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IV.1.1. Fodder basis and livestock

IV.1.1.1. Climate and fodder basis

On a world scale, natural pastures provide fodder for about half the productive livestock. Grassland supplies one third of the meat and one fifth of the milk produced. According to different calculations, 30 - 40 % of the land area of the world are situated in warm countries (tropical or subtropical regions).

Thus the warm countries have very good conditions for animal breeding in particular with regard to the utilization of the natural grassland. Temperatures and relative humidity do not impose major restrictions to plant growth in the warm countries. Plant growth is, however, uneven in most of the regions between 30° northern latitude and 30° southern latitude due to insufficient or sporadic rainfall. Even if precipitation is sufficient, plant growth is subject to variations so that in the warm countries, too, additional feed is necessary to supplement what is provided by the natural grassland for high outputs of animal products.

The vegetation of the natural grassland is highly dependent on the climate. Precipitation is the most important climatic factor limiting the vegetation. In the majority of the warm countries, precipitation is irregular and limited to certain months of the year. This affects the natural vegetation and thus the output of animal production. In about 73 % of the tropical regions the annual precipitation exceeds 300 mm. This is the minimum required for cattle breeding on pastures (Table IV.1.1.).

But even in these areas a lack of water can occur due to excessive evaporation caused by intense sunlight and high temperatures. Beyond this, rain falls sporadically and can be utilized by the plants on natural pastures within a limited period of time only.

Table IV.1.1: Classification of tropical land areas corresponding to the rainfall distribution (Mc DOWELL, 1972 and LVOVITCH, 1974)

Regions	Share of the total area (%)	Precipitation (mm)
Desert, semi desert and dry climates (2 months humid)	27	300
Wet dry climates (4.5 - 7 months humid)	21	300 - 500
Humid summer climates (7 - 9.5 months humid)	28	500 - 1500
Rainy climates (9.5 - 12 months humid)	24	1500

For this reason, it is often difficult to estimate the potential fodder supply only on the basis of the annual amount of precipitation. In practice, however, the following limitations to the agricultural utilization of land have arisen in direct dependence on the number and distribution of the humid or arid months within a year. Animal farming is possible up to a maximum of 10 to 11 dry months per year and pasture rearing up to a maximum of 9.5 humid months per year.

Table 2 shows the proportion of the individual climatic zones in different regions of the warm countries and the proportion of the area on which farming is possible. These are mainly areas between 9.5 and 2 humid months per year. All of the areas between 1 - 2 humid months (minimum for animal farming) and 4.5 humid months (minimum for crop farming) can only be utilized by pasturing the natural grassland. As is shown in Table IV.1.2., the proportion of

this type of utilization prevails in the warm countries of Africa. This is clearly demonstrated in Figure IV. 1.1.

Table IV 1.2. Land areas of the tropics classified by characteristic rainfall distribution. Humid months are those with at least 8 cm precipitation (completed according to LANDSBERG et al, 1963)

Regions	Asia & Pacific Islands	Africa	Oceania	South America	North America	Total
Rainy (9.5 - 12 months humid)	6.5	3.7	-	11.2	8.4	29.8
Humid summer 7 - 9.5 months humid)	5.0	9.3	0.2	10.8	0.4	26.3
Wet-dry (4.5 - 7 months humid)	2.8	11.9	0.9	1.9	1.5	19.0
Dry (2 - 4.5 months humid)	1.7	9.1	2.1	1.3	0.4	14.5
Semi-desert and desert (2 months humid)	2.4	5.6	1.9	0.4	0.2	10.4
Total	18.4	39.6	5.0	25.6	11.4	100.0

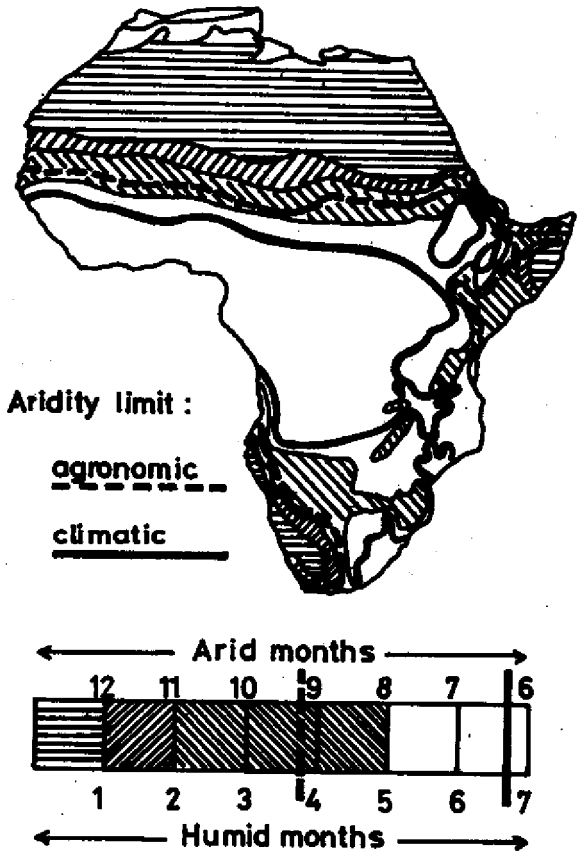

Fig.IV.14. Portion of arid and humid months per year in relation to the aridity line in Africa (LAUER, 1950)

II 1.1.2. Natural grassland (natural pasture)

The utilisation of the natural vegetation in the form of pastures represents the major part of productive livestock feeding (cattle, sheep, goats and camels) in the warm countries. This natural vegetation which is used as fodder mainly for nomadically raised animals is called "grassland" in international usage. In the temperate latitudes, the term means permanent grassland (permanent pastures and permanent meadows) which is characterized by unbroken cover of grasses and herbs. In the warm regions, the grasses can be accompanied by shrubs and trees. The grassland of the warm countries shows degraded forms of vegetation in large areas. It has developed to a differentiated community of grasses and woody plants, in dependence on the amount and distribution of the annual precipitation. The typical plant communities of the semi-deserts, desert-type steppes, thorn-bush savannas, dry savannas, humid savannas and of the mountainous areas developed in this way.

Grassland takes up a much greater area than crop farming. Thus grassland accounts for about 67 % of the agricultural area on a world scale. In warm regions, the proportion is considerably higher and in Latin America it amounts to more than 80 %, in the Near East to about 70 % and in Africa to about 80 %. However, the grassland does not produce enough feed for the productive livestock. At present, only 10 % of the food energy in the world only is produced by animal farming on grassland. The full potential yield that could be obtained from grassland is not used sufficiently in many parts of the world and in particular in the warm countries. Since 50 % of the grassland are situated in the warm countries an improvement of the natural vegetation in these areas would be of great importance for an increase in the production of productive animals and animal products.

IV.1.1.3. Forms of grassland

In general, grassland can be found in all vegetation zones of the warm regions. The plants of the grassland which can be utilized by the productive livestock can be found in rain forests, dry forests, savannas, steppes, mountainous areas, and in swampy areas. The areas which can be pastured are called semi-desert pasture (desert-type steppe pasture), pastures of thorn-bush, dry and humid savannas, pasture in rain forests, mountain pasture and pastures on temporarily or permanently inundated areas.

