil degradation, the problems of environmental degradation will not be solved. This awareness can be developed through appropriate education. Through educational programmes, the nomads could be made to appreciate that the destruction of vegetation cover exposes the soil to the agents of erosion such as surface run off and wind, resulting in soil loss. Using these facts, they could then be convinced of the necessity of dispersing their livestock over the range to overcome the problem of overstocking.

(v) Water-source preferences

The Rendille pastoralists have preferences among the water resources available to them (Table 151).

Table 151. Water sources: Order of preference expressed as a percentage of the total

Preference of water sources	% of total responses
Man-made wells	30.2
Boreholes	28.6
Dams	19.0
Surface water	16.4
Lagga water	5.8

The order of preference was based on the permanence and ready availability of water in the sources. Shallow man-made wells were preferred because their waters are claimed to be mineralized, so reducing the need for salt licks. It is for this reason that the Rendille herdsmen have a high preference for the saline water of the Korole wells. These man-made wells were further preferred because of their abundant water.

Boreholes came only second on the preference list because of their unreliability and the problem of fuel supplies. Borehole engines often break down and may take many months to repair because spare parts are not available.

Lagga waters were least preferred because of their ephemeral nature; they often disappear into areas which are not used by the nomads.

The Rendille pastoralists do not have strict regulations governing the use of water sources, as their neighbours the Borana and the Gabra do. Their livestock are led directly into the water, quickly polluting it.

The owners should therefore be made aware of the dangers of misusing their water, especially of the fact that pollution of water sources by livestock urine and faeces and domestic effluents may cause health hazards to those who use them.

They should be made aware of the threat of such gastric diseases as cholera. They should be told their modes of transmission and the precautions to be taken to minimize the risk of infection. Women, who are responsible for fetching water and cooking for their families, should be helped to realize the need to boil all the drinking water.

The pastoralists should also be made aware of the serious degradation processes taking place around permanent water points. The role of the people in caring for water sources should be stressed. Water committees that see to the proper management of all water sources should be formed.

(vi) Livestock marketing

The general view held that the pastoralists are unwilling to sell their animals has now been disproved. The real problem has been that marketing facilities and essential goods needed by the pastoralists are lacking.

Therefore, in order to induce pastoralists to market their animals, conditions must be created that make selling stock meaningful, not only by establishing good market conditions but by creating other incentives for sale.

One must remember that to the pastoralists livestock, particularly cattle and camels, are not merely a good resource; they are also capital essential to all kinds of negotiations involving influence and alliance. They are not merely savings, but are the only form of investment available to the pastoral nomads.

Results of the survey show that male adults of all species are sold before adult females or male and female immatures. But if adult males are not available, the pastoralist herders will sell male immatures next.

Male adults and immatures form the first and second orders of marketability because they constitute the non-reproducing component of the livestock population; their sale does not affect the reproductive potential and milk supply of the herds.

In the absence of male adults and immatures, female immatures are chosen. Female immatures form the potential reproductive component of the herds, but their sale has no immediate effect on the food supply of the nomadic families.

The sale of reproductive female adults is seen as a last resort, because their sale directly affects the food supply of the pastoral families. It is because of this that it is extremely rare to see pastoralists bring lactating or pregnant females to market. This explains why one sees very old cows in the herds, though in productive terms these cows can be said to be 'useless'.

The Rendille pastoralists should also be told of the policy of such organizations as the LMD, which is interested in buying male immatures, and not old cows or castrates. This will certainly require a considerable educational effort because of the general belief held by the pastoralists that only mature castrates will fetch good prices.

(vii) Livestock diseases

The Rendille pastoralists are quite knowledgeable about most common livestock diseases, such as rinderpest, foot-and-mouth, anthrax, black-quarter and C.B.P.P., as shown by Table 152.

