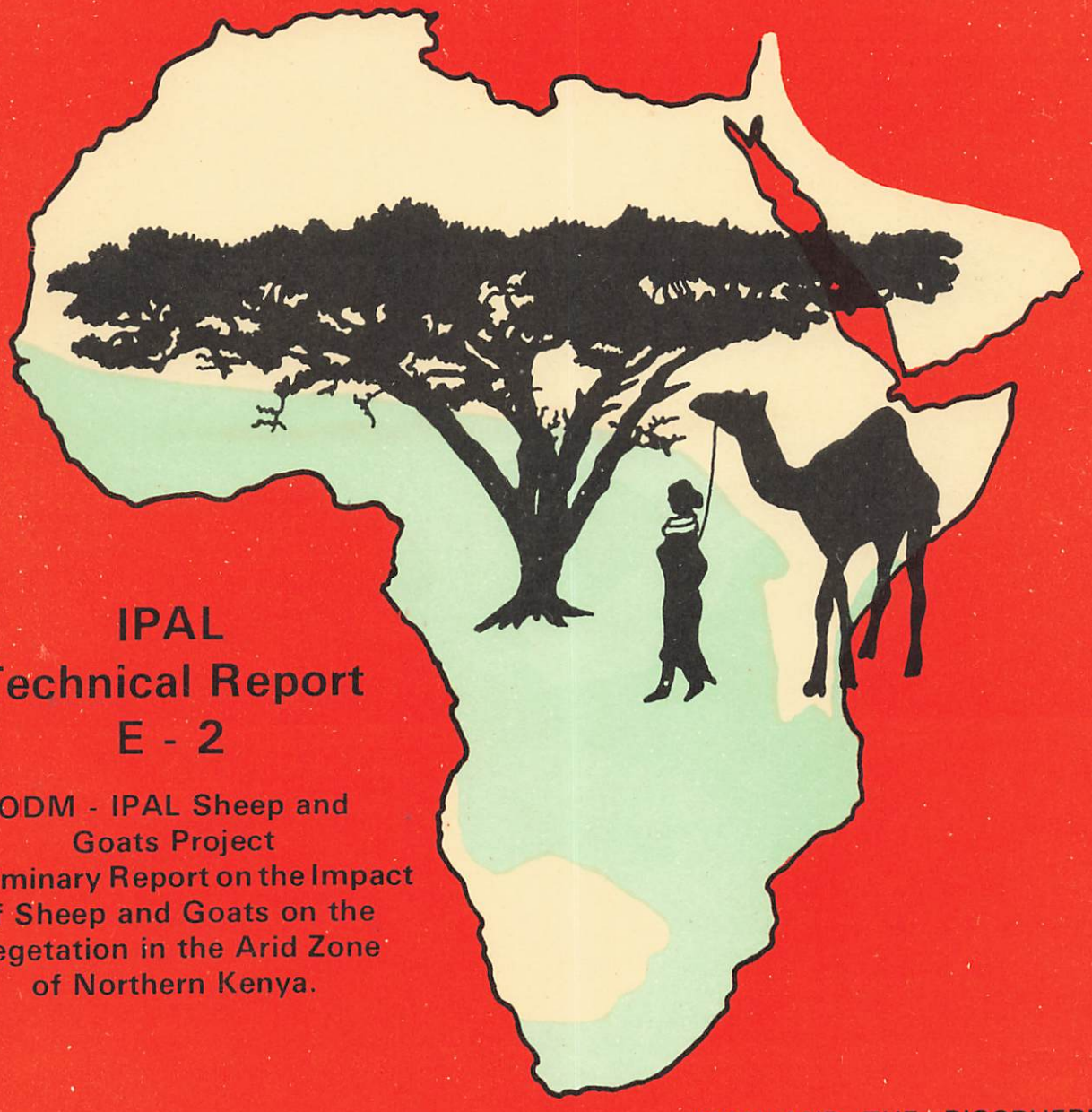
Unesco Programme on Man and the Biosphere (MAB)

United Nations Environment Programme (UNEP)

Integrated Project in Arid Lands (IPAL)



IPAL Technical Report E - 2

ODM - IPAL Sheep and Goats Project
Preliminary Report on the Impact of Sheep and Goats on the Vegetation in the Arid Zone of Northern Kenya.

MAN AND THE BIOSPHERE PROGRAMME

Project 3: Impact of Human Activities and Land Use Practices on Grazing Lands

IPAL Technical Report Number E - 2

ODM - IPAL SHEEP AND GOATS PROJECT
PRELIMINARY REPORT ON THE IMPACT OF SHEEP AND GOATS ON THE VEGETATION IN THE ARID ZONE OF NORTHERN KENYA

By
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April, 1978

UNEP - MAB Integrated Project in Arid Lands

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Summary Introduction to IPAL and the Technical Report Series

The Integrated Project in Arid Lands (IPAL) was established jointly by UNEP and UNESCO 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 operations under MAB Project 3, the Secretariat of which is jointly held by UNESCO and FAO, and also those of UNEP's Desertification Unit, established in response to the Plan of Action adopted by the United Nations Conference on Desertification. It is an example of the type of pilot activity that UNEP and UNESCO, together with other organisations and a number of governments, 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 early operational work of IPAL, a co-ordination unit was established in Nairobi and the initial field work started in the arid zone of Northern Kenya in a working area of 22,500km^2 situated between Lake Turkana and Marsabit Mountain. The Project now operates five field stations at Mt. Kulal, Olturot, Kargi, Korr and Ngurunit, with the Project headquarters in Marsabit, the administrative centre of the District. Since its establishment the Project has worked on several aspects of the ecology and experimental management of the region, concentrating upon the interaction of pastoralists and their livestock with the soils and vegetation of the environment and the constraints to the production of the ecosystem.

During the next three years (1980 - 1983), the investigations in progress will be extended and intensified to develop a resource management plan or model for the area, taking into account the increasing human population, the trend towards sedentarization, the degradation of primary productivity, and the increasing incidence of soil erosion, all of which are factors which contribute to the necessity for constant famine relief measures in this region. Results obtained in this Project will be compared with those from similar research in the Sahel region and other arid regions in the world.

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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ODM - IPAL SHEEP AND GOATS PROJECT
PRELIMINARY REPORT ON THE IMPACT OF SHEEP AND GOATS ON THE VEGETATION IN THE ARID ZONE OF NORTHERN KENYA

1. Introduction

ODM Research Scheme R3164 'The impact of sheep and goats on the vegetation in the arid zone' was initiated on 1 May 1976. The primary aim of the Project was to elucidate the role of smallstock in the process of desertification in the arid zone of Africa. The work was carried out in close cooperation with the UNEP/MAB Integrated Project in Arid Lands (hereafter referred to as IPAL) which is operating in Marsabit District, northern Kenya. This area is considered to be representative of Sahelian north Africa, both in the composition of its vegetation and in its climate. A brief description of the study area ecosystem is given below; for more detailed accounts of the vegetation and climate see IPAL Technical Reports Numbers B - 1 and D - 1.

Sheep and goats (hereafter referred to as 'smallstock') are numerically by far the most important types of livestock in Marsabit District. In 1971 livestock numbers in the District were estimated as 508,000 sheep and goats; 230,000 cattle and 149,000 camels (Statistical Abstract, 1971). A recent survey over the whole district estimated 480,000 sheep and goats (KREMU, 1978). Almost all livestock in the District belongs to nomadic or seminomadic peoples of the Samburu, Turkana, Rendille, Gabbra, and Boran tribes. The role of smallstock in traditional domestic economy has been described by Gulliver (1955) for the Turkana, Spencer (1973) for the Samburu and Rendille, and Torry (1973) for the Gabbra. Sheep and goats always occur in mixed flocks in northern Kenya.