The pasture areas of the savannas and desert-type steppes are the forms of grassland which are most important for animal production. These are the natural pastures of the warm countries which are most important for animal farming. Their distribution in tropical and subtropical areas can be seen from Figure IV.1.2.

Steppes (mainly desert-type steppes) and savannas are large, more or less treeless grasslands in the interior of the continents, which, in most cases, are located above low ground-water levels. They are characterised by a large number of monocotyledons which can be found there, in particular grasses which constitute the basic feed. In some areas, savannas turn into semi-deserts or deserts due to a lack of precipitation, with fluid transitions. Desert-type steppes appear as deserts in arid years, but after a short rainfall, they produce a vegetation which can be utilized by nomadically raised productive animals. Grass steppes as such can be found in the tropics only at the cooler altitudes of the mountains or plateaus, such as the South African Velds or the grassland of the Andean region (Páramos, Punas). The transition from the desert-type steppe to the savanna is fluid and more and more woody plants are found (in the majority acacias) (see Figure IV.1.3).

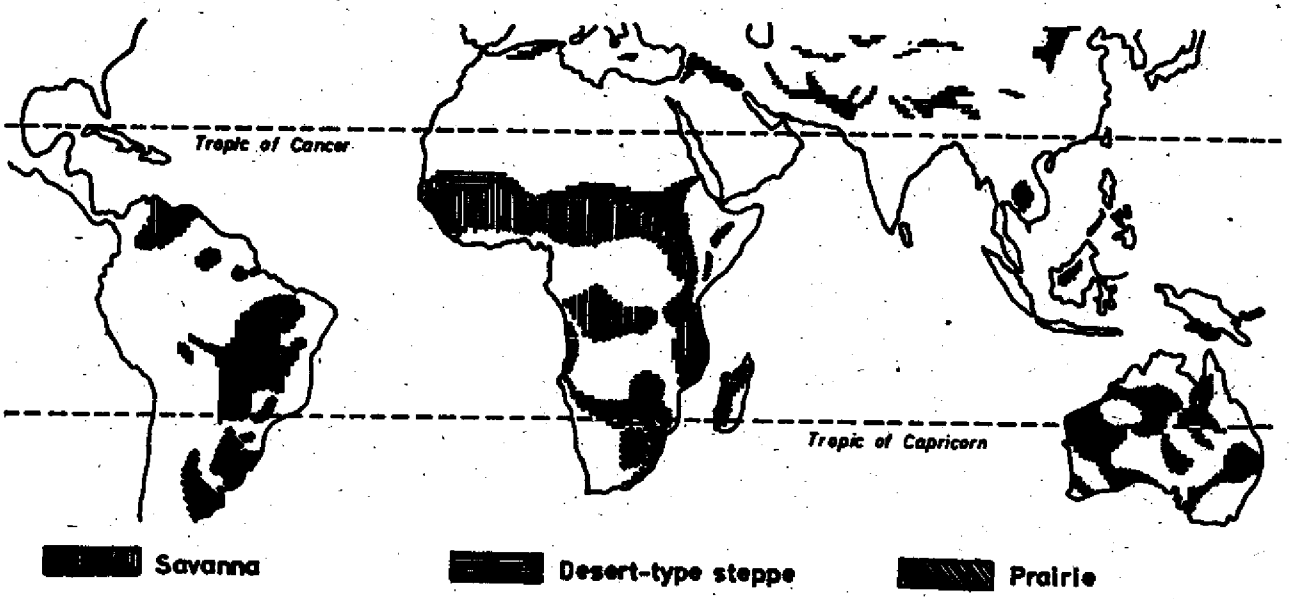

Fig.II 12 Approximate distribution of natural pastures in tropical and subtropical areas (HALTENORTH, 1973)

Fig. II.1.3. Forms of plant associations: Transition from the desert-type steppe to the savanna (WALTER, 1964)

II.1.1.4. Savannas

Savannas are treeless grasslands in the tropical and subtropical regions, sometimes with isolated bushes and trees, mainly umbrella acacias. The average annual precipitation is 600 to 1500 mm (one to two rainy seasons). The thorn-tree or thorn-bush savannas are typical for

Africa. In most of the cases, these are acaciae or other mimosa plants. Similar climatic conditions are prevailing in Australia and South America. In Australia, thornless shrubs and low trees most of which also belong to the species of acaciae replace the thorn-plants. In South America Cactaceae prevail. The many thorns of African savanna plants might be the result of a defence reaction of the plants to hoofed animals feeding on leaves and twigs which has developed in millions of years. Recurring bush fires even nowaday keep the forest away from the savannas and displace fire-sensitive plants. Most of the grasses and herbs are able to recover quickly after a bush fire. Forest growth in the savanna is restricted by the big herbivores feeding on the young shoots of the trees. The natural plant cover of the savanna does not suffer from the natural animal community. If the big game is replaced by pasturing domestic animals, the harmonized composition of the plant species will be changed and the sward affected due to overgrazing. In many warm countries, large grasslands have been turned into semi-deserts or deserts due to undue overgrazing. Savannas exist not only in Africa (15^{0} northern to 25^{0} southern latitude) but also in South America where they are called "Chaco, Campos and Llanos", and in Australia where they are known as "scrub".

With more than 1 million km^2 the African savanna belt (Guinea-Sudan savanna, East African savanna) is the largest region of uniform plant communities on the earth. It is the most widespread typical landscape of Africa. (See Figure IV.1.2) The Guinea-Sudan savanna is characterized by grassland covered with few species of trees only. From the south to the north, the trees become lower and more scattered. During the rainy season (April to October) the annual precipitation in the north amounts to 1000 mm and in the south to 1500 mm. At some places, treeless swampy

lowlands or gallery-type forests along rivers break the uniformity the grass areas. The large rivers Senegal, Niger, Benue, Volta, Jadseram and Schari form wide flooding planes.
The East African savanna is more arid. It is characterized by thorny bushes and low trees. Ridges of hills and islands lend life to the landscape. Generally, the trees of the grassland grow higher and stand more densily towards the south and the west. The duration of the rainy and dry seasons corresponds almost to that of the Guinea-Sudan savanna. The same amount of precipitation falls in the southern hemisphere from October to May.
The African savanna belt is surrounded by the so-called Sudan grassland in the north and by the bush veld in the south. The grassland without woody plants is the transition between the typical savanna and the desert-type steppe.

