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Grazing in the Ishiara mapsheet

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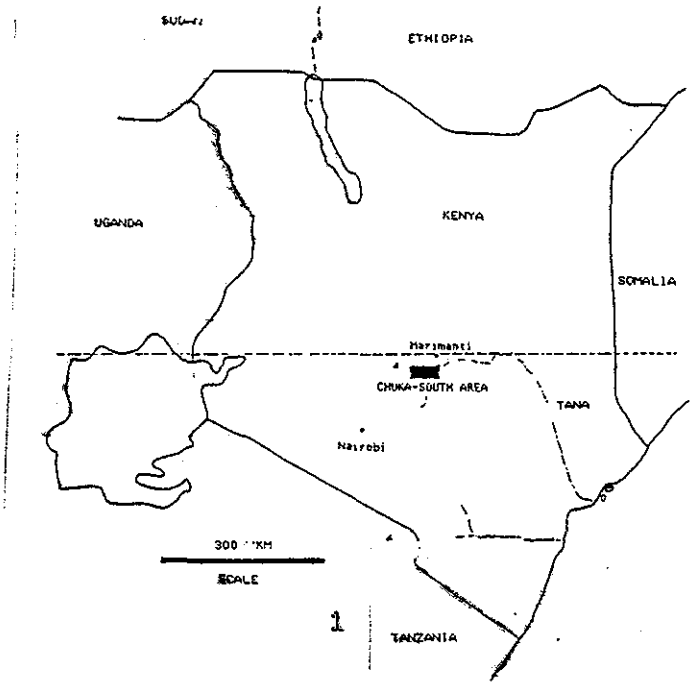
INTRODUCTION

In the Chuka-south area (Chuka and Ishiara mapsheet) Eastern Province Kenya, the TPIP (Training Project in Pedology) of the Agriculture University Wageningen the Netherlands carries out surveys of soil and related subjects like vegetation and geology. Finally all these surveys will contribute to one overall land evaluation of the Chuka-south area.
See figure 1 for location of Chuka-south area.

One of the major land utilisation types of the drier eastern part of the area (Ishiara mapsheet) is extensive grazing, which has a large impact on people and land. It differs from the more intensive grazing in the western part of the area(Chuka mapsheet) by utilising (semi)natural vegetation instead of crops like Napier grass.

The aim of this study was to determine the main ecological constraints of the existing grazing system and to asses the importance of the various landscapes (vegetation and soils) in the grazing pattern.
No attempt was made to determine the carrying capacity of the region. Such a study was completely out of reach and would require a much more thorough knowledge of the area and a quantifying of all underlying factors.
We decided to concentrate on one area (south of Ishiara) during especially the dry season and , less intensively , the major part of a rain season.
Regular feeding observations were the major sources of information. Translation of these data into information about the habitats of the plants enabled us to give general remarks about the requirements and the fulfilment of them of the grazing system in the Ishiara mapsheet.

Figure 1: Location of the Chuka-south area



MATERIAL and METHODS

Study area, general

An area south of Ishiara (Eastern Province) was selected for detailed research to the foodhabits of livestock. The permanent river Ena is the daily watering place for many herds in this area. The area where we followed the animals is situated between the Ena and the road Ishiara-Kigwambiti (to the south).
This area is situated in zone IV (semi humid - semi arid) of the Agro-climatic Zone Map of Kenya (Sombroek et al 1982). Jaetzold (Jaetzold 1982) calls this zone the Livestock-Millet zone and does not distinguish the Ishiara area from the more eastern situated area near the Tana river which is called zone V (semi-arid) on the Agro-climatic Map.
Figure 3 (page 6) shows the rainfall distribution in the survey year 1985.

Study area, soils

See fig. 2 for a comprehensive landscape map of the Chuka-south area (Oostveen & Scholte 1986).

Descending Mt.Kenya the main transition in parent material can be found five kilometer west of our study area. Young volcanic material no longer dominates but material from the old Basement System is the basis for soil genesis. Most of the soils in the area are developed from gneisses rich in ferromagnesian minerals (eg Biotite gneiss). Granitoid gneisses form only a minor part of the parent material. The dominant landforms are Uplands, with an undulating to rolling topography with deeply incised rivers. Along the Ena river a river terrace can be distinguished formed by accumulation of material descended from the Basement System.

Two soiltypes are dominant in our study area: Chromic Luvisols and Calcic Luvisols (FAO-Unesco).The Chromic Luvisols cover more than 70% of the area. These red soils are usually moderately deep and consist of sandy clay, their chemical fertility is low. A very important property of these soils is that their darker, more sandy topsoil (never more than 30 cm) is easily eroded during periods of cultivation. The consequence is a sealing of the subhorizon which hampers infiltration of rainwater and causes much run-off.In this way large tracks of the land receive less than half of the yearly mean 800mm rainfall and become arid land! See Scholte '86 for a detailed discussion.

Along the seasonal streams Calcic Luvisols occur, developed on petrocalcics. Although they cover less than 10% of the total area their importance is large due to their relative high chemical fertility and good structure (without danger of surface sealing).

A minor part of the land consists of shallow soils. Especially on rock outcrops a complex is formed by erosion of very shallow soils (Lithosols), alternated with deeper, fertile soils. These spots receive more water than the actual rainfall due to the high run-off of the rocks.

Much of the distribution of these soils could not be mapped on the 1:25000 semi-detailed soil map of the Kanyambora-Ishiara area which covers the major part of the study area and the 1:100000 reconaissance soil map of the Chuka area (Chuka south-middle section) which covers the whole study area (T.Veldkamp and P.Visser 85). However both maps are useful to compare our study area with other parts of the Ishiara mapsheet (see chapter on landevaluation). More detailed information of soil is given in the detailed vegetation-landuse map description of the study area.

Study area, vegetation and landuse

The Ishiara study area is located in the Acacia-Commiphora landscape (see fig. 2). This landscape is a mosaic of stages in the bush-fallow system. Landuse often dominates differences in environmental factors. However the main differences are reflected by vegetation. The main difference between the vegetation on Chromic and Calcic Luvisols is the higher recovery rate of the vegetation after exploitation on the latter soil.

A map was made of the study area which shows the distribution of the different stages in the bush-fallow system. Ten vegetation-relevees and accompanying augurings were made on various spots during the Vegetation and Landuse mapping of the Chuka south area. This information as well as the various notes during the foodhabit observations were used for the preperation of this map. See pag. 4 for the legend and fig. 3 for the vegetation/landcover map.

Figure 2: The Chuka-south area (1:250.000)
1: Ocotea usambarensis - Strombosia scheffleri Ls
2: Croton megalocarpus - Coffea arabica Ls
3: Dombeya rotunifolia - Mangifera indica Ls
4: Combretum zeyheri - Combretum binderianum Ls
5: Hyparrhenia sp. - Heteropogon contortus Ls
6: Acacia senegal - Commiphora africana Ls
7: USP 10 - Ochna ovata Ls