Table 152. Awareness of common livestock diseases expressed as a percentage of total response

Dangerous livestock diseases	% of total responses
Survey I	
Rinderpest	24.4
Foot-and-mouth	11.0
Anthrax	29.0
Black quarter/C.B.P.P.	35.6
Survey II	
Rinderpest	30.7
Foot-and-mouth	24.9
C.B.P.P.	44.4

The diseases mentioned by the respondents are those which can be controlled through vaccination programmes. Such programmes have two advantages. First, they increase contacts between the pastoralists and extension workers, and second, through such campaigns the Rendille pastoralists will have opportunities of coming to accept the use of drugs for treating livestock.

Their knowledge of the contagious diseases is quite important. Outbreaks have often been met by quarantine restrictions in order to reduce the spread of a disease. But an outbreak of disease is often known to the veterinary authorities only after it has spread, because of attempts by individual herd owners to conceal an outbreak in their herds, for fear of having restrictions imposed on them.

This attitude has important educational implications since unless the nomads themselves can be brought to realize the importance of reporting these diseases control will not succeed.

5. Extension Programmes

5.1 Introduction

Extension programmes are the means by which the local population is involved in long-term educational processes through a series of planned activities. Extension services are the channel through which Government and other developmental agencies translate their programmes to the people in order to have their recommendations implemented.

The role of the local people in the extension programme is the vital factor which determines the success or failure of a project. The programme also plays an important role in monitoring people's needs, knowledge, and expectations.

While the extension officer is also expected to play a part in public relations for his organization or department, his true role is to help the people to integrate the project management proposals with their requirements and approaches, in order to enhance the success of the project.

5.2 Past extension programmes: conflict with the pastoral way of life, knowledge and expectations

In the traditional situation, the pastoral nomads of northern Kenya made their own decisions on the use of resources, such as water and pasture.

With the coming of the colonial administration they lost much of their independence in decision making. Their movement from one grazing zone to the other was restricted and offenders were punished. Their knowledge of the range, gathered over many generations, was considered inferior to the new scientific approach of controlled grazing. The pastoralists on their part vehemently resisted these changes, as shown by the failure of numerous development projects in the pastoral areas.

To them, some projects appear to interfere with their freedom of movement and range use. Indeed, since projects are often based on the formulation of similar projects operative in other countries, they are bound to be rejected.

The way the nomads refer to these projects often reflects their attitude to development programmes in general. It is not uncommon to hear them say 'that project of the Catholic mission', 'that well of the Government', or 'that school of the NCCK' or 'this hospital of this or that organization'. They do not consider these projects as being their own or that they should be responsible for their proper care and utilization. They use them as long as they are operative but never lift a finger if they see them being misused or breaking down, because they do not belong to them. Some of them will take the opportunity of illegally helping themselves to some of the facilities, as exemplified by the Rendille moran, who often unscrew nuts from water tanks for their club heads!

All this happens because these projects are for the most part developed in isolation from the people's socio-economic lifestyles. The people's role in them is not well defined, and they see them merely as a free resource which they can use as long as it works.

Such negative responses to Governmental and other projects have earned the pastoralists the blame for project failures. One criticism often directed at the pastoralists is their lack of interest in sending their children to school. The administrators, politicians and other local leaders tell them that if they send their children to school, some will become D.O.s, police officers, doctors, nurses etc. This in itself has raised aspirations which are foreign to their real socio-economic expectations.

Their failure to respond positively to projects is therefore to be attributed to the nature and scope of the extension programmes rather than to the rigidity of the pastoralists, as is often claimed. There are few extension workers among the pastoral communities of the district. Those who are posted to remote areas often remain in isolation from the people they were meant to serve, as they are confined to their stations, so that their contacts with the people are limited to orders given through chiefs and sub-chiefs at barazas (official meetings called and addressed by Government officers).