IV.1.5 Utilisation of the available fodder

The energy and nutrient potential of natural pastures in the warm countries is the basic feed for the productive livestock and the game of these regions and can be utilized for animal production only. Thus there is a close interrelation between climatic factors - vegetation (fodder basis) - livestock (productive livestock and game).
How the types of productive livestock farming depend on the number of rainy or dry months and, thus, on the various utilizable vegetation communities can be seen from Figure IV.1.4 The utilization of the types of vegetation as a pasture dominates here.
In general, the following conclusions can be drawn from Figure IV.1.4:

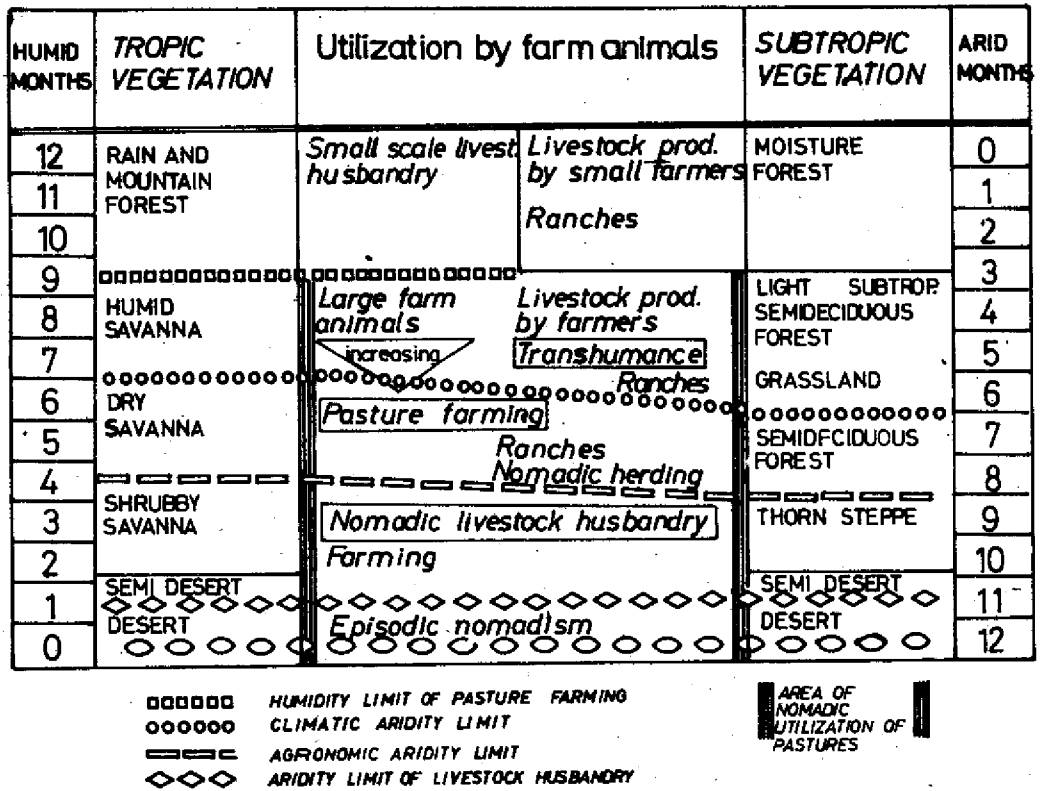

Fig. II.4. Limitation of livestock production in the tropics and subtropics in relation to both the number of humid and arid months and the forms of vegetation (UHLIG, 1965)

a) Pasture farming is possible only up to a certain extent of rain fall. The upper limit coincides with the dividing line between the evergreen rain forest and the humid savanna because, with small exceptions, cattle or sheep breeding is not possible in the rain forest owing to the tsetse-fly. Existing pastures would be overgrown with bushes or trees in a very short time.

b) In the rain savanna, cattle keeping increases with the increasing number of dry months per year, but it does not find optimum conditions (danger of epidemics). Grass-grown elevated plateaus do not supply a sufficient quantity of fodder.

c) Pasture farming prevails in the region between the climatic and agronomic aridity limits. Animal production accompanies agriculture. Ranches are typical for this region.

d) The thorn-bush savanna is exclusively used for animal farming. Many different types of pasture farming can be found (stationary to nomadic).

e) The vegetation of semi-deserts or desert-type steppes can be utilized by animal breeding only. The limits of utilization vary in dependence on the annual precipitation and its distribution. Even beyond the normal aridity limit of animal farming a temporary utilization by sheep and camels is possible.

f) The desert proper cannot be used for animal production though here, too, a scanty vegetation can exist for a very limited time.

g) The regions of nomadic animal farming with all its types and transitional types reach from the humid savanna to the oecumenical aridity borden line in the desert.

The utilization of the types of vegetation for pasture farming can be subdivided as follows:

I. Nomadic animal farming
   1. Desert nomads (camels)
   2. Savanna nomads (cattle, sheep, goats, camels)
   3. Semi-nomads (cattle, sheep, goats)
      - Mountain nomads
      - Fulbes/Sudan, Masai/Kenya and Tanzania

II. Savanna pasture farming with representative cattle breeding
   (Bantus of East Africa, region around the Lake Tchad)

III. Market-oriented pasture farming
   1. nomadic (sheep)
   2. sedentary (cattle, sheep)

Table 3 shows the relations between the climatic zone, vegetation and productive livestock farming demonstrated by the example of a country. Similar surveys for other countries can be elaborated in analogous form.
The types of vegetation which can be utilized for animal production in dependence on humid or arid conditions can be seen from Figure 15. In the warm regions of the earth (in the Figure between 40° northern and 40° southern latitude, respectively) almost all types of vegetation can be used for pasture farming with the exception of the rain forest and a part of the desert vegetation. Within the tropics, only the rain forest restricts the utilization of the vegetation for animal husbandry. It is obvious that the areas in the tropical and subtropical regions which can be used for animal farming are characterized by arid conditions. This refers in particular to the nomadic types of utilization (grey area).
The productive livestock is concentrated in characteristic vegetation zones as is exemplified by the African

Table IV.13: Succession on a rainfall gradient, of vegetation, grass covers, and land-use by farm animals (compiled by Y. SATYANARAYAN, from WHYTE, 1974)

Zones and approximate rainfall range (mm)	Vegetation	Grass cover	Land-use by farm animals	Livestock
Arid, 300 and below	Desert and semi-desert	Lasiurus sindicus-Cenchrus spp.-Panicum spp. P. turgidum and P. antidotale	Nomadic and semi-nomadic grazing	Camels, sheep, goats, cattle, and donkeys
Semi-arid 300 - 600	Thorn forest	Cenchrus-Dichanthium annulatum, Eremopogon foveolatus, Eleusine compressa-Dactyloctenium sindicum, Aristida	Nomadic and semi-nomadic grazing, utilisation of trees and shrubs for grazing	Camels, sheep, goats, cattle, some buffaloes, and donkeys
		Cymbopogon jwarancusa-Sehima nervosum Dichanthium annulatum-Themeda quadrivalvis, Pseudanthistiria heteroclita Heteropogon contortus, Aristida redacta, Aristida funiculata Cymbopogon coloratus-Themeda triandra	Utilisation of residues from dry farming-crops	Sheep, cattle, goats, some buffaloes

Table II.13 (continued)

Dry, sub-humid (600 - 1200)	Woodsland, savannas	Cymbopogon coloratus, Heteropogon contortus-Themeda triandra, Iseilema laxum, Chrysopogon montanus, Aristida spp. Chrysopogon montanus, Bothriochloa intermedia, Eulaliopsis binata	Utilization of products and residues from dry farming and irrigated crops and forage semi-nomadic and stationary grazing	Cattle, buffaloes, goats, some sheep, horses, donkeys
Most subhumid (1200 - 1600)	Open woodlands	Pseudanthistiria heteroclita, Themeda quadrivalvis, Dichanthium annulatum Arundinella pumila, Sehima nervosum Imperata cylindrica, Narenga porphyrocoma, Saccharum spontaneum, Themeda arundinaceum, Microstegium ciliatum	Forest grazing, utilisation of products and residues from shifting cultivation	Cattle, buffaloes, goats, some sheep
Per-humid (1600 - 2000)	Moist forest at low and medium altitudes	Arundinella-Cymbopogon Imperata-Saccharum-Themeda, Phragmites-Saccharum	Utilisation of products and residues from intensive cultivated crops	Cattle, buffaloes, goats
Wet (2000 - 4000)	Wet forests at medium altitudes	No grass in the undisturbed forest		Cattle, buffaloes, goats, pigs, horses