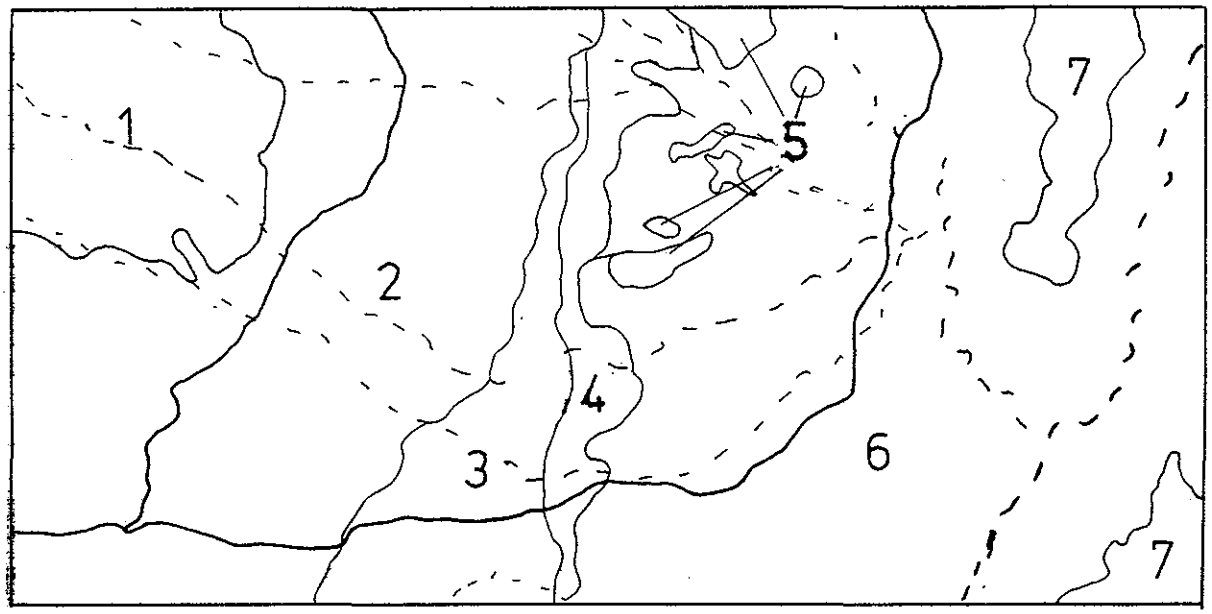
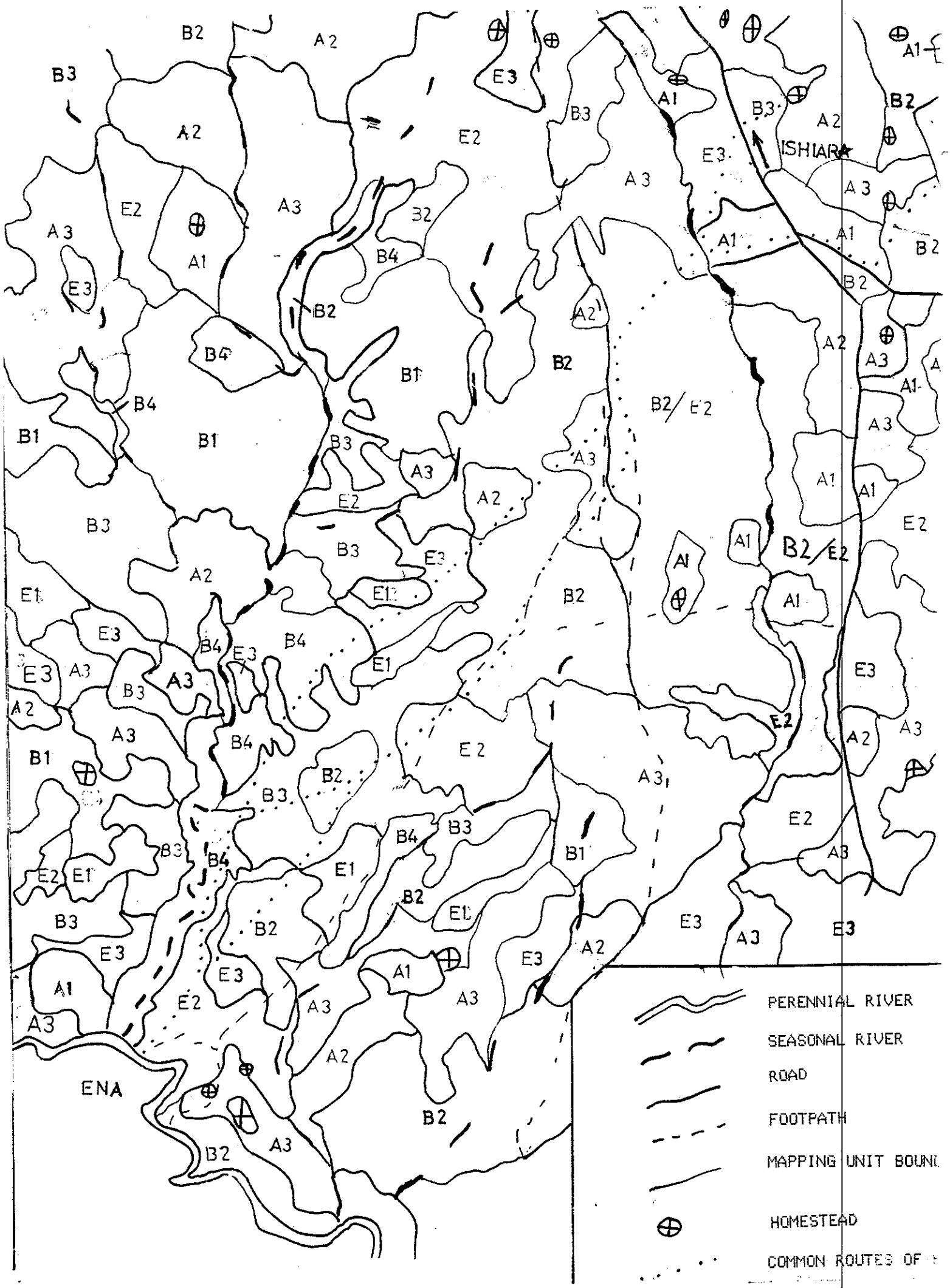


Fig. 4 : DETAILED 1/12500 VEGETATION/LANDCOVER MAP OF THE ISHIARA STUDY AREA



LEGEND DETAILED VEGETATION/LANDCOVER MAP OF THE ISHIARA STUDY AREA

Mappingunit: Vegetation/Landuse relationship soil: Lc = Chromic Luvisol, Lk = Calcic Luvisol cover % of mapping unit in study area	indication of vegetation and landuse
A1: Farmland, currently in use predominantly of Lc,some Lk 4.6%	Sorghum, Cotton, Green Grams, Cow Peas etc. nearly always mixtures of these crops
A2: Farmland, first fallow period predominantly of Lc, some Lk 8.6%	Remaining crops, outgrowing trees, A.tortilis, A.senegal and C. africana and some annual grasses (Tetrapogon cenchriiformis)
A3: Farmland, fallow, bare soil with dwarf shrubvegetation predominantly of Lc 19.5%	Outgrowing trees (A.tortilis,A.senegal, C. africana) and dwarf shrub species like Barleria acanthoides, Ocimum basilicum and Endostemon tetericaulis
E1: Eroded areas < 10% veg.cover comparable with A3 but more erosion (capped soils) only Lc 2.2%	Also typical capped soil species like Blepharis linariifolius.
E2: Eroded areas 10-25% veg cover only Lc 11.5%	Also on some spots grassvegetation of Aristida adsencionis(annual). Shrubs like Acacia mellifera
E3: Eroded areas 25-50% veg cover only Lc 8.8%	Bush is moderately well developped, in dry season no groundcover
B1: low vegetation, no severe erosion predominantly Lc 7.3%	Relative high cover of palatable plants like perennial grasses, and many dwarf shrubs and developping young trees
B2: Bush, 50-80% veg cover (Lc,Cambisols, also Lk) Complex of bush on rockoutcrops and bush on undulating terrain with moderately deep soils 13.1%	A.senegal, C.africana bush well developed, groundvegetation at the base of some trees.Only a minority of E species On rockoutcrops often large trees like Sterculia and Terminalia and a well developped groundvegetation, Triumfetta flavescens and many short living herbs.
B3: Bush, 80-90% veg cover Lk, also some Cambisols minority rockoutcrops 10%	Well developed bush-forest,with typical bushspecies, but also outgrown Grewia Maerua etc shrubs.Sterculia and Terminalia species present. A. tortilis along the rivers Well developed ground vegetation, comparable with B2
B4: Bush, > 90% veg cover Lk, also some Cambisols 5.2%	idem, but all species better developped
B2/E2: Complex of B2 and E2 (1:1) 9.1%	

Grazing system and grazing routes

The main activity of people in the study area is small scale farming. They grow millet, sorghum, green grams etc. Most families also have livestock. The size of their herds varies much, but an average herd of one family consists of approximately 35 goats,4 cattle and 10 sheep (the latter group lacks sometimes). The goats are known as East African goats, cattle are local zebu and sheep are of the fat-tailed Masai type.
Nearly all people herd their animals, except at the end of the dry season when some people keep the animals around their homesteads. Usually small boys are responsible for the animals during the day, only in cases of large herds(more than 10 cattle and 50 goats) older men take care of the animals. The boys often join their herds and enable themselves in this way to play together.They leave with the animals at approximately 10 am and return usually at 6 pm. In the dry season they stay longer in the field, the total grazing time decreases however due to longer reposes without much vailable food in the surroundings.The main human population is found east of the road Ishiara-Kigwambiti (see detailed map). On their route to the Ena river the herds first cross the main farming zone. Through a zone of alternating fallow lands and bush of Acacia senegal and Commiphora africana the animals move to more incised areas with more variation in soils and vegetation. Especially the well developed bush along watercourses (Calcic Luvisols) are visited for a long time. Finally the route crosses the Ena terrace after which the animals jump down to the river to drink. In the neighbourhood of the Ena is a dried-up riverbed where the animals lick salt shortly after drinking. The way back forms often a variation of the described route (see also the map and under results where changes in routes during the year are described).