The first six months of the Project coincided with the last months of an extended drought which had lasted for seven years. Most of the livestock had left the study area in search of better grazing. Extensive overgrazing was evident in the vicinity of the towns of Kargi, Korr and Loglogo in the Rendille area, Maikona in the Gabbra area and Gatab, Mt. Kulal which is occupied by Samburu. The drought was broken at the end of 1976 by heavy rains which continued over the two rainy seasons in 1977. It became evident that the main foci of overgrazing and desertification were around the above mentioned settlements; the rest of the area which had appeared degraded during the drought quickly recovered with the onset of the rains. Approximately 27% of the sheep and goats in the district are owned by people resident in the settlements and it is these flocks, rather than the more nomadic 'fora' flocks, which are to blame for much of the damage near urban centres.

There is a well-known reluctance on the part of pastoral peoples to divulge information on their livestock. Most of the experimental work was therefore performed on a small flock of sheep and goats which were purchased mainly from the Gabbra people of North Horr. However, some information on local flocks was gathered through the cooperation of local chiefs and councillors and from people working for the Missions at the various centres. Public Relations Assistants working for IPAL also gathered some information on smallstock flocks, through questionnaires.

2. Description of study area

The study area (Figures 1 and 2) comprises 22,500km^2 (including the Hurri Hills) or about one-third of Marsabit District. It contains a wide range of soil and vegetation types; The major part of the area lies below 1000m A.S.L. and is hot, dry subdesert scrub. The Chalbi desert is a saline pan supporting halophytic plant communities along its perphery. The Koroli and Kaisut 'deserts' are strictly speaking subdesert communities supporting several Acacia species and annual grasses.

Fig. 1 Location of study area

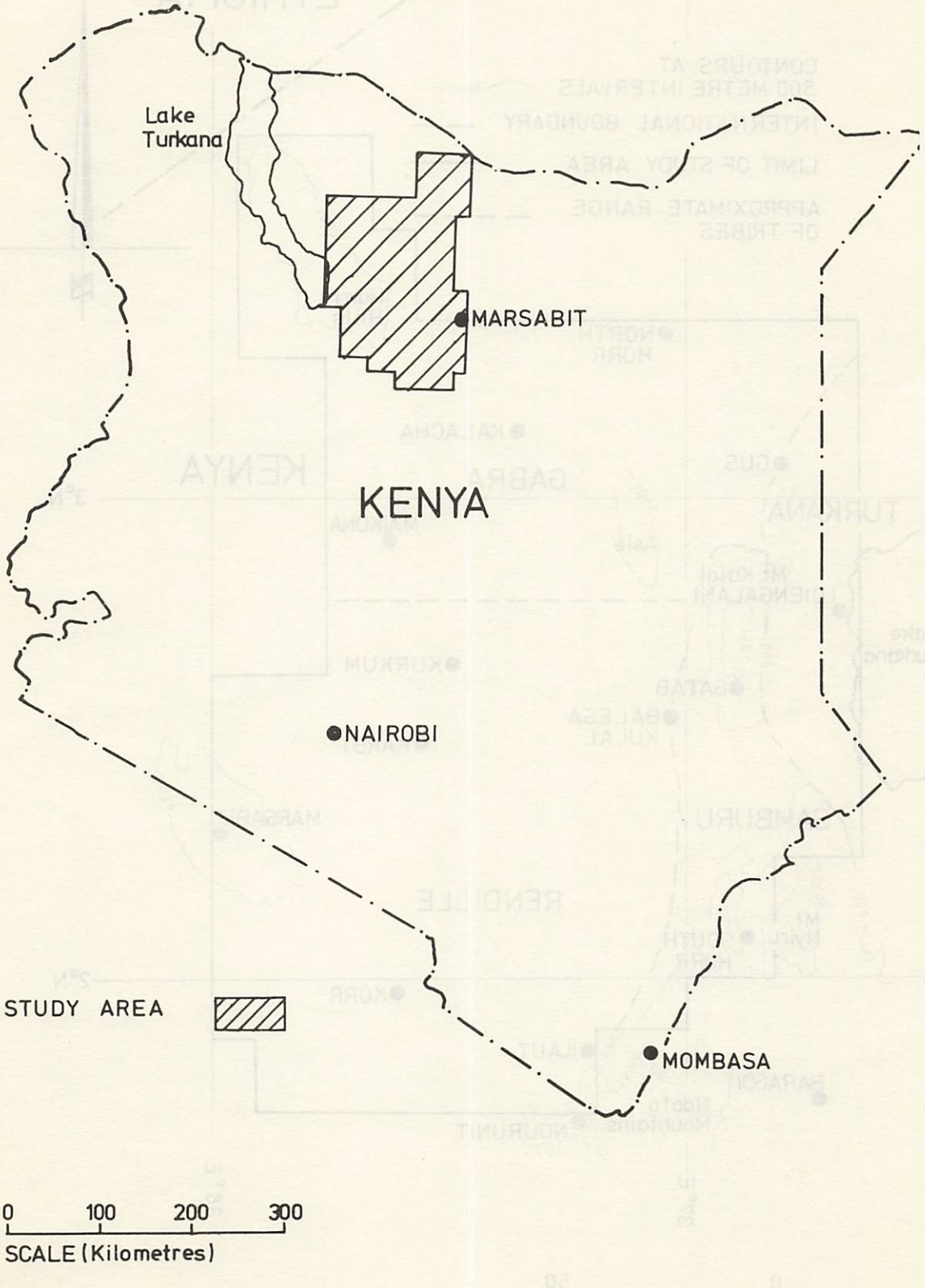
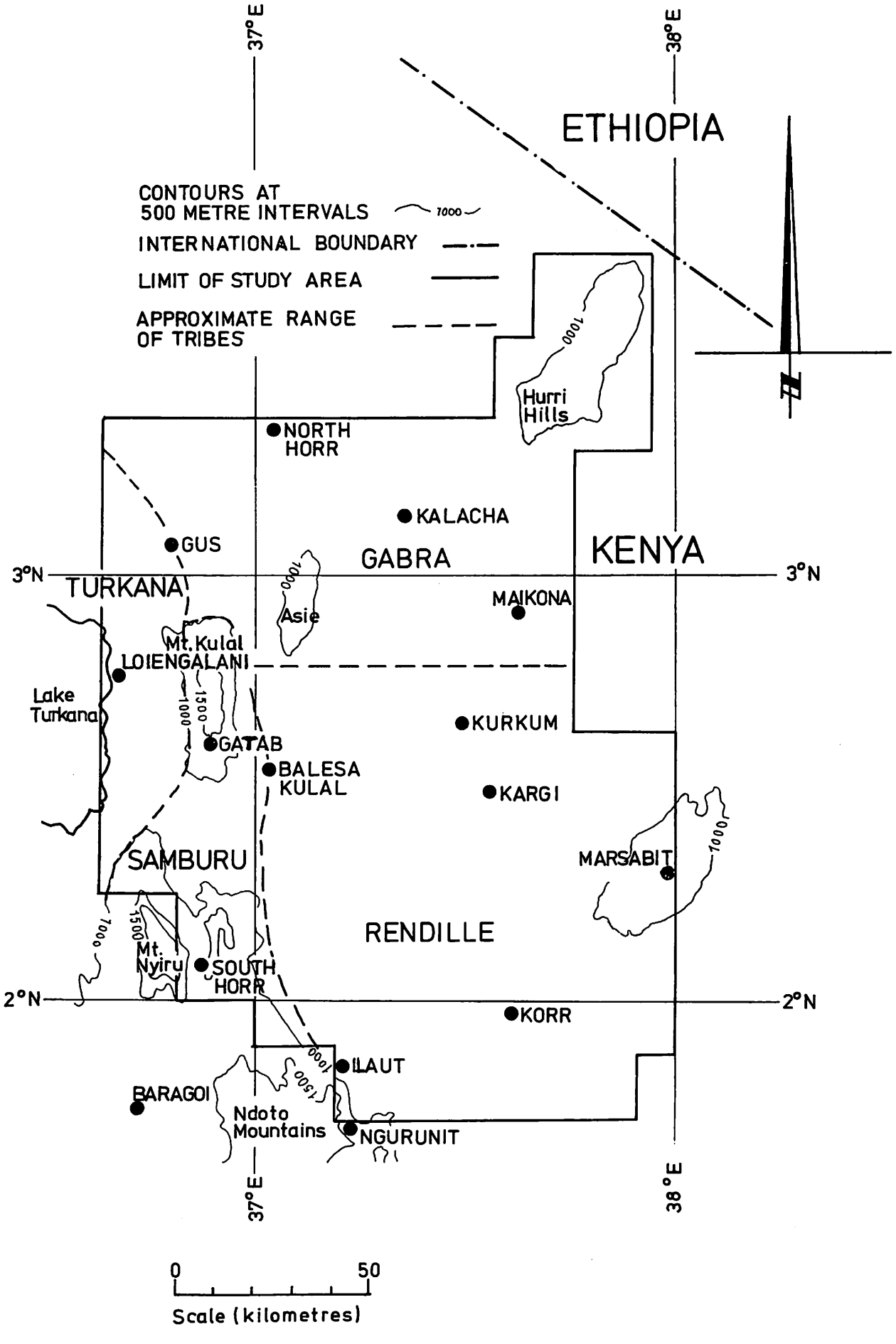