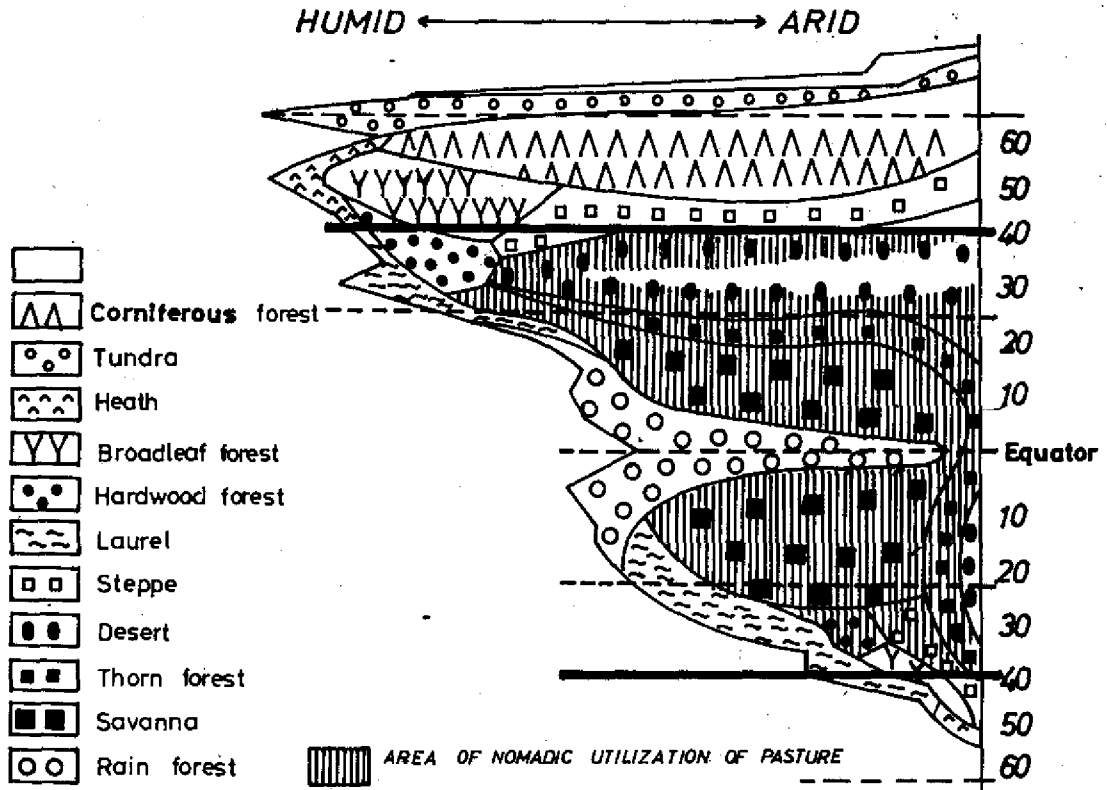

Fig.IV.15 Types of vegetation which can be utilized for animal production in dependence on humid or arid conditions (Form of vegetation according to HALTENORTH, 1973; Area of nomadic utilization of pastures according to author)

continent (Table IV.1.4 and Figure IV.1.6). More than half the total productive livestock of Africa is concentrated in arid or semi-arid areas (50 % of the total area of Africa) with less than 600 mm of annual precipitation (Table IV.1.4). The areas where the individual species (cattle, sheep and goat, camel) are concentrated are directly related to the forms of vegetation there, i.e. to the natural fodder basis (Figure IV.1.6.).

Table IV.1.4 Distribution of livestock over different regions of Africa (LE HOUEROU, 1977)

Regions	Area in percent of the total area of Africa	Farm animals in percent of the total farm animals of Africa
Desert	18	2
Arid and semi-arid	28	52
Sub-humid	10	21
Humid	18	10
Heavy humid and tropical rain forest	23	2
Hight latitude vegetation	3	13

For this reason, the relations between climate, vegetation and animal farming must be taken into account for the feeding of the productive livestock in warm countries.

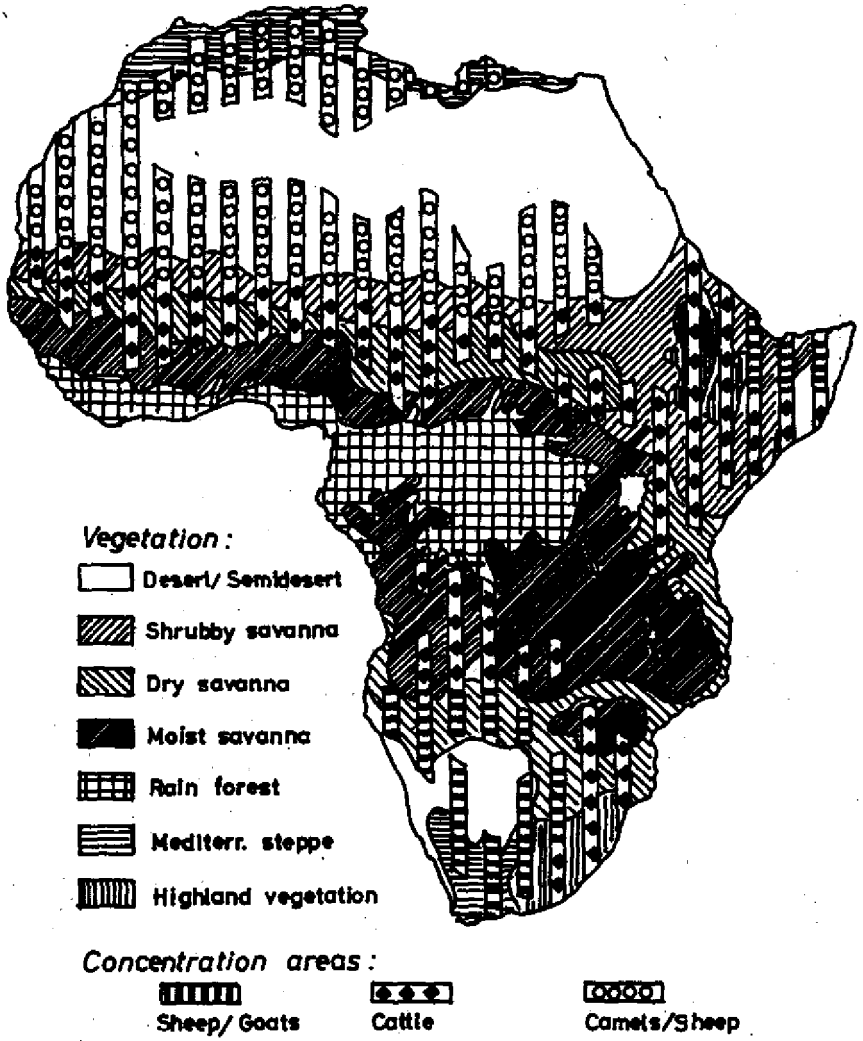

Fig.IV.1: Distribution of livestock over different regions of Africa in relation to forms of vegetation (Map elaborated by the author)

IV.1.2. Potential of fodder supply basis

IV.1.2.1 Plant production

All warm areas have a large production potential of plant biomass. The maximum possible biomass production is determined by the light and the temperature in relation to their influence on the photosynthetic capacity of the vegetation to be considered. Thus, there are favourable conditions in the warm regions for the production of plants which supply the fodder for the game and the productive animals. As regards the production of biomass as a fodder basis for mammals the grassland of tropical and subtropical zones is one of the most productive areas of the earth. For this reason, the grassland has been utilized as pasture for animal breeding for thousands of years and represents an enormous fodder potential even nowadays.