Food habit observations

During ten visits (data see table 1) observations were made in the Ishiara study area of the food habits of goats, cattle and sheep. The first visit was made in the begin of the dry season, the last halfway the next rain season (see figure 3).
In total four different herds were followed during the whole grazing day. The followed routes did not differ between the various herds. A grazing day started when the herd crossed the way Ishiara - Kigwambiti and ended when the animals returned home. Alternating goats, cattle and sheep were followed.
Most attention was paid to goats and cattle, sheep which are in a minority received much less observation time. Three times a herd was followed which did not contain any sheep. See table 2 for the total amount of minutes spend on observations for each animal during the ten visits.

Table 1: List of visit dates and number of visit in 1985

15-6	= 1	13-9	= 6
9-7	= 2	29-9	= 7
25-7	= 3	21-10	= 8
4-8	= 4	1-11	= 9
23-8	= 5	23-11	= 10

Figure 3: Time of visits and rainfall distribution in 1985

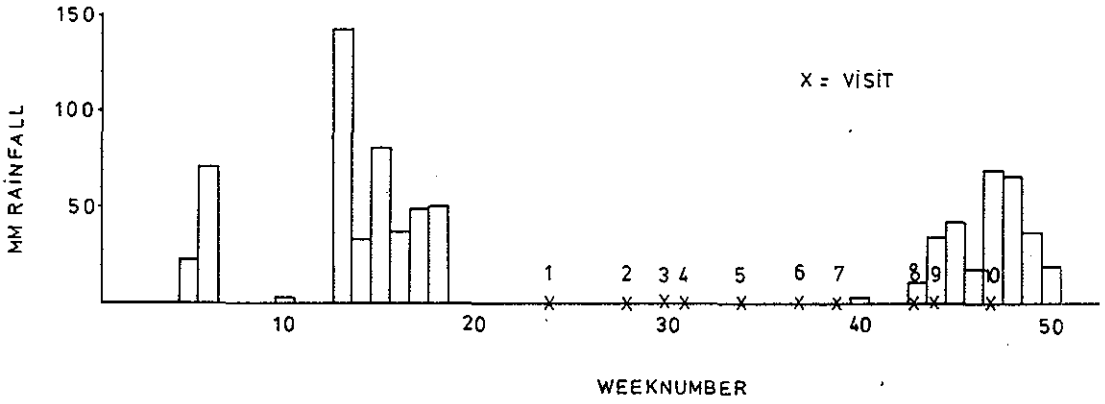


Table 2: Amount of minutes spend on eating during observations per animal per visit.

	1	2	3	4	5	6	7	8	9	10	total
Goat	18	71	81	91	160	163	68	126	74	81	933
Cow	25	84	121	104	137	133	83	52	36	20	795
Sheep	16	56	0	55	134	88	30	0	0	15	394

Visit 3, 8, 9 no data of sheep, herd without sheep

One animal was observed for some minutes (5-15 min.) each plant which was eaten was noted as well as the amount of time spend on eating of that particular plant. The minimum amount (one bite) was calculated as 1/3 minute, especially in the dry season an animal could graze for several minutes.

Time	Animal type	number	Plantspecies	Product	Height
12.31-33	goat	3	A. tortilis	leaves	1.5m
1 bite	cattle	1	T. flavescens	leaves	-

Although it was the intension to follow one animal also notes were made of the amount of animals eating that particular plant. This yields much more information but uncertainty exist about the objectivity of this method. It is possible that more attention is paid to plants and products which are eaten in an open environment eg Acacia pods in an open heavily eroded area.

The one-animal method is followed here and only some notes are made about the other method.
When possible the plant species were noted, if not the plant was given a nick name (or the local name) and taken with for identification. The part of the plant (product) was noted , often the whole plant was eaten (grasses, herbs), in that case we did not mention the product.
In cases in which plants did not have their usual physiognomy (cutted or lopped trees, seedlings etc.) also height or physiognomy was noted.
During the observation day notes were made of the condition of the land, followed routes of other herds and a rough estimate was made of the time spend in each of the land units. Much information was gained by the herding boys about the importance of the plantspecies, other uses of those plants and of the grazing system in general.

Other data

The main plant species and products at the begin and end of the dry season were sampled to get an idea about the quality of the food.They were taken in duplo for crude protein , crude fibre and ash content analysis at the National Agriculture Laboratories in Nairobi. We have also taken material of the same species growing on the two different soil types (Chromic and Calcic Luvisols). Due to some problems not all the samples could be analysed (see results).

Observations in other areas

Seven visits were made in other areas. Two visits in the Hyparrhenia - Heteropogon landscape (see fig.2), five in other places in the Acacia-Commiphora landscape. These visits were meant to compare the study area with other areas in the Ishiara mapsheet. Only during a part of the grazing day a herd was followed (usually 3-5 hrs), conversations with the stephards were relatively important.During the whole period may'85 - january'86 additional observations were made in the Ishiara mapsheet. All those gathered data are only used in descriptive form and compared with the results of the more intensive observations in the study area.

RESULTS

Description of results for each animal
Goats

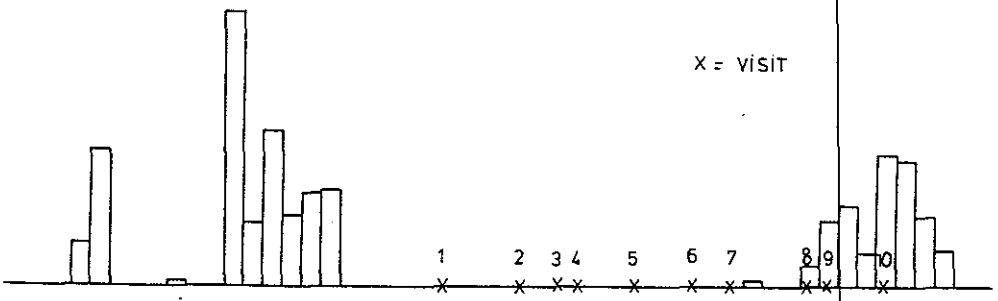
Table 3 and 4 show the change in consumed planttypes and plantspecies during the season . During the rain season goats eat leaves of (dwarf) shrubs and trees and only just after the onset of the rains grasses, sedges and herbs.In the begin of the dry season they eat a lot of litter which is gradually replaced by Acacia pods halfway the dry season. During the dry season they fully depend on those two sources of food. It suddenly drops after the onset of the rains. Acacia senegal pods often form more than half of the food intake during the dry season. Halfway the dry season the animals shift from eating the whole pod (fruit+seeds) to only the seeds, which are easily available and are of a much higher food quality. Acacia tortilis pods form a quarter of the total foodintake of goats in the dry season.These fruits are always eaten as a whole. Grewia bicolor, Duosperma kilimanscharicum and especially Commiphora africana are the main litter producing species, all growing in the well developed bush along the dry river, and (Commiphora) anywhere on places which were not cultivated for some time.
The most attractive leafproducing plantspecies are Acacia tortilis, Acacia senegal and Commiphora africana (shrubs and dwarfshrubs) and Boscia coriacea (high shrub). Acacia tortilis produces already in the dry season high quality leaves when the other food is of low quality. The other species start after the onset of the rains with the production of new leaves. Especially A. senegal and C. africana form an important source of food. Both species are easily available for goats on the fallow lands, where the trees were cut to 0.5 m heightduring the clearing of the bush. Soon all the leaves will be eaten and the plants will remainb leafless. Remarkable is the low content of the evergreen Boscia coriacea (inferior in food quality) in the dry season diet of goats and the higher content in their diet during the wet season when the overall foodquality is much higher.

Table 3 : Composition of planttypes in the diet of goats for each visit data:

	1	2	3	4	5	6	7	8	9	10	mean
gras,sedge	0	0	0	0	0	0	0	0	1	10	1.1
herb	8	1	2	0	0	0	0	2	5	7	2.5
dwarf shrub(<1.5m)	33	3	10	2	0	2	6	11	39	30	13.6
shrub(>1.5m,<5m)	37	6	21	5	3	3	3	7	32	27	14.4
tree (>5m)	14	1	8	4	0	1	5	13	16	25	8.7
litter	8	89	44	10	19	10	21	16	5	1	22.3
pods of Acacia	0	0	14	78	77	84	64	52	1	0	37.0
total percentage	100	100	99	99	99	100	99	101	99	100	99.6

Table 4: Composition of plantspecies in the diet of Goats (as percentage) during each visit
Only those plants are noted that contribute to at least 0.5% of the mean value of all visits.