Fig. 2 The study area



Rainfall in these areas is between 100 and 300mm per annum. In dry years it may fall below this and be spatially erratic, some areas not receiving any rain at all. The Koroli and Kaisut systems have sandy soils derived from the granitic mountains to the south of the area.

The eastern, western and northern peripheries of the study area are volcanic in origin and the soils are formed from outpourings from the extinct volcanoes of Kulal, Asie, Hurri and Marsabit. Mts. Kulal and Marsabit have a much higher rainfall than the surrounding deserts and they support forests above 1500m A.S.L. The steep rainfall gradient from the top of Mt. Kulal (over 1000mm p.a.) to the Chalbi Desert (less than 100mm p.a.) together with the altitude gradient is reflected in a series of vegetation communities along the gradients. These are described in IPAL Technical Report Number D - 1. The forest on Mt. Kulal is dominated by *Olea africana* and *Juniperus procera*, the pencil cedar, with *Teclea* spp. and *Schrebera alata* among the more common tree species. Below 1500m the forest gives way to a bushed grassland community dominated by *Euclea divinorum, Carissa edulis* and *Ormocarpum trichocarpum*. Below this is an *Acacia drepanolobium - Pennisetum mezianum* scattered tree grassland association, which gives way to various communities dominated by *Acacia reficiens, A. mellifera* and various *Euphorbiaceae* on the lower slopes of the mountain.

The sandy plains between Kulal and Marsabit contain various communities dominated mainly by *Acacia reficiens, A. senegal* and *A. nubica* with *Aristida* spp. and *Cenchrus* sp. as common grasses. The area is intersected with various drainages and larger water courses (which usually flow for only a few days during the rains) fringed with *Acacia tortilis, Salvadora persica* and *Cordia sinensis*. Dwarf shrubs are a feature of the whole area and these include *Indigofera spinosa, Duosperma eremophilum* and *Sericocomopsis hildebrandtii*, with *Salsola* sp. and *Suaeda* spp. in the saline depressions. The gravel plains in the north west of the study area support a much sparser vegetation with *Dasyphaera (Volkensinia) prostrata* and *Seddera* sp. as important perennial forage plants.

After heavy rains a large number of annual herbs and grasses appear briefly and form an important part of the diet of smallstock and cattle. These include *Gisekia pharnaceoides* *Boerhavia repens* and *Blepharis linariifolia* in the herb layer and *Eragrostis* spp. in the grass layer. A fuller list of the edible annual species occuring in the diets of sheep and goats if found in section 5. Food habits.

Along the shore of Lake Turkana is an evergreen fringe of *Sporobolus spicatus* and *Dasyphaera prostrata* supporting a small resident population of smallstock in the Loiyengalani area, which supplements its dry season diet with *Salvadora persica* and *Acacia tortilis* in the adjacent water courses. Elsewhere in the low-lying parts of the study area the vegetation is largely deciduous in the dry season, and the smallstock either migrate in search of better grazing, or in the case of sedentary 'urban' flocks, concentrate around water courses where some palatable evergreen vegetation may persist. Near towns and villages the overgrazing problem (which is also contributed to by 'resident' camels) is exacerbated by tree-cutting by townspeople who lop branches or even cut down mature trees for firewood, stock enclosures and to supplement their livestock's diet.

3. Smallstock in Marsabit District

3.1 Smallstock types

3.1.1 Goats

The main type of goat in the hot low-lying parts of the District is a short-eared, short-haired white variety which is intermediate in size between the true 'Galla' type (Allonby pers. comm.) and the Small East African type (Mason and Maule, 1960). These goats are predominantly white but darker markings may occur on the face and neck. Weak horns are present in both sexes. Neck wattles are common. The bucks have a pronounced mane of hair on the neck and ridge of the back. Average liveweight of adult females is about 32kg and of males about 40kg.

Towards the north and east of the District the white type predominates in the flocks. In the south and in the vicinity of Lake Turkana the flocks are more heterogeneous, most of the goats resembling the Small East African type which is varicoloured, black, brown, white, red and a mixture of these. Turkana goats near the Lake tend to be black or dark brown in colour.

3.1.2 Sheep

The predominant type is the black headed, fat-rumped 'Somali' sheep which occurs widely in the Horn of Africa, extending westwards into northern Kenya and southern Sudan (Mason and Maule, 1960). Mason and Maule distinguish between the Somali and Blackheaded Persian sheep, the latter being an improved type occurring in South Africa. They also designate the northern Kenya breed as a sub-type, the Gabbra or Boran sheep.

The typical Somali sheep occurring in Marsabit District has the following characteristics. Horns generally absent in the ewes, weak horns often present in the rams. Coat colour white, with a black or brown head, this coloration often extending to the shoulders. Wool absent. Fat deposits occur on the head and the rump and base of tail. In rams and castrates in good condition fat is also deposited in the dewlap, face and upper legs. The point of the tail is thin and short. Wattles are sometimes present on the neck.

Average weight of adult females 33kg of rams 42kg.

Sheep in the north and east of the district are predominantly the Somali type. To the south and towards Lake Turkana two other types occur:

(a) Black or pied sheep which may be either fat rumped or fat tailed (the 'East African Black-headed' of Mason and Maule (1960)).

(b) Sheep of varying colour, though usually brown, with fat tails ('Samburu' variety of Mason and Maule).

3.2 Importance of smallstock in the local economy

The role of smallstock in the economy of pastoral peoples has been discussed by Dahl and Hjort (1976). Briefly, smallstock is kept by the nomadic peoples of Marsabit District for meat, for milk, for blood and for trade. It is also kept for more erudite reasons such as the cementing of friendships or the provision of dowry (bride-price). Sheep and goats are usually slaughtered and eaten during certain ceremonies, when important visitors arrive, if a member of the family is sick or after a woman gives birth. There does not appear to be a preference for one type of meat over the other; sheep are prized for their fat and goats are generally considered more succulent. Young girls and warriors in charge of smallstock 'fora' (i.e., nomadic flocks) may subsist entirely on smallstock milk and blood, whereas in the village the diet is usually supplemented with camel or cattle milk and meat, and maizemeal.

Although there is not, at present, a substantial official marketing infrastructure for smallstock, an outlet exists via resident and visiting traders who offer between 60 and 120 shillings for an adult sheep or goat. Recently even higher prices are being obtained. In this way it is estimated that around 400 head of smallstock are leaving the District weekly, for markets elsewhere in Kenya and even abroad. As these are not official figures it is difficult to gauge their accuracy. The local people say that a larger outlet is needed, that they would be prepared to sell more of their smallstock if a marketing system offering fair prices is developed. The sale of smallstock is an important factor in the cash economy of the local people, who are more reluctant to sell cattle or camels.