Two aspects of grassland productivity must be considered:

(1) Amount of biomass production per unit area and unit time (e.g. dry weight/hectare/year)
(2) Quantity of plant substance produced which can be utilized by the animal for an output to be produced.

The latter aspect is more difficult to estimate because it depends on the animal species and the selection ability of the individual animals.

There is a large number of varying data on the actual and potential dry matter output from natural grassland or grasses in warm countries. Tables IV.1.5 and IV.1.6 show two examples.

Table IV.1.5 shows the output of natural grassland communities and Table IV.1.6 those of pure grass and of grass-legume mixtures. These and other data vary to such an extent that only a rough estimate is possible of the output attainable in the warm regions.

Table IV.1-5. Productive capacity of natural grassland compared with grassland capacity under European conditions (KNAPP, 1965)

Type of grassland	Country or region	Yield(dt/ha)
Dry-grassland, perennial species	Canary Islands	14.0
Montane grazings dry (400 mm rain, 21°C)	Southern Rhodesia	12.2
Montane grazing wet (400 mm rain, 21°C)	Southern Rhodesia	74.0
Savanna grazings (650 mm rain, 26°C)	Sambesi-valley	109.4
Tropical montane grazings (2100 m over sealevel)	Central-Africa	80.4
Dry pasture 380 mm rain 200 mm rain 120 mm rain	South-West-Africa	 32.0 16.0 9.5
Temporate grasses: Tall oat-grass Pasture	 GDR Netherlands	 68.1 131.0

Based on data from the literature and the experience gained with several types of utilization estimations of the potential output can be formulated as they are shown in Table IV.1-5 in a comparative way. Generally, higher grassland yields can be achieved under tropical conditions than in temperate climates.

Table IV.16 Dry matter yields and crude protein content in temporate and tropical grasses (WHITE et al., 1975)

Type of grass	Country or region	Dry matter yield dt/ha	Crude protein %
Ryegrass	New Zealand	90 - 110	over 20
Grass and clover	Great Britain	45 - 50	15 - 20
Permanent pasture	Netherlands	90 - 110	15 - 20
Bluegrass pasture	USA	20 - 45	10 - 15
Brome grass/ alfalfa	USA	45 - 90	15 - 20
Elephant grass (cut every 3 months)	El Salvador	850	5
Elephant grass (cut every 12 weeks)	Trinidad	220	6
Elephant grass (unfertilized)	Rhodesia	55	10
Elephant grass (heavy fertilized)	Rhodesia	300	10
Elephant grass	Puerto Rico	200	4
Star grass (unfertilized)	Rhodesia	10 - 45	5 - 7
Star grass (heavy fertilized)	Rhodesia	90 - 160	7 - 12
Grass/legume pasture	Hawaii	80	18

Table IV.1.7: Potential productive capacity of natural grassland in different regions (completed according to ALBERDA, 1977)

Environment	Rainfall	Type of grass-land-using	Dry matter yield t/ha
Tropical climates	sufficient	intensive	15
		extensive	7
	limited, but > 200 mm	extensive	5
Temperate climates	sufficient	intensive	10
		extensive	5
Mediterranean climates	limited, but < 200 mm	extensive	2
Semi-desert climates	< 200 mm	extensive	0.5

Useful comparisons can be made by calculating the dry matter produced on the basis of meat and milk output data (Table IV.1.8). The output of fodder dry matter has been calculated on the basis of FAO production data for the meat and milk output from cattle, buffalos, sheep, and goats. Eleven kg of fodder dry matter have been taken as a basis for 1 kg of meat and 1.25 kg of fodder dry weight for 1 kg of milk.

As regards the warm regions, Table IV.1.8 shows two tendencies:

(1) In the warm continents and in the continents with warm regions, the calculated output of fodder dry matter is below the necessary one.

(2) Maximum values are given for the potential output of fodder dry matter in the warm and partially warm continents.

Table IV.8 Forage crop production (dry matter) calculated on the basis of meat- and milk-production with regard to the necessary and potential production (ALBERDA, 1977)

Continent	Population	Dry matter production			Calculated dry matter production; percent of potential production (p.p. = 100 %)
		Necessary for nutrition of farm animals	Calculated on the basis of meat-and milk-produot.	Potential Production	
	x 10^6	kg x 10^9	kg x 10^9	kg x 10^9	
Africa	384	165	54	10991	0.49
North-and Central-America	340	146	252	5272	4.78
South-America	212	91	96	9155	1.05
Asia	2223	956	135	3984	3.39
Europe	473	203	316	1278	24.73
Oceania	21	89	48	4951	0.97
USSR	252	108	197	4132	4.77
Total	3905	1758	1098	39763	2.76

This means that the realized (calculated) production of dry matter in the warm continents is about 0.5 to 1 % of the potential output of dry matter. This indicates the potential fodder reserves of tropical and subtropical regions.

IV.1.2.2. Animal output

The potential for the production of green matter is high in the warm regions. In contrast to arable farming, this potential on the natural pasture can be utilized for human nutrition only via animal production. Under natural conditions which are not influenced by man, a biomass of wild animals of 5000 kg of hoofed animals, 450 kg of small mammals and 850 kg of predatory animals, 25 000 kg of small herbivores and 10 000 kg of invertebrates is estimated per 1 km^2 of the East African thorn-bush savanna. These animals consume much more plant matter, the plant-eating mammals in the thorn-bush savanna consuming only 20 % of the vegetation.
It can be generally estimated that the natural vegetation on 1 km^2 of savanna contains the following biomass:

12 000 to 25 000 kg from wild animals or
5 000 to 7 500 kg from productive livestock (ranch)
or
2 500 to 3 500 kg from productive livestock (nomadic breeding)

Wild animals have a greater biomass because they make better use of the natural vegetation in coordination with other species, and without competition. The existing biomass does not say anything about the productivity. With reference to the above biomass, the following model calculation can be made:

12 000 - 25 000 kg/km^2 from wild animals with 3 % increase in live weight/ year results in an increase of 360 - 750 kg/km^2 per year.

5 000 - 7 500 kg/km^2 from productive livestock (ranch system) with an increase in live weight of 50 %/year results in an increase of 2 500 - 3 750 kg/km^2 per year.

The productivity of the productive livestock thus exceeds that of wild animals.

The potential outputs of meat and milk from pastures of temperate and tropical regions and those which have been achieved in experiments are compared in Table IV.1.9.