Rainfall distribution 1985 and data of visits:



Speciesname	product	1	2	3	4	5	6	7	8	9	10	mean
Acacia mellifera	litter	0	11	-	4	3	-	3	0	0	1	2.2
Acacia senegal	leaves	0	0	0	0	0	0	0	-	19	16	3.5
Acacia senegal	pods@	0	-	6	55	63	59	34	49	1	0	26.7
Acacia tortilis	leaves	13	0	1	0	-	2	5	11	5	11	4.8
Acacia tortilis	pods	0	0	4	23	13	25	30	2	0	0	9.7
Albizia anthelmintica	litter	0	4	1	1	4	1	-	0	-	-	1.1
Balanites aegyptica	litter	2	0	0	-	-	1	2	-	2	-	0.7
Barleria acanthoides	leaves	7	1	0	0	0	0	0	-	-	0	0.8
Barleria eranthoides	leaves	0	1	3	0	0	0	0	0	3	3	1.0
Berchemia discolor	leaves	0	0	0	-	6	0	0	0	0	0	0.6
Blepharis linariifolius	whole	0	0	-	0	0	0	4	5	-	-	0.9
Boscia coriacea	leaves	6	3	2	-	-	-	0	2	8	5	2.6
Canthium phyllantoideum	leaves	9	0	5	0	0	0	0	0	0	0	1.4
Capparis sepiaria	leaves	7	1	6	1	-	1	1	3	-	1	2.1
Commiphora africana *	leaves	2	0	0	0	0	0	0	1	35	11	4.9
Commiphora africana *	litter	4	28	8	1	1	3	9	1	0	0	5.5
Combretum aculeatum	leaves	11	0	0	0	0	0	0	-	3	11	2.5
Combretum aculeatum	litter	0	-	8	-	0	4	0	0	0	0	1.2
Cyperus bulbosus	whole	0	0	0	0	0	0	0	0	0	8	0.8
Duosperma kilimanscharicum	litter	0	13	0	0	0	0	0	0	0	0	1.3
Grewia bicolor	litter	0	16	13	0	0	1	6	0	0	0	3.6
Maerua kirkii	leaves	0	-	6	0	1	0	0	1	-	0	0.8
Ocimum basilicum	whole	2	0	0	0	0	0	-	4	0	0	0.6
Sterculia rhynchocarpa	litter	0	3	7	0	0	1	0	0	0	0	1.1
Terminalia brownii	litter	0	0	5	2	0	1	0	2	0	0	1.0
Terminalia prunioides	litter	0	0	0	0	-	1	0	11	0	0	1.2
Terminalia sp. ^	litter	0	8	2	0	0	0	0	1	0	0	1.1
Triumfetta flavescens	leaves	11	0	2	0	0	0	0	0	1	2	1.6
Total percentage		74	89	79	87	91	100	94	93	77	69	85.3

Remarks:
* Commiphora africana (>90%), but also some C.boiviniana and C. holziana
^ Terminalia sp. : T.brownii or T. prunioides
@ Acacia senegal, till 4th visit pods (fruit + seed) later seeds only
- less than 1%, not calculated for the mean value
0 zero percent

Cattle (see table 5 and 6)

In the rain season a major part of the foodintake are grasses sedges, herbs and dwarf shrubs. Their part in the diet of cattle drops rapidly after the start of the dry season when litter forms the bulk of their food intake. A few weeks later than for goats Acacia pods become the most important food. Cattle only eat the entire pod which is often without seed which goats and sheep have already removed. Remarkable is the high content of shrubleaves at the end of the dry season. At this time pods are no longer available and the new fresh food will appear only after the onset of the rains. Also litter (old with a very low nutrient content) is increased in the diet.

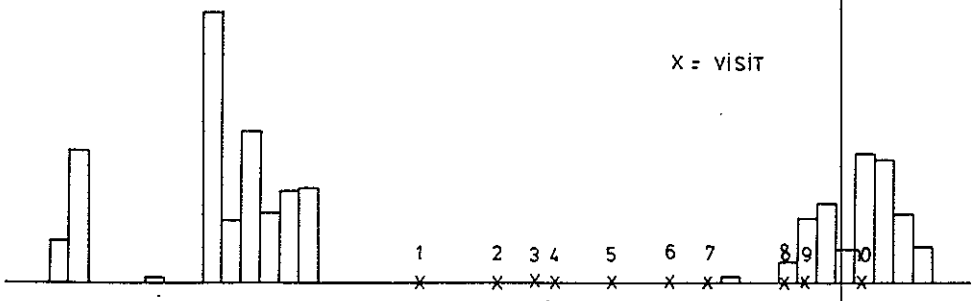
Cattle eat relatively more A.tortilis pods and less A. senegal pods than goats , probably because of the lower foodquality of the often empty A. senegal pods whereas the A. tortilis pods remain of good quality. The amount of A. tortilis pods drops very dramatically at the end of september, this highly desirable food is then just out of stock. The most important litter is of Acacia mellifera (growing on the Ena terrace and on the Calcic Luvisols) of Commiphora africana (also on those Calcic Luvisols and elsewhere in the area), Grewia bicolor and Duosperma kilimandscharicum all growing exclusively in the welll developed bush on the Calcic Luvisols. Also the litter of Sterculia rhynchocarpa and the Terminalia species (growing in that same bush and on rockoutcrops) forms an important part of the diet of cattle in the begin of the dry season(and at the very end Terminalia prunioides). At the end of the dry season Boscia coriacea (shrub) forms a quarter of the total food , striking because in the rest of the season cattle hardly eat any of those leaves. Triumfetta flavescens , Pentas sp. and Barleria eranthomoides (all dwarf shrubs growing in bush on rockoutcrops) form in the wet season a major part of the food. A large number of species of herbs and grasses forms in the wet seson part of the diet of cattle. Only a few of them contribute to more than 0.5% of the total yearly intake. The majority of them grows in the bush on the Calcic Luvisols and espesially in the bush on and around rockoutcrops. Tetrapogon cenchriiformis is the most important grassspecies. It also forms during the dry season an important part of the diet of cattle. It usually grows near shrubs on eroded areas. Cyperus bulbosus which covers just after the the onset of the rains much of the Ena terras and bare but not sealed soils, forms during a short time the majority of the foodintake.

Table 5: Composition of planttypes in the diet of cattle for each visit

	1	2	3	4	5	6	7	8	9	10	mean
gras,sedge	9	5	6	3	0	5	6	0	17	50	10.1
herb	13	2	15	2	0	0	0	2	19	20	7.3
dwarf shrub (<1.5m)	48	5	6	22	0	0	1	21	47	30	18.0
shrub (>1.5m;<5m)	8	7	6	1	1	2	1	25	0	0	5.1
tree (>5m)	1	0	0	0	0	0	0	0	8	0	0.9
litter	20	80	68	35	12	16	15	34	8	0	28.8
pods of Acacia	0	1	0	38	87	76	76	19	0	0	29.7
total percentage	99	100	101	101	100	99	99	101	99	100	99.9

Table 6: Composition of plantspecies in the diet of Cattle (as percentage) Only those plants are noted that contribute to at least 0.5% of the mean value of all visits.

rainfall distribution 1985 and data of visits:



Species	product	1	2	3	4	5	6	7	8	9	10	mean
Acacia mellifera	litter	0	6	0	13	2	0	2	0	0	0	2.3
Acacia senegal	litter	0	0	0	4	2	0	0	0	0	0	0.6
Acacia senegal	pods	0	1	0	26	58	54	36	19	0	0	19.4
Acacia tortilis	pods	0	0	0	12	28	22	28	0	0	0	9.0
Albizia anthelmintica	litter	0	2	0	-	3	6	1	0	0	0	1.2
Asclepias sp. winder	litter	0	8	0	-	0	0	0	0	0	0	0.8
Barleria acanthoides	leaves	5	0	0	0	0	0	0	0	0	0	0.5
Barleria eranthoides	leaves	3	2	1	0	0	0	0	0	1	11	1.8
Boscia coriacea	leaves	0	-	3	0	2	1	1	24	6	0	3.7
Chlorophytum gallabatense	whole	0	0	6	0	0	0	0	0	0	0	0.6
Commiphora africana*	litter	20	19	35	13	0	4	2	1	0	0	9.4
Combretum aculeatum	litter	0	1	5	-	0	0	0	0	0	0	0.6
Commelina benghalensis	whole	0	0	1	-	0	0	0	0	2	3	0.6
Conostomium quadrangulare	whole	1	0	0	0	0	0	0	0	1	11	1.3
Cyperus bulbosus	whole	0	0	0	0	0	0	0	0	14	46	6.0
Duosperma kilimancharicum	litter	0	12	0	0	0	0	0	0	0	0	1.2
Endostemon tetericaulis	whole	1	0	2	7	0	0	-	6	5	0	2.1
Grewia bicolor	leaves	0	6	0	0	0	0	0	0	0	0	0.6
Grewia bicolor	litter	0	21	9	2	1	1	1	0	0	0	3.5
Grewia villosa	leaves	8	-	0	0	0	0	0	0	0	0	0.8
Heliotropum sp.	leaves	0	0	4	0	0	0	0	0	6	0	1.0
Ocimum basilicum	whole	0	0	0	15	0	0	1	9	5	0	3.0
Pentas parvifolia	leaves	0	1	0	0	0	0	0	0	11	0	1.2
Sterculia rhynchocarpa	litter	0	6	4	1	0	2	-	0	4	0	1.7
Terminalia brownii	litter	0	0	7	-	0	1	0	8	6	0	2.2
Terminalia prunioides	litter	0	0	0	0	0	2	5	21	0	0	2.8
Terminalia sp. ^	litter	0	8	0	0	0	0	0	2	0	0	1.0
Tetrapogon cenchriiformis	whole	7	4	4	2	0	0	6	1	4	2	3.0
Triumfetta flavescens	leaves	36	2	1	-	0	0	0	5	14	11	6.9
Total percentage		81	99	82	95	96	93	83	96	79	84	88.8