5.3 Channels of communication among pastoralists and points to be considered for extension programmes

The IPAL study area is the home of the greater part of the Rendille and Gabra and of a small section of the Borana ethnic groups. These groups have similar communication channels, which are important factors to be considered for any extension programme.

a. The baraza

The official channel of communicating with the people in the study area is the baraza. Barazas are often attended by elders representing each village who in turn convey the information gathered to the people of their own manyatta.

The baraza as a communication channel has, however, three main disadvantages. Firstly, barazas are often used for administrative or disciplinary purposes rather than for the communication of information. Secondly, administrative barazas are often conducted in Kiswahili, which, though a national language, is not understood by the majority of the local people. Therefore, large numbers of individuals who attend these barazas end up understanding nothing but gathering a few crumbs of information from others who have some slight knowledge of the language. Such people will not be able to convey any effective information to the people of their village. Thirdly, communication is usually from the administrators to the people and dialogue is limited.

Therefore, the administrative baraza needs to be modified for the purposes of the extension worker. It should be as close as possible to a normal

gathering of the local people and should be used as a means of disseminating information over a wider area before actual individual contacts with the people are made.

b. Person-to-person communication

In the IPAL study area person-to-person communication is the commonest mode. When, for example, two people meet, after exchanging greetings, they ask each other's news - 'news from the right and the left' as the Borana say.

This will include details about the water and pasture situation, their distribution, the condition of livestock, whether they have an adequate milk supply, whether their cows or camels are in calf, then news of the neighbouring grazing areas and whether each one has plans to move to another grazing zone, and so on. Such detailed questions help in quicker dissemination of vital information to all the members of the community.

c. Group communication channels

Another very important channel of communication is that which involves all groups in the society. It is characterized by gatherings of the local people, still conducted on the same lines as those of their forefathers.

In the pastoral areas, villages are important functional units where decisions on the communal use of pasture and water are made. In these villages, individual decisions made do not go beyond one's household and herd. While the herd owner can graze his livestock in any part of the range he wishes, he is not free to use water or other communal resources arbitrarily. Therefore, if an extension officer is interested in knowing people's attitudes towards new approaches to range use, it is of no use depending on the views expressed by an individual. While it is true that he may have personal needs which require to be looked into, this can only be done in the light of the needs of the community. Therefore, an individual needs the whole community for making such decisions. Even when decisions are made, not all the members of the community may agree, but majority decisions are always respected. Two such traditional gatherings where problems are solved and decisions made are the Boran and Gabra *koora* (meeting) andthe Rendille *naapo*.

d. The *naapo* assembly as a target group

Among the Rendille, settlements are based on kinship. Thus the Rangomo clan, the Saale clan, the Galderlan clan, the Rahowen clan, etc. inhabit different settlements.

Each Rendille manyatta or settlement has a central enclosure which the Rendille call *naapo*. It is in this enclosure that the elders of the manyatta meet every night. Each manyatta has an elder-leader whom the Rendille call *Et-gobi-iwen*. The manyattas themselves are often called after such leaders, for example, *Gob-Ogum* - *Gob* is a manyatta of the Orowen (Rahowen) section in Kargi and *Ogum* is the *Eti-gobi-iwen*. Therefore, *Gob-ogum* means the village of *Ogum*.

Each *Eti-gobi-iwen* is the person in charge at the *naapo* of his settlement. After the completion of smallstock and camel milking, the *Eti-gobi-iwen* calls the elders of the settlement to the *naapo*. When they arrive, there are prayers, asking *Wakha* (God) to bless the pasture, water, livestock, children, women and country and to keep away all their human enemies. The elders then settle down to discuss all the problems experienced by the village - water supply, pasture condition, when and where to move the manyatta, perhaps a message from the administration that the people should contribute to a certain fund, or a conflict between members of the manyatta, and so on. The *naapo* is such an important centre in the life of the Rendille that it should be considered as a target group for extension work. However, the extension worker should be aware that the *naapo* assembly is not accessible to all members of the manyatta. Those not included are children, moran, and women, but all married men are allowed to participate in the assembly. The extension worker, if he is not married, will himself be excluded from the *naapo* assembly, and he should therefore use the *Eti-gobi-iwen* in raising his points in the *naapo* and arrange for the other elders to meet him for further discussion.