Table IV.1.9: Potential meat- and milk-production in temperate and tropical regions (high doses of fertilizers and irrigations) (PEREZ-INFANTE, 1977)

Production gain/kg/ha	Region	Calculated (theoretically)	Realised by animal trials
Meat (gain/Kg/ha)	Temperate	1750	900
	Tropical	2486	2760
Milk (kg/ha)	Temperate	12500	14600
	Tropical	13600	20346

The values showed considerable variations in experimental animal production in favour of tropical pastures. These were about 180 % higher for meat and just under 40 % higher for milk than on pastures in the temperate zones. The fact that the experimentally obtained values exceeded the theoretical ones in the tropics to a much higher degree than in the temperate regions, shows the great potential that exists for improving the utilization of na-

tural pastures by the productive livestock in the warm regions.

The results of numerous studies on an increase in the meat output from natural pastures in the warm regions are available. A summary is given in Table IV.1.10 and Table IV.1.11.

Table IV.1.10 Meat production of different grassland vegetations (NUTHALL and WHITEMAN, 1972)

Type of grassland	Meat production kg/year/ha	Live weight gain kg/day/anim.	Stocking rate (Live-weight of herd per ha of grazing land) animals/ha
Grass/legume pasture	420	0.335	3.5
Grassland, unfertilized	263	0.418	2.1
Grassland, N-fertilized	876	0.536	4.4

Table IV.1.11 Estimates of the potential for beef production from forage in the humid tropics (WILLIAMSON and PAYNE, 1978)

Type of forage	Potential productivity under good management (kg liveweight gain/ha/year)	
	Minimum	Maximum
Natural grasslands		
Improved grazing management	10 - 80	60 - 100
Oversowing with suitable legumes	120 -170	250 - 450
Cultivated grasslands		
Grass/legume mixtures	200 -300	300 - 600
Grass fertilized with nitrogenous fertilizer	300 -500	800 -1500

Good results have been obtained under practical conditions, through an improved organisation of the pasture management, through sowing legume and grass-legume mixtures, respectively, and nitrogen fertilizing.
Studies have also been made by several authors how to increase the potential for milk production on pastures of warm regions. Table IV.1.12 gives a survey. A high milk output is possible only on specially prepared grass and legume areas and where pastures are well fertilized and managed.

Table IV.1.12: Maximum milk yields per lactation and cow in tropical regions feeding only pasture forages (completed according to CHOPPING et al., 1976; PAYNE, 1963; COWAN et al., 1974 and 1975; CARO-COSTAS et al., 1974)

Milk yield (kg/cow/lactation)	Stocking rate (liveweight of herd per ha of grazing land) cow/ha	Remarks
2828	8.9	672 kg N-fertilizer/ha/year Digitaria decumbens, Average of 3 years
2720	5.0	Humid tropical climates, heavily fertilized
3345	1.6	Mixture of Panicum maximum var. trichoglume and Glycine wightii, Average of 2 years
4100	1.2	Mixture of Panicum maximum var. trichoglume and Glycine wightii, Pennisetum clandestinum and Panicum maximum, Average of 6 years
3258	6.7	316 kg N-fertilizer/ha/year Panicum maximum, Rainfall: 635 mm/year

The decisive factor for high milk yields is the concentration of energy in the pasture grass. In general energy concentrations of about 2.5 Mcal/kg of dry matter (pasture of the temperate zone) and about 1.9 Mcal/kg of dry matter (tropical pasture grass) are taken as a basis for comparisons. The latter energy concentration would be insufficient for the yields given in Table 12. On good pastures in Cuba, energy concentrations of 2.1 to 2.3 Mcal/kg of dry substance have been determined. Comparable values should be also achieved in the other warm regions.

IV.4.3. Situation of nutrition

IV.4.3.1. General

The extensive production to animal breeding and farming for animal products in warm countries is mainly characterized by the nomadic utilization of natural pastures. On the one hand, this is by camel und sheep breeding in deserts and desert-type steppes (e.g. North Africa, Arab peninsula) and on the other hand by cattle breeding in the savannas (e.g. Sahel region, savannas of East Africa). A periodic malnutrition which depends on the season is characteristic of all these extensive types of production.

Ruminants have the special feature in their metabolism of oxydizing lower fatty acids formed in the omasum and therefore do not tolerate long periods without food. In the case of malnutrition the adipose tissue is the first to be consumed very rapidly and it is restored slowly when nutrition has normalised. In order to countereact this rapid fat consumption, ruminants which are periodical underfed have additional fat depots in the form of fat-tails, steatopygia (sheep) or fat-humps (zebu) and a higher proportion of surface fat. The cause of the tem-

porary lack of nutrients is the vegetation which develops cyclically depending on the precipitation. With regard to the food situation in the desert-type steppe and the savanna - as the main fodder basis for the livestock in warm regions - the following two conclusions must be drawn:

(1) In the dry season, the animals in both regions suffer from a lack of fodder.
(2) During and after the rainy season there is enough fodder available in the savanna to maintain the livestock and achieve a limited yield from the animals. In the desert-type steppe, however, this applies only to sheep, goats and camels.

IV.4.3.2 Desert-type steppe situation

The types of vegetation characteristic of semi-deserts or desert-type steppes are found in climatic zones with winter rains and dry summers (North Africa, Near East). They are the basis of nutrition of animals which need less feed, such as sheep, goats, and camels. The desert-type steppe vegetation develops in several steps. A more or less pronounced period of rest in the winter months is followed by the main vegetation period in very early spring. The annual and geophytic plants develop first followed by the desert xerophytes proper. The vegetation period of the plants mentioned first is completed at the end of May, that of some xeromorphous plants is completed in August. On condition that enough plants are available, the nutrient content of the desert plants during the vegetation period is sufficient to meet the nutrient requirements of sheep, goats, and camels. Often as much as 10 hectares of desert are necessary to feed one sheep. At the end of the vegetation period, the plants start

drying up and are available to the animals as "standing hay" only. This is just sufficient to meet the maintenance requirements (of digestible crude protein) of the smaller ruminants (sheep and goats). In the following time, when most of the dams are pregnant, the supply with the required protein is no longer guaranteed. As a consequence of the deficiency of fodder in the summer, as from June the nomades migrate with their flocks of sheep and goats to areas of cultivation in more favourable climates (use of crop residues) or to mountainous regions (mountain pastures). Overstocking is typical of the Arabian desert-type steppe. In arid years, this has disastrous effect on the sparse vegetation and the sheep stock. Camels are less demanding on the vegetation of the desert-type steppe than sheep and goats. They get over dry periods well and can cover greater distances and can do without water for a prolonged period so that they can utilize the vegetation of desert areas which cannot be reached by sheep and goats. In general, however, camels suffer as much from the lack of fodder during dry periods as the smaller animals. As can be seen from Table 13, the development of the live weight of camels highly depends on the seasonal fodder supply. During the rainy season, the daily increase in live weight is considerably higher than in dry periods. Camels, too, show reductions in live weight during the dry season (winter) (Table IV.1.13). Supplementary feeding is necessary.