Remarks:
* Commiphorta africana(>90%) but also some C. boiviniana and C. holziana
^ Terminalia sp.: T.brownii or T. prunioides
- less than 1%, not calculated for the mean value
0 zero percent

Sheep (see table 7 and 8)

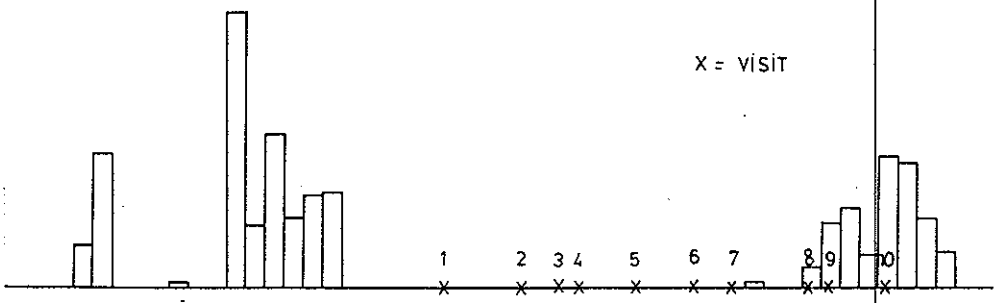
More than in case of goats and cattle, sheep almost entirely eat litter and pods during the whole dry season. Their foodintake in the wet season consists of grasses, sedges, herbs and dwarf shrubs. Sheep consume relatively the highest amount of A.senegal pods and seeds
as well as a lot of Commiphora africana litter. The list of consumed plantspecies resembles much of the list of cattle. Because of the limited observation time spend on sheep detailed differences were not visible.

Table 7: Composition of planttypes in the diet of sheep during each visit date:

	1	2	3	4	5	6	7	8	9	10	mean
gras, sedge	0	0		1	0	0	0			50	7.3
herb	14	2		0	0	0	0			13	4.1
dwarf shrub (<1.5m)	39	1		1	0	0	0			38	11.3
shrub (>1.5m;<5m)	6	1		0	0	0	0			0	1
tree (>5m)	0	0		0	0	0	0			0	0
litter	41	95		9	14	7	17			0	26.1
pods of Acacia	0	0		90	86	93	82			0	50.1
total percentage	100	99		101	100	100	99			101	99.9

Table 8: Composition of plantspecies in the diet of Sheep (as percentage) during each visit.
Only those plants are noted that contribute to at least 0.5% of the mean value of all visits.
No data of sheep during visit 3, 8 and 9

rainfall distribution in 1985 and data of visits:



Species	product	1	2	3	4	5	6	7	8	9	10	mean
Acacia mellifera	litter	0	5		6	2	0	0			0	1.9
Acacia mellifera	pods	0	0		10	0	0	0			0	1.4
Acacia senegal	pods@	0	0		59	75	68	40			0	34.6
Acacia tortilis	pods	0	0		22	10	25	43			0	14.3
Albizia anthelmintica	litter	0	7		1	0	0	0			0	1.1
Aristida adsencionis	whole	0	0		0	0	0	0			7	1.0
Barleria acanthoides	leaves	8	1		0	0	0	0			4	1.9
Barleria eranthoides	leaves	4	1		0	-	0	0			13	2.6
Barleria micrantha	whole	6	0		0	0	0	0			0	0.9
Berchemia discolor	litter	0	0		0	5	0	0			0	0.7
Combretum aculeatum	litter	0	0		0	0	7	0			13	2.9
Commiphora africana	litter	39	31		1	-	0	13			2	12.3
Cyperus bulbosus	whole	0	0		0	0	0	0			39	5.6
Dicliptera sp.	whole	6	1		0	0	0	0			0	1.0
Duospermua sp.#	litter	0	20		0	0	0	0			0	2.9
Grewia bicolor	litter	0	20		0	0	0	0			0	2.9
Ocimum basilicum	whole	2	0		0	0	0	1			1	0.6
Pupalia lappaceae	whole	2	0		0	-	-	0			4	0.9
Sterculia rhynchocarpa	litter	0	5		0	0	0	0			0	0.7
Triumfetta flavescens	leaves	27	2		0	0	0	0			4	4.7
Total percentage		94	93		99	92	100	97			87	94

* Commiphora africana (>90%), but also some C.boiviniana and C. holziana
@ Acacia senegal, till 4th visit pods, later on seeds
\# Duosperma kilimandscharicum
\- less than 1%, not calculated for the mean value of all visits
0 zero percent

Changing routes

During each visit the herd followed more or less the same route as is shortly descriped in Grazing system and grazing routes (pag 5). The most obvious changes are in time spend in each of the landscapes in the area. Compared to some other areas in the Ishiara mapsheet those changes are small, mainly because of the dependence on the same spot at the river which is situated 4 kilometer from their homes. In other areas herds change from watering place during the season or do not move distances as large as in our study area.
For five main "landscapes" we estimated the relative amount of time spend there during the wet and dry season, without notice of their size, see table 9.

Table 9: Relative time spend in the five major landscapes.

	wet season			dry season	
	begin	middle	end	begin	middle
Cultivation land A1,A2,A3	+	-	-	-	+
Eroded areas with scattered trees E1,E2,E3	+	+	-	-	++
Bushland (A. senegal, C. africana) B1,B2(65%)	+	+	+	++	+
Bush on Calcic Luvisols B3,B4	+	+	++	++	+
Bush on rockoutcrops B2(35%)	++	++	+	+	+

\- < 10% + 10-40% ++ > 40%

Remark: This figure does not say much about the importance of the five landscapes. For example, during the dry season much time is spended in the eroded areas without much possiblities for the animals to eat. A shorter time spend in the bush on Calcic Luvisols yields more.

Forage quality, analysis data

Table 10 shows the analytical data of the most important forage plants of the Ishiara study area and some dominant plants in other landscapes.
We considered a Crude Protein percentage of less than 4 so low that an animal living exclusively with this diet can not maintain its weight. Demarquilly and Weiss (1970) give the equation:
Digestible Protein = 0.929 . Crude Protein - 3.52
Therefore below a CP percentage of 3.79% no protein can be digested.
Ketelaars (1983) found for non-lactating cattle a minimum nitrogen percentage of .6% (= 3.75 CP) for maintenance level.

Energy content of forage can be estimated with values of Crude Fibre and ash percentage, Boudet 1975 gives tables (Dijkstra) to calculate the feed unit. Values of 0.45 U.F./100 kg dry matter are supposed to be at maintenance level. This corresponds with a CF percentage of less than 40, how much depends on the ash percentage. Forage with a higher CF percentage than 40 (and an ash percentage of more than 5%, which is usual) is therefore of a bad quality. We do not have enough data to indicate for all samples the energy content of the forage , but in general forage with a CF content of 20% or lower is of a good (energy) quality, and forage with a CF content of 20-40 % is of a moderate energy quality (supposing moderate ash percdentages values).

All values must be seen as rough indicators of the forage quality. For more detailed use one should know more about the digestibility of the various products.

Lowest CP percentages are reached by all the grasses , especially after flowering when their CF content is very high (till 60%). This forage is hardly eaten by livestock, only parts of it (younger shoots) are of a higher quality but are not in easy reach.
Low CP values are also reached by litter of Commiphora africana , especially later in the season and by Terminalia brownii. Their CF percentage is much lower than in case of the grasses. Probably both CP and CF drop during the period between dropping and the next rain season.
Of both the grasses and the litter later in the dry season the CP percentage is below maintenance level. In case of the litter this does not say that the forage is useless (livestock eats it), a supplementary higher quality food (browse, pods, young grasses and herbs) is then probably necessary.
CF percentages indicate that the grasses are too fibrous to be digested, litter (especialy later in the season) is of a high energy content.
Litter of Balanites aegyptica (still green) is of a much higher quality and was more desired by the animals.