In addition to the sale of live animals, hides and skins are also sold to local licensed traders and usually fetch between 5 and 10 shillings depending on quality. An average number of 43,600 goatskins and 54,100 sheepskins were exported from Marsabit District annually between the years 1969 and 1975 (D.A.O. Reports, Ministry of Agriculture), a small proportion of which originated in Ethiopia.

4. Numbers and distribution of smallstock in the study area

IPAL has made seven systematic aerial surveys of the study area at the time of writing this report. Two observers sitting in the back of the aircraft (a Cessna 185) count both wildlife and livestock, record presence of water, greenness of the vegetation and occupied or unoccupied manyattas. The aircraft flies at 100m above the ground, transecting the area every 10km in an east-west direction. Animals observed in a strip 300m on either side of the plane are counted. In this way a 6% sample of the whole study area is counted. Herds of livestock more than 30 animals strong are photographed using black-and-white film, as well as being estimated by the observers.

Precise details of this method of counting can be found in Norton-Griffiths, (1975).

Estimates of the total population of sheep and goats in the study area, the population variance and standard error, and the 95% confidence limits were calculated using Jolly Method 2 (Jolly 1969). In June, August and October, 1977 the Hurri Hills were also counted. This is treated as a separate area in the estimate of the population.

Estimates of the smallstock population in the study area

Month	$\hat{Y}$	S.E.$\hat{Y}$.	95% C.L. as % of $\hat{Y}$	
Jul 1976	65,780	27,754	82.7	(a)
Aug 1976	96,483	30,777	62.5	(b)
Jan 1977	389,783	127,471	64.1	(b)
Mar 1977	243,066	46,326	37.3	(b)
Jun 1977	319,466	91,738	56.3	(b)
Aug 1977	331,833	77,623	45.8	(b)
Oct 1977	138,466	28,357	40.1	(b)

$\hat{Y}$ = Population estimate

(a) = 14,600km^2 only, excluding Hurri Hills

(b) = 19,600km^2, excluding Hurri Hills

Estimates of livestock population in the Hurri Hills (area = 3,400km^2)

Month	$\hat{Y}$	S.E.$\hat{Y}$.	95% C.L. as % of $\hat{Y}$
Jun 1977	39,900	20,524	100.8
Aug 1977	34,450	28,920	83.9
Oct 1977	50,766	41,122	81.0

The influx of smallstock to the study area in 1977 coincided with the end of the drought. From January until September 1977 an average of 320,000 smallstock remained within the study area. In October, rains just outside the area led to a temporary exodus of about 2/3 of the smallstock.

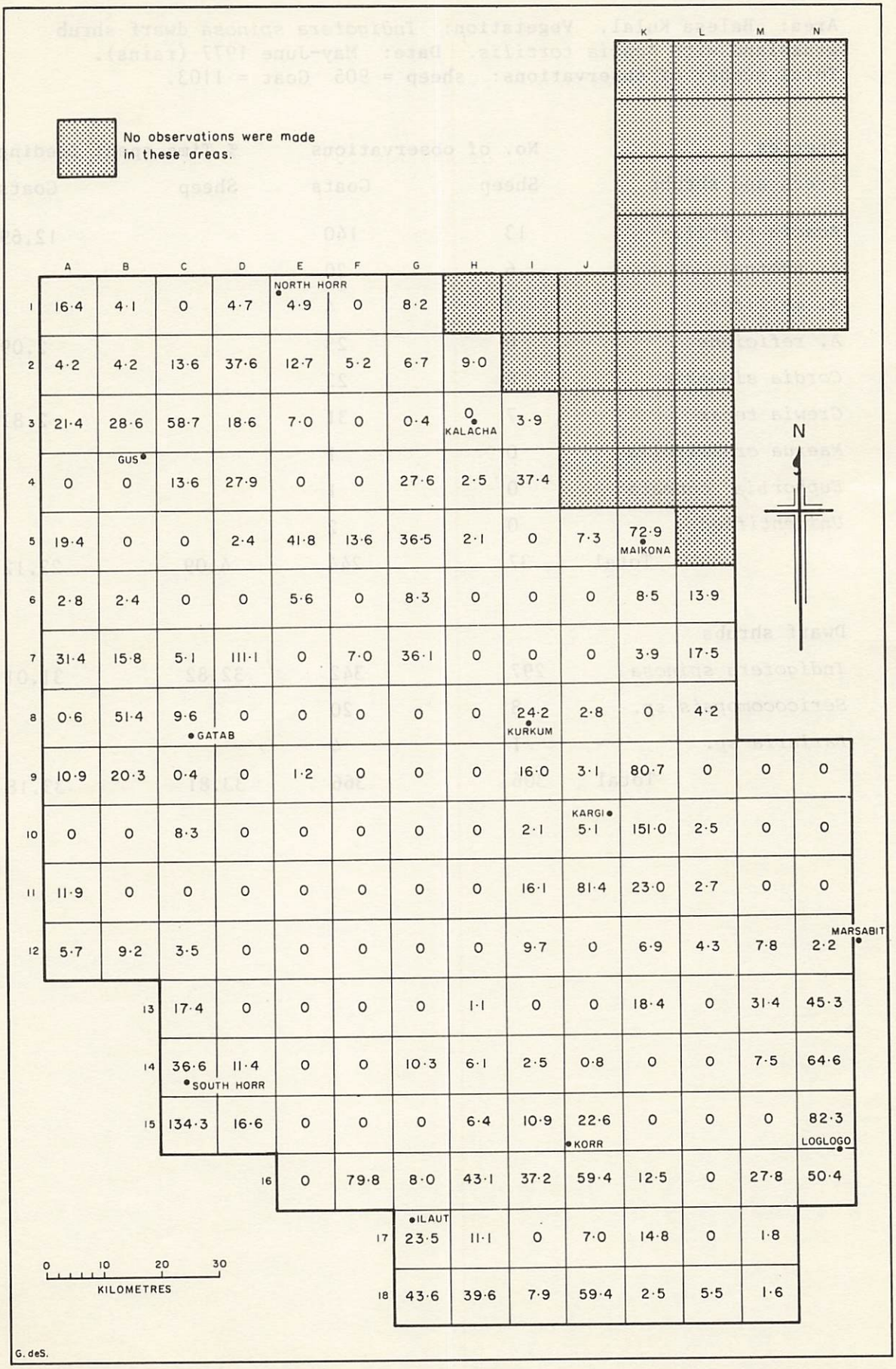
From the results of the aerial counts, average density of smallstock for each 10km^2 over the past 2 years has been calculated (Figure 3). The significance of these density figures in terms of carrying capacity and stocking rates are discussed in section 8. Optimum stocking rate for sheep and goats.

It should be noted that the above population estimates are calculated from observer estimates only; correction factors to account for observer error should be calculated for each observer by comparing his estimate with the number of smallstock counted from the photograph of that flock.

5. Food habits of sheep and goats

Food habits of sheep and goats were studied by direct observation using the feeding minutes technique (Buechner, 1950). Over 4,000 feeding observations were made in this way in several different vegetation communities which are frequently used by smallstock. The following tables are a resumé of the observations.

FIG. 3. DENSITY OF SMALLSTOCK PER SQUARE KILOMETRE PER ANNUM



Area: Balesa Kulal. Vegetation: *Indigofera spinosa* dwarf shrub grassland with *Acacia tortilis*. Date: May-June 1977 (rains).
Total number of observations: sheep = 905 Goat = 1103.