The issues raised in the *naapo* assembly will find their way to all the members of the manyatta through those who attended it. Certain decisions to be made may require the involvement of members of neighbouring manyatta, as in the case ofsuch things as *harambee* funds to be raised, a labour force to be provided for a harambee project, a veterinary campaign to be conducted in the area, security arrangements after being attacked by livestock rustlers, or meetings with IPAL scientists to discuss management

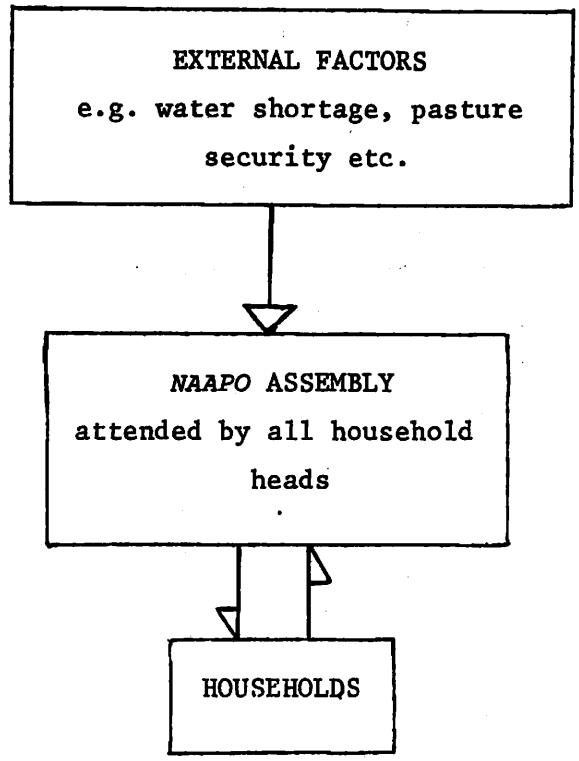
guidelines. Such meetings are attended by all representative *Eti-gobi-iwen,* who are also on the chief's committee. Decisions made at these meetings and issues raised are carried back home to the *naapo* assembly by each elder.

If the meeting called by the chief or sub-chief requires the involvement of people not present, the chief or his assistant explains to the elders the problem discussed and requests them to discuss it further with the members of their manyatta and bring back a response on a fixed date.

These two approaches may be summarized in the following simplified models of communication, indicating points of entry by extension workers:

Figure 30

Model 1: Channels of communication from the *naapo* assembly to each household in the manyatta





Channels of communication showing positive feedback

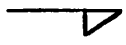
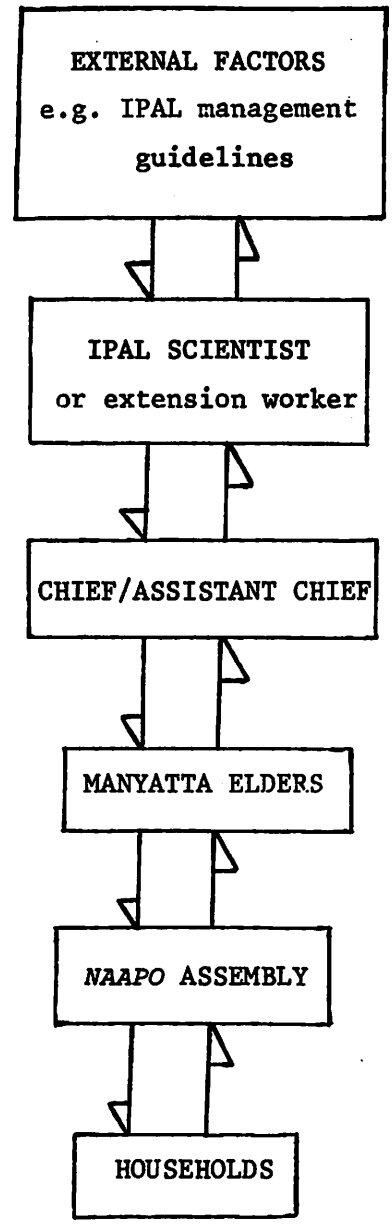


Figure 31

Model 2: Channels of communication from the IPAL scientist through the chief's baraza to the villages.