Table 10: Analysis of the most important forage and browse plants sampled in the Ishiara mapsheet.
CP: Crude Protein
CF: Crude Fibre
FU: Feed Unit
* : Tree growing on Calcic Luvisol
# : Tree growing on Chromic Luvisol

TREES and SHRUBS

Plantspecies		product	date	%CP	%CF	ASH%	FU
Acacia mellifera		litter	26-7			27.91	
,, ,,		pod	26-7			5.38	
,, ,,		pod	29-9	7.45	40.15		
,, ,,		litter	29-9	5.89	19.03		
Acacia nilotica		pod	26-7			4.02	
Acacia senegal		pod	26-7			7.09	
,, ,,	*	pod,empty	29-9	7.13	37.15		
,, ,,	*	,, full	29-9	14.00	30.85		
,, ,,	*	seed	29-9	29.54	9.78		
,, ,,	#	pod,full	29-9	17.45	24.92		
,, ,,	#	pod,empty	29-9	6.88	38.55		
,, ,,	#	seed	29-9	30.32	10.23		
Acacia tortilis		pod	26-7			4.21	
,, ,,		pod	29-9	10.00	16.14		
,, ,,		leaves young	29-9	15.41	10.68		
Albizia anthelmintica		litter	26-7			20.99	
Balanites aegyptica		litter	29-9	8.50	12.48		
Boscia coriacea		leaves	29-9	9.47	41.35		
Capparis fischeri		leaves	29-9	13.56	23.61		
Combretum aculeatum		leaves	26-7			11.45	
Commiphora africana		litter	9-6	5.72	18.98	18.96	80
,, ,,		litter	26-7			18.93	
,, ,,		litter	29-9	4.10	9.20		
Grewia bicolor		litter	26-7			13.73	
Sterculia rynchocarpa		litter	26-7			12.66	
Terminalia brownii		litter	26-7			10.21	
,, ,,		litter	29-9	3.35	16.99		

Plantspecies	product	date	%CP	%CF	ASH%	FU
GRASSES and HERBS						
Aristida adsensionis	whole	2-6	5.44	39.41	8.32	41
Barleria erantomoides	whole	29-5			16.62	
Blepharis linariifolius	whole	5-7	9.00	30.97		
Blauwlancetbloem	whole	29-5	12.25	31.68	11,17	
Boerhavia erecta	whole	1-7	7.00	37.63		
Brachiaria leersioides	whole	2-6	2.63	29.50	11.81	67
,, ,,	whole	9-6		27.51	11.05	73
Dactyloctenium aegypticum	whole	29-5	6.31	34.00	10.24	56
Endostemon camporum	whole	28-5	10.00	25.09	12.94	77
Enteropogon macrostachys	whole	28-5	4.00	38.31	9.19	45
Eragrostis superba	whole	2-7	3.34	63.46		-
Fijngras	whole	2-6		66.72	32.18	-
Heteropogon contortus	whole	22-5			9.57	
,, ,,	,,	22-5	3.69	35.52	8.23	55
,, ,,	,,	28-5	3.75	38.55	9.17	43
Indigofera atriceps	leaves	28-5	10.94	38.30	20.25	21
,, ,,	stem	28-5		28.08	12.71	68
,, ,,	whole	28-5	11.00	28.20	16.44	64
Ocimum basilicum	whole	28-5	6.44	35.86	9.65	51
,, ,,	whole	2-6			13.15	
Polygala liniflora	whole	2-6	9.63	26.71	11.90	75
,, ,,	whole	29-5	6.56	40.89	3.59	-
Ruwgras	whole	28-5	5.31	35.80	17.63	36
Spermacoce senensis	whole	28-5	7.50	27.64	9.85	75
Tephrosia uniflora	pods	1-7	7.50	47.26		-
,, ,,	leaves	1-7	7.19	44.72		-
,, ,,	leaves,stem	1-7	3.34	63.46		-
Tetrapogon cenchriiformis	whole	9-6			11.04	
,, ,,	whole	29-9	4.13	31.61		
Themeda triandra	whole	2-6	5.50	35.00	8.48	56
Triumfetta flavescens	leaves	29-5	8.56	27.02	8.39	79
Vernonia aemulans	whole	2-6	8.81	27.93	11.84	71
Vertisolgras	whole	2-6	4.75	29.78	12.71	63
Vertisolkruid	whole	2-6	7.94	37.12	7.39	51

Striking is the difference with the values reached by the pods of Acacia senegal and of Acacia tortilis. Although the pod itself (the leathery fruit) has moderate values for CP and CF (the latter not much above maintenance level), especially the seeds are very nutricious. This explains the shift of eating the whole A. senegal pod (fruit + seed) to only the seeds halfway the dry season by sheep and goats. The pods of A. tortilis (preferred by all animals) have lower CP values but also a lower CF content.
Although the CF content of the seeds is very low (<10%), this does not say that they are easily digested. When an animal eats a pod (with seeds) a large amount of seeds can be found in their faeces. However goats and sheep who eat the individual A. senegal seeds chew them a long time and probably digest the majority of them.
Striking is the result of the analysis of A. senegal pods of trees growing on the two different soil types (Chromic and Calcic Luvisol): no difference was found despite supposed differences in soil fertility.
High quality forage are also the young leaves of Acacia tortilis, as well a high CP and a low CF content.
A significant part of the forage is of a moderate protein quality and has a reasonable energy content, litter of A. mellifera, leaves of Triumfetta flavescens and shrubby herbs like Blepharis linariifolius and Endostemon tetericaulis. Also with a moderate protein content, but of a very high limiting CF content are the pods of A. mellifera, the leaves of Boscia coriaceae , Ocimum basilicum , Indigofera atriceps and the pods and leaves of Tephrosia uniflora. However goats eating pods of Tephrosia during pregnancy did not loose weight, an indicator that the forage quality can not be that bad.

Forage quality, literature review

Table 11 shows analysis of plants species also found in the Ishiara mapsheet. Using these data must be done with reserve. Differences in analytical methods and in environmental circumstances cause much variation. Here we will discuss the importance of these data for our study area, in chapter discussion the data will also be used to compare our study area with other areas. Roughly the same picture emerges from the data as the ones from our area. Interesting are the data of young grasses which we did not analysed. They show a much higher CP content than the older stages, although the CF content is astonishing high. This is an important grazing resource, especially in the Hyparrhenia - Heteropogon landscape (Wooded Grassland). The high CP values of all browse plants is striking, especially of young leaves. Also trees of which the litter is of a poor quality (Commiphora africana) produce high quality leaves. An exception are Terminalia brownii and T. prunioides leaves which reveal already the very poor quality of the litter. Many literature values indicate a higher CP and a higher CF content than our analysis, this might be caused by different analyse methods, difference in sampling and by environmental circumstances.

Table 11: Literature review of analysis of some forage and browse plants important in the diet of livestock in the study area.

Sources
1 Dougall, Drysdale and Glover '64
2 IBPGR '84
3 P. Kuchar '82

Abreviations products:
fl = flowering
le = leaves
po = pods
se = seeds
sh = shoots
st = stem
tw = twigs
wh = whole plant

PLANTSPECIES	PRODUCT	DATE	LOCATION	LIT.	CP%	CF%	A$H%
TREES AND SHRUBS							
Acacia mellifera	tw,le	dec 61	Mbuguni	1	7.98	45.78	10.16
,, ,,	young le	feb 57	S.Baringo	1	42.85	16.19	6.17
Acacia senegal	young le,tw	oct 62	Mara	1	20.26	27.72	6.79
,, ,,	young le,tw	nov 62		1	20.51	27.74	8.26
,, ,,	green po		Uganda	2	22.03	39.02	7.06
,, ,,	dry po		Uganda	2	19.65	29.64	5.31
Acacia tortilis	tw, le	nov 61	Tsavo	1	6.46	34.09	8.84
,, ,,	po + se	jan 57	S.Baringo	1	17.79	17.50	8.37
,, ,,	green po		W.Africa	2	16.6	20.09	5.9
,, ,,	dry po		W.Africa	2	16.8	19.1	6.5
Acalyphe fruticosa	st +le	apr 62	Kandeitcha	1	10.05	40.45	9.39
,, ,,	st +le	may 62	Voi	1	12.71	39.81	10.29
,, ,,	st +le			3	8.7		5.8
,, ,,	le			3	12.7-20.1		
Albizia anthel-mintica	tw,le	apr 62		1	14.82	42.87	6.45
Balanites aegyptica	young sh,le	feb 57	S.Baringo	1	27.48	23.28	6.57
,, ,,	young sh, le	nov 61	Mara	1	20.80	21.60	9.60
Boscia coriacea	le		Marsabit	3	8.3-16	35.8	19.3
Combretum aculeatum	tw, le	apr 62	Voi	1	11.87	36.16	6.99
,, ,,	young le		U. Volta	2	29.8	15.4	10.2
,, ,,	green le		U. Volta	2	10.5	19.4	9.8
,, ,,	young sh		U. Volta	2	7.4	29.9	7.1
Commiphora africana	young le			2	14.25	12.9	9.39
,, ,,	le			2	16.50	10.0	10.9