Species	No. of observations		% Time spent feeding	
Trees and shrubs	Sheep	Goats	Sheep	Goats
Acacia tortilis	13	140		12.69
A. nubica	6	20		
A. mellifera	3	4		
A. reficiens	0	23		2.09
Cordia sinensis	8	22		
Grewia tenax	7	31		2.81
Maerua crassifolia	0	1		
Euphorbia cuneata	0	1		
Unidentified	0	2		
Total	37	244	4.09	22.12
Dwarf shrubs				
Indigofera spinosa	297	342	32.82	31.01
Sericocomopsis sp.	8	20		
Barleria sp.	1	4		
Total	306	366	33.81	33.18

Species	No. of observations		% Time spent feeding	
Annual herbs	Sheep	Goats	Sheep	Goats
Gisekia pharnaceoides	100	65	11.05	5.89
Ipomoea kotschyana	98	23	10.83	2.09
Cleome hirtella	61	61	6.74	5.53
Cleome sp.	16	18		
Achyranthes aspera	13	31		2.81
Heliotropium sp.	20	12	2.21	
Indigofera sp.	21	19	2.32	
Blepharis linariifolia	4	5		
Euphorbia inaequilatera	1	14		
Aerva lanata	2	7		
Mollugo cerviana	1	0		
Gynandropsis gynandra	2	4		
Phyllanthus sp.	1	4		
Euphorbia sp.	1	4		
Tribulus terrestris	0	1		
Lycium europaeum	0	1		
Monsonia sp.	2	0		
Commicarpus sp.	1	0		
Unidentified	4	11		
Total	349	298	38.56	27.02
Grasses				
Leptothrium senegalense	17	33		2.99
Dactyloctenium sp.	18	25		2.27
Eragrostis spp.	68	80	7.51	7.25
Aristida sp.	78	15	8.62	
Brachiaria sp.	7	17		
Tragus berteronianus	3	3		
Microchloa kunthii	1	1		
Sporobolus sp.	8	3		
Chloris roxburgiana	2	0		
Unidentified	11	16		
Sedges	0	2		
Total	213	195	23.54	17.68

Area: Kargi. Vegetation: Overgrazed *Indigofera spinosa* dwarf shrub grassland. Few trees or bushes; annual herbs only. Date: January 1977 (rains). Total number of observations: Sheep = 71 Goats = 74.

Species	No. of observations		% Time spent feeding	
	Sheep	Goats	Sheep	Goats
Dwarf shrubs				
Indigofera spinosa	21	41	28.8	55.4
Duosperma sp.	0	3		4.0
Total	21	44	28.8	59.5
Annual herbs				
Gisekia pharnaceoides	19	15	26.0	20.3
Indigofera sp.	5	0	6.8	
Boerhavia repens	11	2	15.1	2.7
Indigofera hochstetteri	3	1	4.1	1.3
Hermannia kirkii	4	3	5.5	4.0
Euphorbia inaequilatera	1	1	1.4	1.3
Heliotropium sp	0	3		4.0
Unidentified	1	1	1.4	1.3
Total	44	26	60.2	35.1
Grasses				
Eragrostis sp.	3	1	4.1	1.3
Aristida sp.	4	1	5.5	1.3
Unidentified	1	2	1.4	2.7
Total	8	4	11.0	5.4

Area: Luai, Mt. Kulal. Vegetation: *Acacia drepanolobium - Pennisetum mezianum* Treed grassland. Date: November 1976 (rains). Total number of observations: Sheep = 191 Goats = 355.

Species	No. of observations		% Time spent feeding	
Trees and shrubs	Sheep	Goats	Sheep	Goats
A. drepanolobium	16	62	8.4	17.2
A. etbaica	0	1		
A. mellifera	0	1		
Acacia spp.	0	4		

Species	No. of observations		% Time spent feeding	
Trees and shrubs	Sheep	Goats	Sheep	Goats
Commiphora spp.	8	26	4.2	7.3
Ormocarpum trichocarpum	0	8		2.2
Rhus natalensis	0	12		3.4
Plectranthus igniarius	0	17		4.8
Grewia spp.	2	16		4.5
Crotalaria sp.	0	1		
Unidentified	8	16	4.2	4.5
Total	34	163	17.8	45.9
Dwarf shrubs				
Aspilia sp.	6	13	3.1	3.7
Barleria sp.	2	0		
Duosperma sp.	4	3	2.1	
Sericocomopsis sp.	1	6		
Total	13	22	6.8	6.2
Annual herbs, climbers				
Asparagus spp.	2	2		
Unid. creepers	0	2		
Vigna sp.	3	16		4.5
Indigofera	0	2		
Heliotropium sp.	0	3		
Commelina sp.	4	2	2.1	
Portulacca sp.	1	2		
Unid. Liliaceae	2	5		
Unidentified herbs	1	1		
Total	13	35	6.8	9.9
Grasses				
Pennisetum mezianum	25	20	13.1	5.6
Unidentified sp.	85	78	44.5	22.0
Sedges	21	37	10.9	10.4
Total	131	135	68.5	38.0

Area: Gatab. Vegetation: *Euclea divinorum/Carissa edulis/Rhus spp. Juniperus procera* sub forest bushed grassland. Date: October and February (dry season). Total sheep = 277, goats = 184.

Species	No. of observations		% Time spent feeding	
Trees and shrubs	Sheep	Goats	Sheep	Goats
Carissa edulis	4	19		10.3
Rhus spp.	24	22	8.6	11.9
Osyris compressa	1	4		2.2
Maytenus senegalensis	0	2		
Euclea divinorum	1	1		
Jasminum floribundum	1	4		2.2
Myrsine africana	2	2		
Clerodendrum sp.	2	0		
Allophyllus sp.	0	4		2.2
Lippia sp.	0	2		
Juniperus procera	0	1		
Unidentified spp.	6	13	2.2	7.1
Total	41	74	14.8	40.2
Dwarf shrubs				
Aspilia mossambicensis	14	1	5.0	
Vernonia sp.	0	5		2.7
Total	14	6	5.0	3.3
Herbs				
Commelina sp.	17	2	6.1	
Aloe sp.	5	0		
Crinum kirkii	1	0		
Unidentified	13	11	4.7	6.0
Total	36	13	13.0	7.1
Grasses				
Eragrostis spp.	75	34	27.1	18.5
Themeda triandra	48	19	17.3	10.3
Unidentified grasses	30	37	10.8	20.1
Sedges	31	1	11.2	
Total	184	91	66.4	49.4
Leaf litter	2	0	0.7	0.0

Area: Balesa Kulal (lava). Vegetation: *Acacia mellifera - Indigofera spinosa* sub desert scrub. Date: July 1977 (fairly dry, woody green only). Total number of observations: sheep = 64, Goats = 95.

Species	No. of observations		% Time spent feeding	
Trees and shrubs	Sheep	Goats	Sheep	Goats
Acacia mellifera	2	14	3.1	14.7
A. tortilis	0	6		6.3
Grewia sp.	13	31	20.3	32.6
Cordia sinensis	2	11	3.1	11.6
Caucanthus albidus	3	3	4.7	3.1
Commiphora sp.	0	2		2.1
Unidentified	0	1		
Total	20	68	31.3	71.6
Dwarf shrubs				
Seddera sp.	2	0	3.1	
Indigofera spinosa	2	0	3.1	
Sericocomopsis sp.	1	1		
Duosperma sp.	0	4		4.2
Total	5	5	7.8	5.3
Herbs				
Amaranthus sp.	3	3	4.7	3.2
Gisekia pharnaceoides	3	0	4.7	
Blepharis linariifolia	1	0		
Unidentified herbs	1	6		6.3
Total	8	9	12.5	9.5
Grasses				
Eragrostis sp.	4	6	6.3	6.3
Cenchrus sp.	9	0	14.1	
Aristida sp.	3	2	4.7	2.1
Unidentified	5	0	7.8	
Total	21	8	32.8	8.4
Leaf litter Total	10	5	15.6	5.3

Area: Balesa Kulal (lava). Vegetation as above. Date: November 1977 (rains). Total Number of observations sheep = 106, goats - 107.