IV.1.3.3. Savanna situation

IV.1.3.3.1 Seasonal lack of fodder

The natural vegetation of the steppes, thorn-bush and dry savannas is the main source of fodder for the nomadic cattle, sheep and goat breeding. The total productivity

Table IV.13 Liveweight development of camels in dependence of the quality of semi-desert vegetation (ACHMEDIJEW and DSHUMAGULOW , 1966)

Age of camels (years)	Average liveweight gain (g) per animal and day			
	summer season		winter season	
	March to May	June to August	September to October	November to December
2 - 3	1268	413	975	- 1180
3 - 4	1840	337	950	to
over 4	2520	174	1110	- 1900
	Spring rain	without rainfall	Autumn rain	without rainfall
	only pasture forage			Supplementary

of the natural pasture is considerably higher than that of semi-deserts. Not the general lack of fodder, but the seasonal lack of fodder - in connection with an insufficient supply of drinking water - is the output-limiting factor. During the rainy season (summer), cattle and sheep find enough fodder in the savanna so that daily increases in live weight of 500 g for cattle and 60 g for sheep can be achieved and there may even be a surplus of protein. After the rainy season, the feeding value of the grasses reduces rapidly, particularly that of annual grasses, and in the beginning of the dry season, daily increases in live weight of 200 - 300 g for cattle and 25 g for sheep are obtained only. Later on, only the maintenance requirement is met and the live weight reduces during prolonged dry seasons. The development of live weight is influenced by the seasonal change in the supply of fodder depending on the amount of precipitation. As a result the live weight of cattle develops gradually (Figure IV.17). During and after the rainy season, the curve

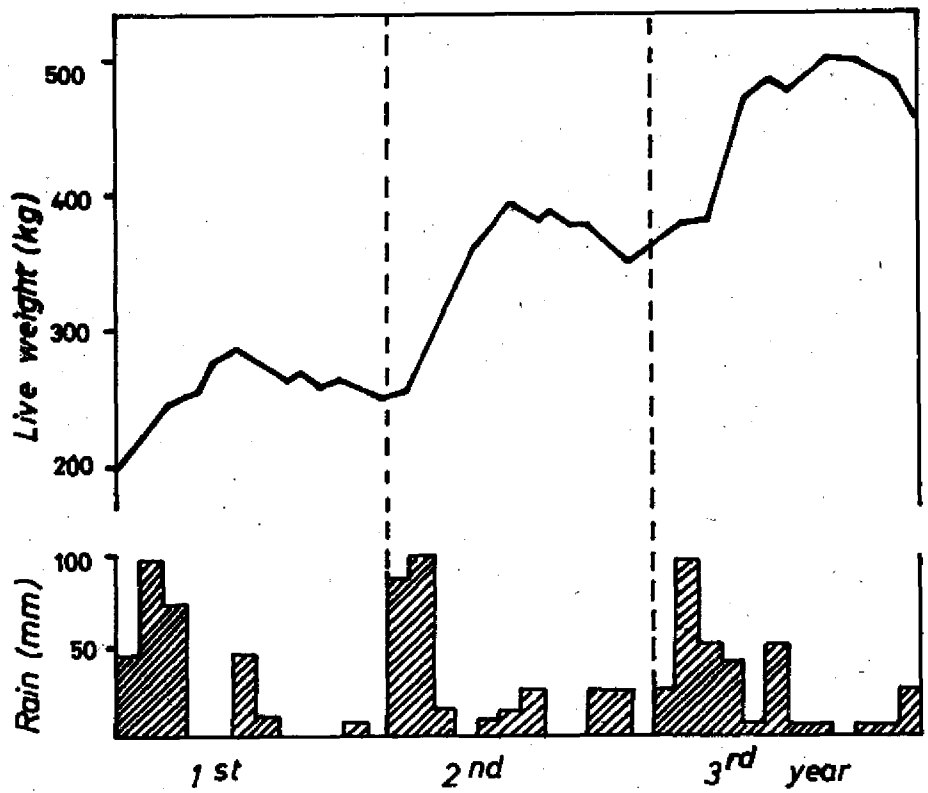

Fig.IV.1.7 Normal growth pattern of beef steers on natural pasture in relation to the rainfall in Australia. Weight losses in the second half of the year are obvious (Report - FAO, 1955)

of the live weight rises steeply. It stagnates during the dry season or drops again. Often the reduction of live weight extends into the beginning of the rainy season (Figure IX.1.8). After prolonged dry periods, this reduction can continue even if young grass is available. This phenomenon occuring in Africa is called "green-grass-loss".

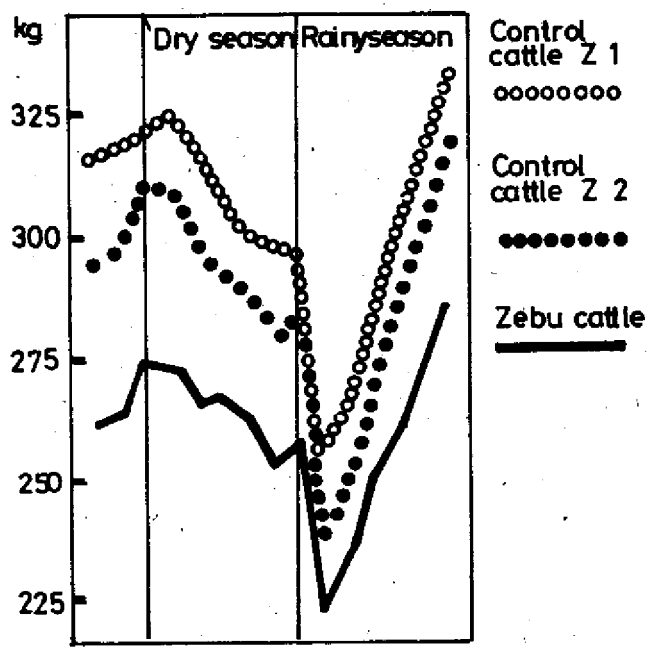

Fig.IX.1.8 "Green-grass-loss" and "Compensatory growth" of twin-cattle (Z 1 and Z 2) and zebu-cattle on natural pasture (PAYNE, 1965)

Subsequently, in connection with the rapidly growing supply of fodder, extremely steep rise of the growth curve can be observed (Figure IX.1.8) This is known as "compensatory growth". The steep increase in live weight is partly because more water is collected in the animal tissue (during the dry season, the proportion of tissue

water is reduced) and more fodder accumulates in the digestive tract. Thus only part of the additional live weight gain is real. The development of live weight of sheep and goats is analogous. On an annual average, daily increases in live weight of 40 to 60 g are achieved for sheep raised on natural pastures (Table IV.1.14). However, about 18 months are required for a final weight of 25 to 30 kg. Under the conditions of intensive lamb fattening this takes 3 to 4 months only.

Table IV.1.14: Growth rate of sheep in Tanzania (FRENCH, 1938)

Age	Liveweight / kg		
	Blackhead	Masai	Ugogo
Birth	2.6	3.0	2.1
1 month	5.8	6.3	4.6
3 months	9.9	11.9	8.1
6 months	14.7	17.4	14.7
9 months	17.9	23.0	16.6
12 months	21.0	26.9	19.1
18 months	25.2	34.7	24.8
Average liveweight gain/day/kg	0.047	0.064	0.045

When the fodder quantity at the location is no longer sufficient and all usable grasses, and other plants - which are available in the form of "standing hay" during the dry season - have been consumed, the nomades migrate to more humid areas with their animals. As in the Sahel zone, this migration can be horizontal from the northern zone (grassland) to the southern zone (savanna with shrubs and trees) or, as in Ethiopia, vertical from the

lowlands to the highlands. During transhumance, often only 60 % of the nutrient requirements are met. The vegetation of the more humid areas is richer in species and denser so that the animals find enough fodder even during the dry season. This results, however, in a high animal concentration which, in turn, worsens the fodder situation. The seasonal variations in fodder supply which depend on rain falls make it necessary for the nomades to move from one place to another continuously. In many cases, these nomades have permanent dwellings and migrate to other pastures at certain times of the year only. Some groups of the Baggara tribe in Sudan who practise some cultivation of soil migrate to the north with their cattle, sheep and goats during the rainy season to utilize the vast grassland and savanna areas in the Darfur province.