PLANTSPECIES	PRODUCT	DATE	LOCATION	LIT	CP%	CF%	ASH%
Grewia bicolor	le	dec 61	Tsavo	1	14.23	31.75	7.70
,, ,,	tw	sep 62	Irim	1	6.55	50.86	8.06
,, ,,	young le,tw	aug 56	S.Baringo	1	12.73	22.99	6.05
,, ,,	tw,le		Kenya	2	11.70	30.92	8.43
,, ,,	flushing sh			3	17.9		
,, ,,	sh 2-3 weeks			3	15		
,, ,,	le dry season			3	6.0		
Grewia villosa	sh,le	apr 62	Kandetcha	1	10.85	34.67	10.33
,, ,,	sh,le	apr 62	Kandetcha	1	11.87	29.82	9.72
,, ,,	le		12/5	2	18.50	20.06	10.76
,, ,,	le		3/58	2	22.17	19.74	11.61
,, ,,	le		8/58	2	17.68	20.87	19.88
,, ,,	le		8/58	2	11.71	20.88	18.55
,, ,,	le		11/58	2	15.77	17.91	6.58
,, ,,	le		1/59	2	14.85	20.25	10.64
,, ,,	le		U.Volta	2	14.5	19.9	11.4
Terminalia brownii	young sh,le	aug 56	S.Baringo	1	5.73	16.19	6.12
Terminalia prunioides	tw,le	apr 62	Voi	1	7.05	43.10	7.30
,, ,,	st+le			3	7.9-12.9		
,, ,,	le			3	4.6-5.7		
GRASSES AND HERBS							
Aristida adsensionis	wh,early fl	aug 61	Marigat	1	8.90	36.84	11.44
,, ,,	wh,fl		Niger	2	6.23	41.25	7.84
,, ,,	wh ,dry		Niger	2	5.16	39.50	9.64
Brachiaria leersioides	wh,early fl	dec 61	Tsavo	1	11.78	31.47	13.47
,, ,,	wh,early fl	apr 62	Tsavo	1	7.88	35.46	14.67
Commelina benghalensis	tops	dec 61	Mbuyuni	1	8.42	22.84	33.25
,, ,,	st,le	mar 62	Tsavo	1	14.21	25.13	26.65
,, ,,	le,st	dec 62	Mara	1	19.41	21.05	26.55
,, ,,	st, brown le	nov 62	Mara	1	9.29	26.60	15.93
Dactyloctenium aegyptium	wh,full fl	aug 61	Marigat	1	15.62	27.91	13.65
Pupalia lappaceae	wh	sep 62	Voi	1	10.88	32.44	9.15
Tephrosia uniflora	wh	jul 62		1	10.82	40.86	6.20
Tetrapogon cenchriiformis	wh, full fl	aug 61	Marijal	1	12.60	34.60	8.66
Themeda triandra	wh,full fl	feb 62	Mara	1	4.37	38.56	11.01
,, ,,	wh,after burn.	oct 62	Mara	1	11.91	23.94	12.34
,, ,,	le,after burn.	nov 62	Mara	1	9.36	38.17	14.59
,, ,,	le,after burn.	dec 62	Mara	1	11.38	28.05	13.31

DISCUSSION

Importance of plantspecies and their habitats

For an evaluation of the importance of the consumed plantspecies and their habitats a comparison has to be made between the relative abundance of the plants in the area and the amount of minutes spend on eating them. No intensive research was done to determine the abundance of the several plantspecies. However with the knowledge of the area and the comparison between the foodhabits, the information on the detailed map and the description of the units an estimate can be made of the importance of several plantspecies and their environment. One has to realise that amount of minutes spend on eating from a certain kind of plant is not the same as amount of foodintake. The importance of a plant is not only determined by the abundancy but also by its quality and the time of availabilty. It is not easy to quantify all these factors. Therefore we limit ourselves by giving only a rough estimate in descriptive form of the importance of the plantspecies and their habitats in the study area in the period june - december '85.

Although the wet season seems to be a time of abundance and thus of few constrains, the amount and quality of food determine the condition of the animals and so of their chance to survive during the dry season. Important is that not all available plantmaterial is eaten but that a part of it remains for worse times. Striking was that many species already completely consumed in the Ishiara area where still available at the end of the dry season in protected areas (e.g. Grewia villosa). Not all material can be eaten without exhausting the system, a plant which looses all it leaves a few days after they have grown has little chance to survive. Also the system itself needs a certain amount of material to maintain itself(e.g. biomass for termites which maintain the soilporosity).
Not one landscape is on the fore with regard to the wet season plantproduction. But taking into consideration their relative size, bush on rockoutcrops is the most important wet season grazing place. These areas are relatively undisturbed during decades of clearing and burning, and are covered by a high groundvegetation which consists of species like Triumfetta flavescens, Barleria eranthomoides and Pentas sp..But also more disturbed areas can deliver large amounts of food, like for instance the riverterrace along the Ena which is responsible for the high amount of Cyperus bulbosus shortly after the onset of the rains in october.

At the end of the wet season and the beginning of the dry season the amount and especialy the quality of litter is responsible for the condition with which the animals can survive during the dry season. The majority of litter is produced by Commiphora africana (and the other Commiphora species) and is of a rather poor quality. Only the litter of Acacia mellifera is of a slightly higher quality (the litter of the other Acacia species is too small to be eaten of the ground). The other litter producing plants all grow in the well developped bush along watercourses. In the present situation no danger of exhausting this resource seems to exist. However by decreasing the proportion of this vegetation (especisally the bush along dry rivers) problems will arise and cause foodshortages early in the dry season. No information about a proper use factor of this resource exists, what is the annual possible use factor without causing exhaustion? A special case form the rockoutcrops with Sterculia rhynchocarpa and the Terminalia species, which remain isles of litter till the end of the dry season.

From halfway the dry season to the end of the dry season Acacia senegal pods form the most important food for livestock in the area. It's habitat is not very specific and at the moment a major decrease of this tree does not seem to be likely. However 1985 was an extrordinary year for the production of A. senegal pods, in drier years (82,83,84) the pod production seemed to be only a fraction of the 1985's. In spite of the high production in 85 the majority of the pods were eaten at the end of the dry season. In those drier years only some little litter is left(with a low quality) and the Acacia tortilis pods. They have a high foodquality and are highly desired by all the animals. This caused a shortage of high quality food in september 85,especially for cattle which cannot eat the young leaves which appear at this time of the year on the trees and shrubs. The production of Acacia tortilis pods seems to be very regularly, and will be the only quality food in drier years. In this way A. tortilis can be considered as the ultimate basis of animal husbandry in these regions. The majority of the A.tortilis pods is produced by the large trees (>6m), not by the more common small trees . They grow along the (dry)rivers and are always able to obtain water (subsurface water which seepages slowly through the rotten rock). However along many watercourses no A. tortilis trees are growing anymore. During clearing of lands these trees are cut or at least lopped. They compete with crops for the available water due to their extensive rootsystem. Charcoal production is also responsible for the decreasing of large A. tortilis trees. Almost certainly this activity will be responsible for a further decrease of the large Acacia trees and will destroy in this way a store of animal food during the dry season.

Acacia tortilis and A.senegal as well as Commiphora africana are also important leafproducing species. They provide valuable food at the very end of the dry season (A. tortilis even a few weeks before the onset of the rains). Especially the easily available leaves of the cutted and lopped trees(dwarf shrubs) growing on the fallow lands are heavily browsed(only by goats and sheep). It is not clear if these trees are able to survive and grow upto form bushland and close the bush-fallow circle in this way.