Species	No. of observations		% Time spent feeding	
Trees and shrubs	Sheep	Goats	Sheep	Goats
A. mellifera	7	22	6.6	20.2
Cordia sinensis	18	16	17.0	14.7
Commiphora sp.	2	0		
A. reficiens	2	1		
Grewia sp.	4	2	3.8	
Euphorbia cuneata	0	22		20.2
Total	33	63	31.1	58.9
Dwarf shrubs				
Duosperma sp.	22	3	20.7	2.7
Indigofera spinosa	13	14	12.3	12.8
Indigofera sp.	11	0	10.4	
Sericocomopsis sp.	0	1		
Total	46	18	43.4	16.8
Herbs				
Gisekia pharnaceoides	4	0	3.8	
Lycium sp.	0	2		
Kedrostis gijef	0	18		
Total	4	20	3.8	18.7
Grasses				
Aristida	4	0	3.8	
Tragus sp.	4	0	3.8	
Unidentified	15	6	14.1	5.5
Total	23	6	21.7	5.6

Area: North Horr. Vegetation: *Suaeda/Indigofera spinosa/* Dasysphaera *prostrata* overgrazed scrub near village. Date: April 1977 (rains) Total number of observations: sheep = 90, goats = 76.

Species	No. of observations		% Time spent feeding	
Trees and bushes	Sheep	Goats	Sheep	Goats
A. tortilis	0	5		6.6
Euphorbia cuneata	0	19		25.0
Suaeda sp.	0	1		
Unidentified	2	0		
Total	2	25	2.2	32.9
Dwarf shrubs				
Indigofera spinosa	53	23	58.9	30.3
Seddera sp.	13	24	14.4	31.6
Dasysphaera prostrata	2	2	2.2	
Barleria sp.	0	1		
Total	68	50	75.5	65.8
Herbs				
Gisekia pharnaceoides	6	1	6.7	1.3
Grasses				
Unidentified	14	0	15.6	0.0

Area: North Horr. Vegetation: *Suaeda* evergreen bush. Date: August 1977 (after rains). Total number of observations: sheep = 95, goats = 58.

Trees and shrubs				
Suaeda spp.	1	0		
Acacia tortilis	0	1		
Total	1	1	1.0	1.7

Species	No. of observation		% Time spent feeding	
Herbs	Sheep	Goats	Sheep	Goats
Unidentified	30	27	31.6	46.5
Grasses				
Drakebrockmannia sp.	23	1	24.2	
Unidentified	41	29	43.1	51.7
TOTAL	64	30	67.4	51.7

A few further observations were made at Kargi (dry season), Did Siribi (rains) and Gatab (rains), making a total of 5,188 observations The results of all the observations are summarised as per-centages below

	Trees	Bushes	Dwarf Shrubs	Herbs	Grass	Litter	Total observations
Sheep	2.6	6.7	23.7	29.6	36.9	0.5	2439
Goats	14.9	15.0	22.5	22.0	25.0	0.5	2749
Total observations	437	576	1199	1327	1587	26	5188

The proportions of plant types eaten by sheep and goats differed significantly. For both sheep and goats there is a change in the proportion of browse and graze between the dry and wet seasons.

		Dry	Wet	Total observations
Sheep	Browse	299	507	806
	Graze	813	820	1633
	Total observations	1112	1327	2439
Goats	Browse	491	951	1442
	Graze	602	705	1307
	Total observations	1093	1656	2749

Two general observations should be made about the findings

1) Sheep browse (i.e. eat trees, shrubs and dwarf shrubs) much more in a desert environment than is generally supposed. A third (33%) of their diet over the whole year is made up of browse species.

2) The constraints on diversity of diet of sheep appear to be physical i.e., as sheep cannot reach as high as goats (they do not stand on their hind legs to feed as goats do) they cannot ingest as high a proportion of trees and bushes as do goats.

6. Estimating offtake of vegetation by sheep and goats

Vegetation offtake by livestock comprises (a) that which is eaten by the animals, and (b) that which is destroyed by trampling and other activities.

During the present study, offtake was measured in two different ways. First, sheep and goats were placed in experimental paddocks at different stocking rates and the vegetation measured before and after the trial. Second, vegetation intake was measured directly by weighing the animals before and after a short period of feeding. These two methods are described below.

6.1 Paddock trials

In May 1977 IPAL constructed a 40 ha. paddock at Balesa Kulal in *Acacia tortilis - Indigofera spinosa* riverine scrub. This was divided into three 10 ha. paddocks for camels, and four 2.5 ha. plots, three of which were for smallstock and one of which was used as a control in which no grazing was allowed.

Stocking rate was determined on a weight/unit area/year basis. Both trials (May-June 1977/December 1977-January 1978) were conducted after the rains had produced a flush of annual herbs and grasses in the paddocks. Vegetation biomass density in the herb/grass layer was measured before and after the animals had grazed the paddock. Half-metre square quadrats were placed at intervals along randomly selected parallel transects and the basal cover and rooting frequency of herbs and grasses noted for each quadrat.

All herbs and grasses within each quadrat were clipped and weighed *in situ*, and a sample of each species taken and dried to constant weight in a drying oven. Standing crop biomass of the herb grass layer could then be expressed in terms of dry matter per ha. Dwarf shrubs (mainly *Indigofera spinosa, Sericocomopsis hildebrandtii* and *Duosperma* sp.) were also measured using a point-centered quarter method, their density in each paddock recorded and dry weights estimated.

Animals were weighed before, during and after the trial, their water intake during the trial monitored and their food habits recorded. The flock spent 12 hours each day in the paddocks, and was penned at night outside.

Each paddock was given the same intensity of stocking for the two trials, i.e., the heavily stocked paddock in the first trial was also the heavily stocked paddock in the second, and so on.

The results of the two trials given below are inconclusive for several reasons:

a) As the animals were placed in the paddocks only during the wet season when vegetation productivity was at its height, the results cannot be extrapolated to areas outside where smallstock use the vegetation all the year around, e.g., at waterholes or near villages. However, the results could be extrapolated to be comparable with 'wet-season grazing areas'. (These are usually not areas affected by overgrazing.)

b) For the grass/herb layer, the intensity of sampling the vegetation before and after the experiment was not sufficient to show significant differences in the vegetation biomass which was due to the effects of the animals.

c) In the first trial, growth of vegetation during the trial obscured offtake by the animals. During the second, the animals were placed on the paddocks only after growth had slowed or stopped.

d) Offtake of larger shrubs and trees was not recorded although they may form up to 30% of the diet of sheep and goats.

6.1.1. Results of the first trial

These are not worth reporting for the grass/herb layer as growth in all the paddocks except one exceeded that of the control paddock and obscured offtake.

For the dwarf shrubs: (*Indigofera spinosa* only).

Paddock	Pretrial biomass (kg/ha)	Postrial biomass (kg/ha)	Offtake assuming 11% growth
Control	6.3	6.9	-
Heavily stocked	189.4	112.7	97.5
Medium stocked	30.1	21.5	11.9
Lightly stocked	10.9	8.4	3.9

Indigofera spinosa comprised approximately the following % of the diet:

Paddock	sheep	goats
Heavily stocked	37.6	40.4
Medium stocked	33.8	33.2
Lightly stocked	22.0	7.0

Knowing the stocking rate for each paddock we can calculate the expected intake of *Indigofera spinosa* by sheep and goats for each paddock:

Paddock	Expected intake (in kg DM/ha)	Observed offtake
Heavily stocked	29.6	97.5
Medium stocked	13.7	11.9
Lightly stocked	1.4	3.7

Indigofera spinosa is unlikely to be affected by trampling. The discrepancies may be due to several factors, e.g., sampling error, or offtake by insects.

6.1.2 Results of the second paddock trial

	Standing crop biomass in Kg/ha		
Grass/herb layer	Pretrial	Postrial	Offtake
Heavily stocked paddock	872.9	768.2	104.7
Medium stocked paddock	1780.7	908.8	871.9

6.1.3 Control

Here again the results are inconclusive, probably due to sampling error. Figures for the control and for offtake of dwarf shrubs are not available.