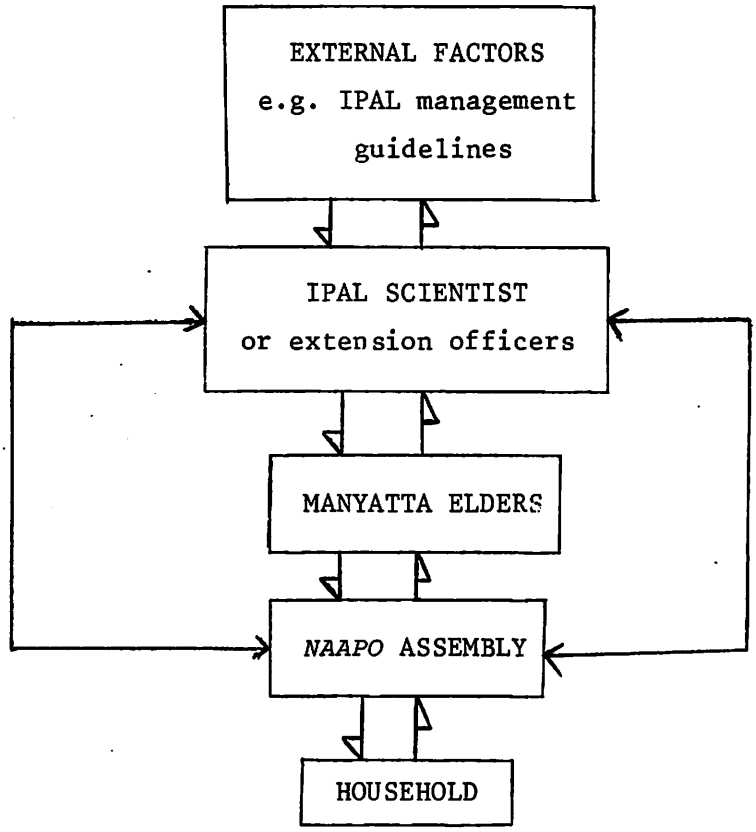


For information to reach a target group such as a household, it has to pass many barriers, as shown in model 2. Its effectiveness is reduced because of the distance between the extension worker and his target group. This could, however, be overcome if the chief or his assistant were used only to officiate over the meeting held in his location, and the extensionworker communicated directly with the elder representives, as shown in model 3.

In this model the extension worker has two opportunities of coming in contact with elders; firstly, he communicates directly with them at the chief's baraza, and secondly, he meets the same elders again at the village level or at a *naapo* assembly if he is allowed to participate.

Figure 32

Model 3: Channels of communication from IPAL scientists to elders through the *naapo* assembly.



This communication channel is comparable to those of models 4, 5, and 6 representing other ethnic groups.

e. The *Koora Dedha* of the Gabra and Borana: a point for consideration in the IPAL extension programme

Like the Rendille, both the Gabra and Borana settle in villages. But, unlike the Rendille, Gabra and Borana village are not composed of members of the same kinship. Gabra villages are normally smaller than those of the Borana, except the Gabra *yaa*, which may have as many as 30-60 households.