Comparison study area with other areas of the Ishiara mapsheet

The visits in the Hyparrhenia - Heteropogon landscape (extensively cultivated Wooded Grassland) showed a quite different diet for the three species. The much higher content of grasses particularly in the diet of cattle is remarkable, Hyparrhenia species, Enteropogon macrostachys and Heteropogon contortus are the most important ones. People burn parts of the area at the end of the dry season, after the onset of the rains a real mat of young palatable grasses is formed on these places. This high quality forage is the main grazing resource in the rain season. Shrubby herbs like the many Papilionaceae species (Indigofera atriceps, Crotalaria sp. etc.) are also important,especially later in the rain season and in the beginning of the dry season. Their quality is relatively high as is their palatability. Occasional observations in the dry season showed a high grazing intensity in the valleys and a very low intensity on the grasslands of the hills. At this time grasses are flowering and have a crude fibre content which is too high for consumption. In the extended grassslands only the shrubby herbs are still eaten. In contrast with this are the valleys where even in the dry season an undergrowth of herbs is available and trees provide litter and fruits during the whole dry season.
Goats (and sheep) are less dominant in this savanna area compared to the Acacia-Commiphora bushland. For example: in the Kaara region a mean size of herds of 6.5 cattle and 9.2 goats/sheep was found (Donk and Helder 1986), compared to an estimated 4 cattle versus 40 goats/sheep in the Ishiara study area.

No fundamental differences were found between other areas of the Acacia-Commiphora landscape in the Ishiara mapsheet and the study area. However due to different extensions of the various landforms differences in grazingpatterns can be found. Different in other areas is for example the importance of the footslopes, which with a relative high soil fertility and lateral flow of subsurface water, are important dry season grazing areas (Acacia tortilis is the dominant tree on these places). In some more intensive agriculture areas differences occur due to shorter fallow periods , but also here grazing depends on bushes and other less intensively used land (for example the riverterrace along the Thuchi river between Ishiara and the Mutonga). The Ishiara area further differs in being more intensively used in the past which caused the extensive sealed soil areas. The study area has more variation in landforms, soils and vegetation than many other parts of the Ishiara mapsheet.

In spite of all these minor differences the same requirements and bottlenecks of the existing grazing system can be found as outlined for the Ishiara study area.

Comparison situation Ishiara mapsheet with other areas

The observations show the importance of the products of trees and shrubs in the diet of livestock in the Ishiara study area. Only in the rain season herbs and annual grasses contribute substantially. Perennial grasses which used to grow here, like in Meru National Park, have disappeaered. There under the same climatic and pedological circumstances a Commiphora africana - Acacia tortilis woodland can be found with an abundant cover of perennial grasses like Chloris roxburghiana and Enteropogon macrostachys (for a more detailed discussion see Scholte 1986). In the Ishiara area shrubs encroached the area due to the intensive exploitation for several decades (always available water in the perennial rivers like the Ena).
Highly preferred species like Grewia villosa which have been eaten already a few weeks after appearence of the leaves can be found in large quantities in the dry season of Meru NP. Still in the Ishiara area a great variation in plant species can be found, possibly due to a heterogenous cultivation practise which left certain areas relatively unused.
As remarked earlier the analysis of the forage of our study area show a lower quality of that forage than could be expected out of literature. We mentioned that this could be explained by a different methodology but it can also be caused by different environmental circumstances.
In general a tendency can be found: high biomass of low quality (especially N) in relative wet semi-arid areas (like the Ishiara area) and low biomasss of a relative high quality in drier areas. This is explained by the fact that the availability of nutrients remains the same and the amount of moisture determines the amount of dilution (Penning de Vries and Djiteye 1982). Ketelaars (1983) mentions values of 5% CP in green leaves and 3.1 CP in dry leaves in grasses under severe N-stress (data of West Africa).The analyses of sampled grawsses in our study area often show lower values and in parts of our study area nitrogen could be a limiting factor. Van Wijngaarden (1985) in a study of Tsavo NP found a critical value of 400mm rainfall per growing season. Below that level moisture will be the limiting factor, above it nitrogen is the limiting factor for plant grow. The Ishiara area (much more exploited than Tsavo NP) has a mean annual rainfall of approximately 900 mm (two growing seasons). For a more detailed discussion see Scholte 1986.
This could be an explanation of the general poor performance of livestock (especially cattle) in the Ishiara area, compared to drier areas where the condition of the animals seems to be much better despite (or because of) the lower rainfall

Relation grazing-agriculture: Degradation and Overuse

Farming and grazing are intensively related to each other. Due to the bush-fallow farming system nearly all land once has been cultivated. A complicated pattern of land is formed with different degree of exhausting, superposed on the variations in environment.Both farming and grazing are responsible for the degradation of the Ishiara area, because both are using land which should be "real" fallow.
Two, three even more years of farming exhausts the soil. Immediately after the cultivation livestock grazes each appearing plant and cut or lopped trees that do not have the chance to grow out of reach of them. In this way years go by in which no vegetation can establish itself. In places this results in the capping of the soil which hampers the rainwater to infiltrate and sterilises the soil. Years can pass without any change. Perhaps with a decrease in grazing pressure (after a drough) trees can grow out and form a bush. Once established the bush can remain years without changes and only very gradually groundvegetation can develop and enlarge the carrying capacity of the bush. The litter and other organic material on the ground initiates this development by feeding the termites which create a porous soil and gives plants the opportunity to germ and establish. But sooner or later cultivation starts again and seizes the valuable grazing land and delivers it a few years later back as bare, exhausted soil.
Nowadays especialy the transition from bare soil with outgrowing trees into bushland is gradually hindered. More exhausted soils and a higher grazing pressure are responsible for this. Although landclearing as such is not accelerating, the amount of (well developped) A.senegal and C. africana bush decreases due to a decreasing developing of bush after cultivation.
In summary one can not speak of overgrazing because the grazing animals are just the last ones that are using the land, earlier in the bush-fallow circle also agriculture took it's share. It is better to talk of overuse.

CONCLUSIONS

The feeding observations showed the dependence of the grazing system of the variation in plantspecies and their habitats. All landscapes (vegetation types, soil types) contribute to the maintenance of grazing in this area. Even heavily eroded areas are essential during parts of the year. This indicates the degree of over using the area. However in the chain of grazing areas relative weak links can be recognised. First the still decreasing amount of large Acacia tortilis trees which threatens the whole livestock keeping in these areas. Secondly the Acacia senegal-Commiphora africana bush, with it's well developed groundvegetation, which is slowly but steadily decreasing. A well organised management is essential to stop these tendencies. One of the targets should be to decrease the turnover time between abandoned cultivated land and bush. A method could be the initiatiation of a non-grazing period of two years immediately after abandoning the land. The fences used to protect the gardens could be maintained and protect the recovering land. However without a full cooperation of the people and a alternative for grazing measures like these will be ineffective.

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LITERATURE:

Agnew, A.D.Q. (1974).
Upland Kenya wildflowers. Oxford University Press

Bogdan, A.V. (1958).
A revised list of Kenya grasses with keys for identification. Nairobi, Government Printer

Boudet, G. (1975).
Manuel sur les paturages tropicaux et les cultures fourrageres. Institut d'Elevage et Medicine Veterinaire des Pays Tropicaux

Dale, I.R. & Greenway, P.J. (1961).
Kenya trees and shrubs. Nairobi, Buchanon's Kenya Estates Ltd.

Donk,G v.d. & Helder, J (1986).
Lutkoek , Internal report TPIP

Dougall, H.W., Drysdale, V.M. & Glover, P.E. (1964).
The chemical composition of Kenya browse and pasture herbage. East African Wildlife Journal 2:86-120

Flora of Tropical East Africa,
Various authors (1952-). London: H.M.S.O.

IBGR,
International Board for Plant Genetic Resources (1984). Forage and browse plants for arid and semi-arid Africa. Royal Botanic Gardens, Kew.

ICRA,
International Course for development oriented Research in Agriculture. Bulletin 15, Wageningen

Ketelaars,J.J.M.H. (1984).
Evaluating rangeland as feed resource for livestock production. Proc. Workshop Land Evaluation for Extensive Grazing. Addis Ababa, ITC/ILCA/FAO, 165-181.

Kuchar, P (1981)
Plants of Kenya. KREMU Nairobi

Le Houerou, H.N. (1980)
Browse in Africa, the current state of knowledge. ILCA Addis Ababa.

Oostveen, M.v. & Scholte, P.
Vegetation- and Landuse map of the Chuka-south area. Internal report TPIP

Penning de Vries, F.W.T. & Djiteye, M.A. (eds) (1982). La productivite des paturages saheliens; une etude des sols, des vegetations et de l'exploitation de cette resource naturelle. Pudoc Wageningen.

Scholte, P. (1986)
Sealed Red Soils in Eastern Kenya, their genesis and maintenance in relation with vegetation and ways to manage them. Internal report Agriculture University Wageningen.

Van Wijngaarden (1985)
Elephants - Trees - Grass - Grazers. International Institute for Aerospace Survey and Earth Sciences (ITC), publication nr. 4.