Clearly this type of paddock experiment needs (a) a good control (the control in the present system does not appear to be representative of the other paddocks), (b) if the animals are only going to be placed in the paddocks for a short period of time a very high stocking rate is required before any effect on the vegetation can be discerned; (c) a better method would probably be to have animals in the paddocks all the year round, as it is in the dry season that animals appear to have the greatest detrimental effect on the vegetation. Clearly another method other than clipping and weighing must be found to estimate vegetation biomass as the present method is time-consuming and inaccurate unless many quadrats are clipped.

7. Estimating intake of vegetation for sheep and goats

Earlier methods for determining intake by herbivores have been rejected as unsuitable under arid range conditions.

A method which appears most likely to succeed under free ranging conditions involves weighing an animal before and after a period of feeding, during which time faeces and urine are collected and weighed. 'Insensible' weight losses would be measured by using the weight loss of an animal harnessed for faecal and urine collection, but not allowed to feed.

Food intake = $Wt_b - Wt_a + F + U + X$

Where Wt_a = Wt at beginning of feeding period (kg)

Wt_b = Wt at end of feeding period (kg)

F = Wt of faeces (g)

U = Wt of urine (g)

X = Wt losses due to respiration, perspiration, etc. (g)

Only three experiments of this kind were performed, using male animals.

1.) Date 22.11.77. DM vegetation = 25%. Male sheep. Duration of trial = 2 hours.

Wt_a = 37.2kg

Wt_b = 37.6kg

Wt faeces = 184g

Wt urine = 290g

Weight increase = 874g

X = 201g (calculated from Maloiy and Taylor, 1971)

Dry matter intake = 268g in 2 hours

Assuming total feeding time = 6 hours a day (data from activity studies)

Daily dry matter intake = 804g = 2.1% of body weight.

2.) Date 20.12.77. DM vegetation = 25%. Male sheep.

Wt_a = 36.7kg

Wt_b = 37.8kg

Wt faeces = 176.6kg

Wt urine = 100g

Duration of Trial = 2 hours

Wt increase = 1376.6g + X

X = 195g (calculated from Maloiy and Taylor, 1971)

DMI = 392g in 2 hours, daily DMI = 1176.4g = 3.2% of body weight.

3.) Date 21.12.77. DM vegetation = 25%. Male goat.

Wt_a = 27.1kg

Wt_b = 27.5kg

Wt faeces = 61.0g

Wt urine = 120g

X = 146.6g (Maloiy and Taylor, 1971)

Total weight increase = 727.6g in 2 hours

DMI = 181,9g in 2 hours = 545.7g daily = 2.0% body weight.

It appears that the above method for calculating dry matter intake of vegetation by sheep and goats under free ranging conditions is feasible but the following refinements of the technique are needed: (a) a control which does not feed is needed to have a better idea of water loss through evaporation (Maloiy and Taylor's figures were calculated from laboratory trials which may not be relevant in the field), (b) the trial may need to be held over the full 12 hours to get exact daily feeding time of the animal.

The figures calculated in the above trials for dry matter intake of sheep and goats are similar to those quoted elsewhere in the literature (e.g., Field, 1977; Quartermain and Broadbent, 1974).

8. Optimum stocking rate for sheep and goats

An attempt to correlate stocking rates with rangeland primary productivity and annual precipitation in the Mediterranean basin and Sahelo-Sudanian zone of North Africa has been made by Le Houerou and Hoste (1977). They found the following relationship between carrying capacity and annual rainfall for North Africa:

$y = a + bx$

1 Tropical Livestock Unit (TLU) = 0.0169 + 0.0004 x

where 1 TLU = 10 sheep or 12 goats.

x = rainfall in mm.

Thus we get the following figures for carrying capacity for sheep:

Rainfall (mm)	100	200	300	400	500	600	700	800
Sheep/km^2/annum	60	100	140	180	220	260	300	340

Other workers have calculated slightly lower carrying capacities, on the other hand Le Houerou's figures could probably be increased as he does not take into account tree and shrub production which as has been calculated in this study, can contribute as much as 33% of the diet of sheep.

The figures for sheep and goat density in Figure 3 should not be taken as the existing stocking rate as they exclude figures for cattle, camels, donkeys and wildlife. Assuming that the rainfall over much of the study area (excluding the mountains) is betweeen 100mm and 300m per annum then carrying capacity is exceeded (by sheep and goats only) in only one area (east of Kargi). Taking camels into account (1 camel = 1.5TLU or 15 sheep) carrying capacity is probably exceeded in many areas especially near waterholes.

It should be noted that a large proportion of the study area in the Hedad region and east of Ol Donyio Mara is not used by smallstock (or by other stock). This is due to two reasons: 1) Lack of permanent water, 2) Poor security. It is the second reason which prevents these areas being used in the wet season. Provision of security in these areas would improve the distribution of stock.

Relief of grazing pressure near settlements and water points could be achieved in several ways. These are mentioned briefly here, but several of the points have been raised and were discussed at the Man and the Environment in Marsabit District II Meeting in October 1977.

1. Provision of more watering points.
2. Provison of security at some of the existing/outlying watering points would encourage their greater use, and relieve pressure at urban centres.

3) Discourage permanent town dwellers from keeping large flocks; this could be achieved by making stock owners pay for watering their stock at urban centres, but should be in conjuction with (1) and (2) to encourage movement of stock.

4) Prevention of all grazing within a radius of 2km around watering points.

5) Provision of a more efficient marketing system to encourage stock owners to sell surplus stock.

9. Acknowledgements

The Sheep and Goat Project was funded by the Ministry of Overseas Development, U.K. as a contribution to livestock research and development in Northern Kenya and elsewhere in the arid zone. It was carried out in cooperation with the UNEP - MAB Integrated Project in Arid Lands (IPAL) in Marsabit District, Kenya, and based at the IPAL Field Station on Mt. Kulal.

The author wishes to thank staff members of IPAL for their assistance and cooperation and Mr. Francis Sinehaya, her Field Assistant, who carried out a great deal of the routine observation and looked after the Project's sheep and goat herd.

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Appendix A

Flock Composition in Marsabit District (Ratio = 1:x)

Place	flocks	Sheep:Goat ratio	Adult Female: Young ratio		Male:Female ratio 0 incisors	2-8 incisors
Gatab						
(Aug)	7	1.6	S	1.2	1.2	6.6
			G	0.8	1.5	4.0
Gatab						
(Oct)	6	2.1	S	1.1	1.6	6.8
			G	1.4	1.4	3.8
Gatab						
(Jan)	6	2.4	S	1.1	1.2	5.9
			G	0.9	1.2	2.4
Ngurunit						
(Sept)	1	1.3	S	0.9	4.0	22.0
			G	0.8	1.7	5.6
Ngurunit						
(Jan)	1	1.6	S	0.2	2.0	24.0
			G	0.3	0.6	9.3
N. Horr						
(Apr)	1	1.6	S	0.8	1.3	2.6
			G	0.6	1.5	2.5
Means		1.7	S	0.9	1.9	11.3
			G	0.8	1.3	4.6

Appendix B Growth Rates

Growth rates in gm/day to 5 months of age

1.

Goats	born during rains	born during dry season
Single males	78.6	47.4
	102.4	38.4
	110.1	31.6
	106.5	48.6
	Mean = 99.4	45.4
		49.3
		43.8
		45.8
		48.0
		50.7
		55.9
		65.7
		68.2
		37.9
		Mean = 48.3
Single females	74.3	33.7
	76.2	51.1
	Mean = 75.2	39.2
		41.4
		53.2
		Mean = 43.7

2.

Sheep		
Single males	113.6	79.5
	116.4	104.3
	129.7	Mean = 91.9
	68.8	
	Mean = 107.1	
Single females	85.6	85.9
	98.2	81.1
	Mean = 91.9	108.9
		70.1
		Mean = 86.5

Growth rates of sheep in this study are higher than those reported by Trail and Sacker (1966), but lower than those reported by FAO (1974).