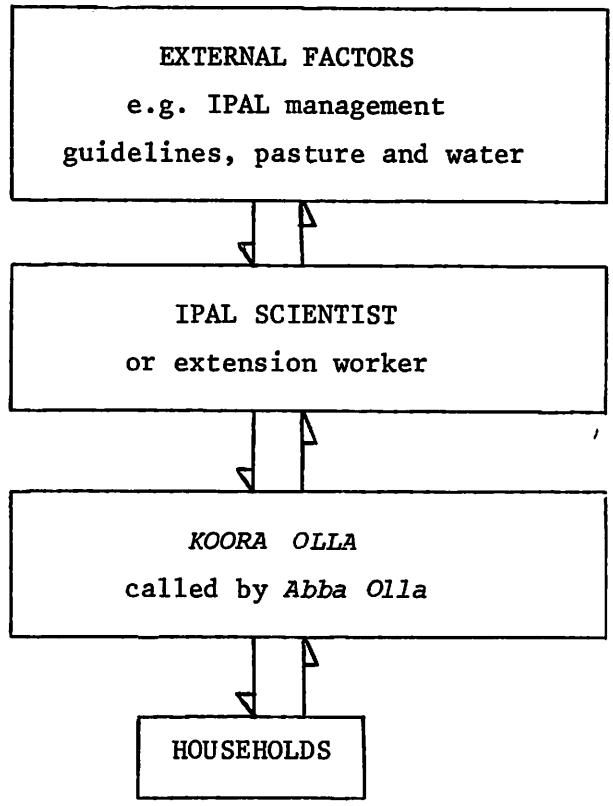
However, as with the Rendille, Borana and Gabra villages are important centres where decisions on the use of pasture and water resources are made. Villages are called *olla* in Boran. Each *olla* has an elder leader whom the Borana called *abba olla* (father of the village). Each village is named after its elder leader; thus one of the villages in Kalacha is called *olla Racha*, which means "village of Racha".

Abba olla are central figures, often very influential personalities around whom the village life revolves. Gabra and Borana often meet at the village level to discuss conflicts between village members, and to make decisions on pasture and water use. Such meetings are called *koora*. Because decisions are made on problems that affect the members of the village, the meeting is called *koora olla*.

There is no special place where the *koora olla* takes place. During the day it may be held under one of the shade trees close to the village or at a water point, if the *koora* is to discuss water problems, but if it is called at night it will be held in front of *abba olla's* household. *Koora olla* has no restriction on any member of the village. The decisions made at such gatherings are carried back to each household by those who have attended.

If decisions and discussions made concern the moving of the village *fora* herds, overgrazing, scouting to investigate the rain situation in some other parts of the range, they call it *maala maari* (suggestions and decisions); hence the common call, '*Maala maari bissaniti koota*' - "Come all for suggestions and decisions on water!"
The *koora olla* approach can thus be summarized in a simplified model of communication channels as in model 4, with the point of entry by the IPAL extension worker.

Figure 33
Model 4: Communication channels from IPAL scientist to *koora olla* through to households



For the purpose of the extension programme, an IPAL scientist or extension worker may approach the *Abba olla*, brief him about his programme, and request him to call the *koora olla* to meet him. In order to have minimum interference from the chores of milking and evening meals, such meetings may be organized during the day, say under one of the trees where the *koora olla* is often held.

If the extension worker required the involvement of a nearby village (*reera*) at the meeting, he could contact the elders of each village and request them to arrange to meet him. The representatives would then call a *koora reera*, where they would discuss the issues which were raised by the extension worker.

A *koora reera* is often called to discuss such things as the movement of *fora* herds from main camps when water supplies for milk herds run low, the use of water sources near the village, or contributions to Harambee funds. The decisions made at these meetings are carried to each village by its representatives. The representatives will then report to the *Abba olla* what the *koora*

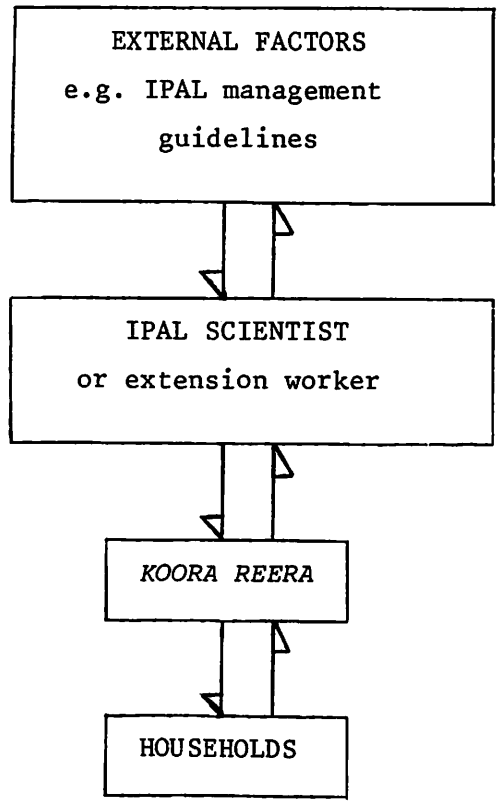
reera has discussed and the decisions made. If the *Abba olla* himself has attended the meeting, he will give details to his village elders.

This is often done as follows. A village member who was not present at the *koora* comes to the *Abba olla's* household and after exchanging greetings asks *Koora reera maniti bufate*? - 'What has the meeting of the *reera* village decided?' After which he will be given details of the meeting.

With the input of the extension officer, the channels of communication may be summarized as follows:

Figure 34

Model 5: Channels of communication from IPAL scientist to the *koora reera* and finally to manyattas through the *Abba olla*



If the decision to be made requires the involvement of all the manyattas in the grazing zone using a common water source, such as wells, the *koora dedha* is called to meet. *Dedha* is Borana word which means "grazing zone". All the *Abba olla* from the villages or their representatives from all over the grazing block will meet to discuss common problems. At such meetings every participant is given an opportunity to express his ideas on the issues raised.

The suggestions made by various participants are then deliberated upon and final decisions made or conflicts resolved. A decision made by the *dedha* assembly carries a great deal of weight and must be respected by all the people in the zone. Decisions made at *dedha* assemblies are carried back to each village by its representatives or *Abba olla*.

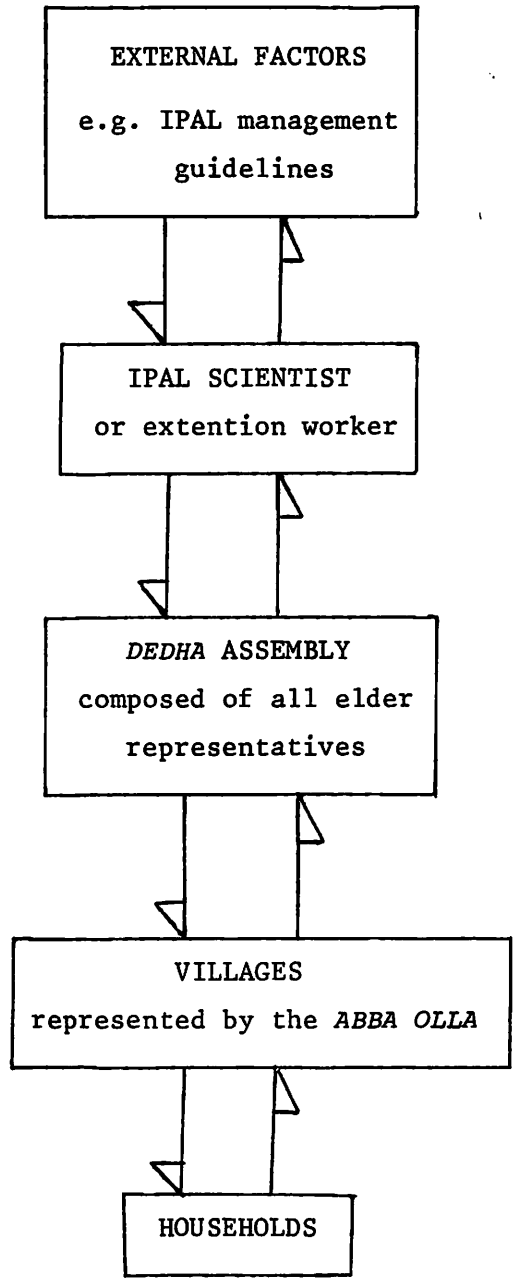
Dedha assemblies are, however, only called to make very important decisions which are vital to the survival of the society, such as water and pasture use, provision of the labour force for the upkeep of wells, food supplies for such projects, conflicts over the use of water, provision of a labour force for *harambee* projects, contributions to *harambee* funds, etc.