Growth rates of goats are extremely low during the dry season, this is probably a reflection of the competition of the kids with humans for the milk.

Seasonal and reproductive influences
on weights of mature female goats at Gatab

Age Group	Preg./ Lact.	Dry Aug 1976 Wt (Kgs)	S.E.	n	V. Dry Oct 1976 Wt (Kgs)	S.E.	n	Wet Jan-Feb 1977 Wt (Kgs)	S.E.	n
	P	32.14	0.75	22	33.18	2.15	4	35.07	1.31	7
8 Incisor	L	27.64	1.07	8	29.51	0.52	14	27.44	1.06	15
	P	28.91	1.11	12	28.58	2.07	4	29.44	2.32	7
6 Incisor	L	27.20		1	25.17	1.55	5	25.61	0.91	8
	P	26.35	0.96	13	23.95	1.31	4	25.64	0.85	10
4 Incisor	L	20.54	1.17	5	21.21	1.80	10	23.21	0.55	7
	P	24.04	0.55	16	22.35	1.55	4	22.32	1.08	13
2 Incisor	L	21.00		1	20.57	0.58	3	20.75	1.48	6

Seasonal and reproductive influences
on weights of mature female sheep at Gatab

Age Group	Preg./ Lact.	Dry Aug 1976 Wt (Kgs)	S.E.	n	V.Dry Oct 1976 Wt (Kgs)	S.E.	n	Wet Jan-Feb 1977 Wt (Kgs)	S.E.	n
	P	33.20		2	31.72	1.22	5	35.28	0.86	8
8 Incisor	L	32.47	0.94	11	28.73	1.20	9	32.11	1.15	8
	P	34.40		2	31.95	0.75	2	-		
6 Incisor	L	31.13	0.81	6	26.43	1.52	4	28.20	0.44	3
	P	37.20		1	37.70		1	31.70	2.83	6
4 Incisor	L	26.60	1.92	4	23.60		1	28.95		2
	P	28.94	1.54	9	24.80	2.56	4	30.70	1.37	5
2 Incisor	L	25.41	1.56	8	27.54	2.43	5	29.97	1.13	3

Appendix C Milk Production

Goats, and to a lesser extent sheep, are milked by the nomads. The milk may be drunk straight or put into tea. The Rendille report that in times of milk surplus, butter is made out of smallstock milk but this was not observed during the time of the study. Torry (1973) reports that smallstock milk comprises 20% of the total milk output of Gabbra livestock (including cattle and camels). Torry goes on to estimate the milk yield for human consumption from smallstock, and its importance in the Gabbra diet. His estimates of 0.1 l/day of goat milk and 0.05 l/day of sheep milk consumed by humans/animal are probably on the low side.

Smallstock are normally milked by women and girls in the early morning and in the evening when the flock returns to the homestead. Kids up to the age of 3, 4 or even 5 months are kept separated from the dams at all times except for a short period morning and evening. On the other hand, lambs are usually allowed to accompany the ewes at night and are only separated during the day when they are very young. Lambs grow faster than kids and usually are allowed out with the flock at an earlier age, say $2\frac{1}{2}$ months. Thus the amount of milk from ewes that is available for human consumption is considerably less than that from goats, and sheep tend to be milked less than goats.

Milk production by all lactating goats in the ODM experimental flock was monitored during the study. All the goats were in good condition during this time so that milk production probably approached the maximum for this type of goat. The Galla type goats in the ODM flock probably gave more milk than the Samburu (Small East African) type on Mt. Kulal, judging by the growth rate of the kids.

Each goat suckled a single kid, which was separated from the dam at night as is customary. Milking took place in the morning and evening, one teat only being stripped, the other left for the kid to suckle. The younger kids were left in the boma during the day, while the older kids whose dams were nearing the end of their lactation grazed with the flocks.

Morning yield was not found to be significantly different from evening yield. The following figures give average daily milk yield in ml from one teat per milking (total daily yield would be approximately 4 times those quantities).

Doe. No.	1	2	3	4	5	6	7	Mean
Week 1.	131.7	129.2	137.8		134.5	195.8	237.0	142.
2.	145.0	221.4	151.4		181.7	228.7	268.8	199.
3.	142.9	166.6	167.8		180.7	213.2	271.3	189.
4.	183.3	166.7	221.4		166.6	225.0	271.7	205.
5.	151.4	178.0	191.7	145.0		239.4	307.4	201.
6.	107.1	83.5	165.7	158.5		216.1	285.7	156.
7.	107.0	77.4	179.2	197.1				140.
8.	108.0		161.7	143.5				137.
9.	112.0		145.0	142.8				133.
10.	110.0		187.5	130.0				142.
11.	81.4		117.8	131.4				109.
12.	38.5		97.0	96.4				77.
13.	32.0		85.0	114.2				77.
14.				127.8				
15.				89.1				
16.				80.8				
17.				68.7				
18.				69.2				
19.				53.7				
20.								

Average daily milk production for human use during peak lactation period of 10 weeks is in the order of 160ml when milking once a day, or 320ml when milking twice a day. Assuming the kid, if suckling twice a day on the other teat, is obtaining a similar amount, then milk production by the doe is 22.4 litre for the kid, 22.4 litre for human consumption, giving a total of 44.8 litre during the first 10 weeks of lactation.

Milk production declines rapidly after the first 10 weeks until the end of lactation at about 20 weeks (140 days - this varies widely). During the second half of lactation milk production is about 50ml during the morning milking. Thus a total of 71. for the kid and 71. for human consumption is produced at this time.

Total milk production for the entire lactation is thus about 29.4 litre for humans and a similar amount for the kid. or 58.8 litre total. This figure is comparable to the yields of other tropical goats (Davendra and Burns, 1970) although the total yield is lower because of a shorter lactation length. On a yearly basis, assuming 1½ lactations a year, total yield would be in the order of 88 litres. This is slightly higher than the 60-80 litre per annum reported by French (1970) for 'primitive herding regimes .

Figures for only two sheep are available. In general the shape of the milk production curve is similar to that of goats, reaching a peak after 2 to 4 weeks. Production declines rapidly after about 2½ months. As in goats, milk production if affected by several factors such as rainfall and frequency of milking.

Average milk production from one teat at one milking (in ml)

Sheep no.	1	2		1	2
Week 1.			Week 11.	100.5	91.6
2.			12.	88.7	80.0
3.			13.	69.7	71.4
4.	196.2		14.	78.3	73.8
5.	218.4		15.	71.6	49.7
6.	188.3		16.	50.0	47.5
7.	127.7	102.6	17.	49.8	49.8
8.	128.5	148.7	18.	49.6	31.4
9.	135.3	105.0	19.		32.5
10.	79.2	97.8	20.		32.5

Usually the lamb stays with the ewe at night and milk is only available for humans at the evening milking. Assuming then that the milk available for human consumption is approximately ¼ of the output;

During the first 10 weeks of lactation, 150ml is available to humans and 450ml to the lambs per day

Total yield = 450 x 70 = 31.5 litre for the lamb

150 x 70 = 10.5 litre for humans

During the second half of lactation, approximately 60ml is available for humans and 180ml for the lamb per day

Total yield = 180 x 70 = 12.6 litre for the lamb

60 x 70 = 4.2 litre for humans

Total yield for humans throughout the lactation is thus 14.7 litres and for lambs is 44.1 litres.

Total lactation yield is thus 58.8 litres.

A discussion of milk yields by sheep and goats belonging to nomadic pastoralists is given in Dahl and Hjort (1976). In general it would appear that the yield from Galla goats and Blackheaded Somali sheep is low compared to some N. African breeds. However, considering the type of terrain they are required to inhabit and the fact that they can continue to give milk even during the driest periods suggests that they yields could not be improved upon. In fact taking liveweight into account smallstock appear to be more efficient milk producers than either cattle or camels in arid conditions (Knoess, 1977).