A minimum period of one week is required to call the *dedha* assembly. This period is needed to decide where the meeting is to be held, arrangements for food for the participants, and allowance of adequate travelling time for participants who come from far away.

The *dedha* assembly is a very important target group which the extension worker should utilize. It is the gathering of all those people involved in decision making for their communities. Its decisions are often unanimously adhered to by all the people. It is a very effective means of reaching every member of the community, and involving them in activities that will improve the lives of all.

The main objective of the *dedha* assembly is actually to try and solve the problems which affect people not only at community level but even at household level. For example, at community level the assembly may be involved in solving water problems by excavating a well which has long fallen into disuse. The household level may be involved in the collective action by contributing food or labour, or both, to the project. But the actual decision is made at *dedha* assembly and carried to the village and finally to each house.

Figure 35
Model 6: Channels of communication from IPAL scientist to the *dedha* assembly through village elder representatives to villages and finally to households

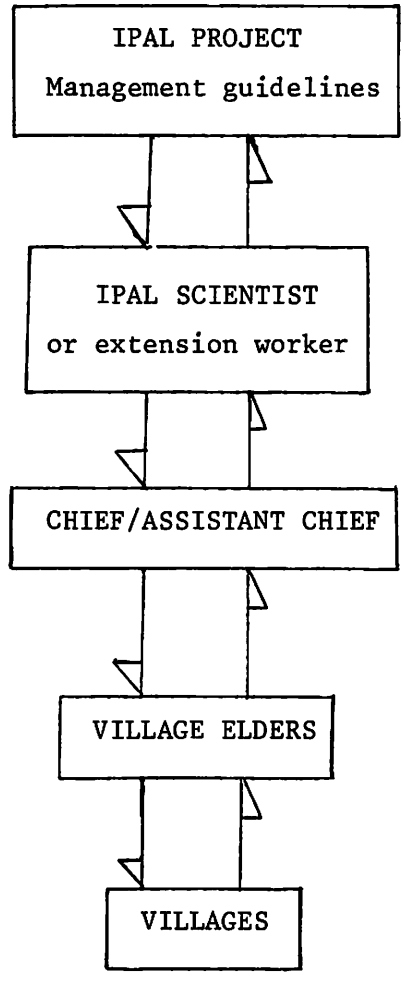


As seen above, the general format of the established communication channels for Rendille, Gabra or Borana is similar. But each group has an important target group unique to itself. For the Rendille the most important target group is the *naapo*, while for the Gabra and Borana it is the *koora olla* and

koora dedha. Therefore, an extension worker working among the Rendille should aim at reaching people at the *naapo* assembly level, while those working among the Borana and Gabra should address themselves to the *koora olla* or *koora dedha*. If the extension workers's communication is related to the use of water and pasture and their problems, the *dedha* assembly should be approached. The meeting with the *dedha* assembly may be arranged through the chief or sub-chief or the location. These interaction may be summarized by model 7

Figure 36

Model 7: A general model of communication channels to be used by extension workers in reaching the local people in the IPAL study area.



Key:



feedback communication channels



direct contacts

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