During the dry season, they migrate in southern direction to the lower areas around the Bahr el Arab (Figure 9) and cover distances of 300 - 400 km. In many regions of east Africa, similar forms of semi-nomadic life can be found. Peasants who have settled in the Ethiopian highland migrate to the humid valleys with their animals.

During the migration to the pastures, partially heavy losses of animals occur. In the Sahel zone, for example, the insufficient satisfaction of the nutrient requirements results in normal years not only in a stunted growth but also in a loss of up to 20 % of the cattle, about 10 % of the sheep and goat, 2 % of the camel and about 7 % of the horse and donkey livestock during the southward transhumance (long migration distances under extremely dry conditions).

The periodical, acute malnutrition can turn into chronic underfeeding in extremely dry years, and the animals are hungry or die from hunger. This was the case in 1973 in six countries of the Sahel zone (Mauritania, Senegal,

Mali, Upper Volta, Niger, and Tchad). Starting in 1968, the annual amount of precipitation was far below the annual mean of long years. In consequence, migration to the south began 3 - 4 months earlier, and the northward transhumance was delayed. In summer 1973 this resulted in a strong concentration of animals in the southern Sahel zone and in the northern part of Sudan.
As a result of the drought that began in 1968, only 50 % of the cattle, 80 % of the sheep and goats and 95 % of the camels had survived by march/april 1973. On the whole, it is estimated that about 25 % of the cattle kept at the beginning of the critical period died. In some regions, the mortality reached 80 %.

IV.1.4. Improvement of fodder basis and nutrition

IV.1.4.1. General

There is a close connection between improving the fodder basis and securing the nutrition of the productive livestock raised on natural pastures in tropical regions. Measures to improve the natural pasture take a direct effect on the animal outputs. For most domestic ruminants in warm countries, natural pastures are the only fodder basis. For this reason creating a sufficient fodder basis in the form of improved natural pastures which can be re-

lied on during the year is of primary importance for improving animal production.
According to NEUHAUS (1964) the following measures for improving the fodder basis should be taken:

A. Efficient and suitable utilization of the existing natural pastures
   1) Avoid overstocking
      a) Eliminate low-yielding livestock
      b) Reduce the number of bulls where applicable
         aa) Reduce the number of working animals
         bb) Slaughter young bulls
      c) Restrict livestock raising in general, if no effective reduction can be achieved by a) and b)
   2) Change in pasture farming which in many cases is uncontrolled
      a) Use rotation pastures
      b) Use hay pastures (which also permit fodder preservation)
      c) Graze in due time in order to prevent the lignification of the plants and thus loss of nutrients
      d) Tether the grazing livestock, in particular on smaller, rich pastures
      e) Night grazing instead of day grazing or grazing of unshadowed pastures during the cooler evening and morning hours.
   3) Arrangement of saving areas for several years for the regeneration of the pasture vegetation
   4) Maintain an optimum population of phytophagous wild animals on natural pastures in order to avoid too great a propagation of the plants rejected by the domestic animals which, however, are consumed by several wild animal species.
   5) Take stock and analyse the nutrients of the exist-

ing pasture vegetation in order to get a survey of the feeding value.

6) Use irrigation
7) Employ fertilization
8) Provide a sunshade for the animals on the pasture
   a) Plant shady trees and bushes
   b) Erect protective roofs or huts
9) Restrict or avoid the uncontrolled burning down of pastures; graze or harvest in due time.
10) Develop and utilize new natural pastures
   a) Provide a suitable drinking water supply
   b) Apply to sanitary measures of tsetse-infested pastures
11) Plough up unprofitable natural pastures and replace them by cultivated pastures

B. Provide new pastures with grasses and other plants which have stood the test over years, i.e. are resistant to droughts and temporary flooding, yield a great amount of biomass and nutrients and are resistant to being bitten off low above the ground.

C. Fodder as the main crop or as an intercrop with tested plants which give a great amount of biomass in the shortest possible time, are rich in nutrients and suit the local conditions or try to cultivate plants which are promising but have not yet been tested for their suitability for warm countries.

D. Provide fodder reserves for times when fodder is scarce.

1) Dry
   a) Hay harvesting
   b) Production of standing hay in the case of grasses which are rich in nutrients and which are seed-bearing

c) Artificial drying of all kinds of green fodder

2) Silage

E. Utilise harvest residues and use them to suit the animal species and the planned output

F. Utilize and use by- and waste products which are obtained in the preparation of raw plant substances

G. Substitute expensive protein fodder imports of animal origin by domestic protein fodder

1) Protein fodder of vegetable origin (soy bean, peanut etc.)

2) Protein fodder of animal origin such as meat-and-bone meal, and fish meals (in particular in connection with deep-sea fishing and fish canning)

H. Test plants which have not been used or only now and then and fruits for their suitability as animal feed

I. Utilize crop remains, which are not yet used as fodder due to the absence of livestock breeding by developing suitable types of animal farming

J. Erect feed mills

1) Mixed fodder and concentrate plants

2) Carcass disposal plants

3) Fish meal plants

K. Make arrangements to secure a sufficient and permanent water supply

1) Sink a sufficient number of wells at appropriate distances which can be conveniently reached by the animals

2) Arrange for tsetse-free watering plants along watercourses

L. Improve the utilization of the available fodder by changing over the other domestic animal breeds and species.

M. Gradually replace working animals (oxen, buffalos, donkeys, horses, mules) by mechanizing agricultural and handling work, to make the existing fodder available to other productive livestock.

Which measures must be taken depends on the local conditions, the type of pasture, the type of pasture utilization and the particularities of the applicable type of livestock breeding in the different regions. For this reason, specific propositions must be elaborated for improving the fodder basis in characteristic regions and individual countries, respectively. Figure IV.1.8. shows an example for the improved utilization of the grassland and the savanna of the Sahel zone.

IV.1.4.2. Examples of improvements

Among the measures aiming at an improvement of the fodder basis, pasture improvement, optimum animal stocks and supplementary feeding during the dry season are of primary importance. They result in a noticeable increase in the animal output on pastures with relative low expenditure.

Improvement of pastures

Table 42 lists selected grasses and legumes which are suitable for the improvement of pastures in warm regions. The controlled use of fire can certainly influence the proportion of shrubs and grasses in savannas (Figure IV.1.9). Shrubs which have developed excessively (at an advanced stage of growth, they have only a low feeding value) are destroyed above ground by fire and in the beginning of the rainy season, they develop young shoots which are rich in nutrients. The grasses which have been suppressed by the larger shrubs can develop better after the fire.

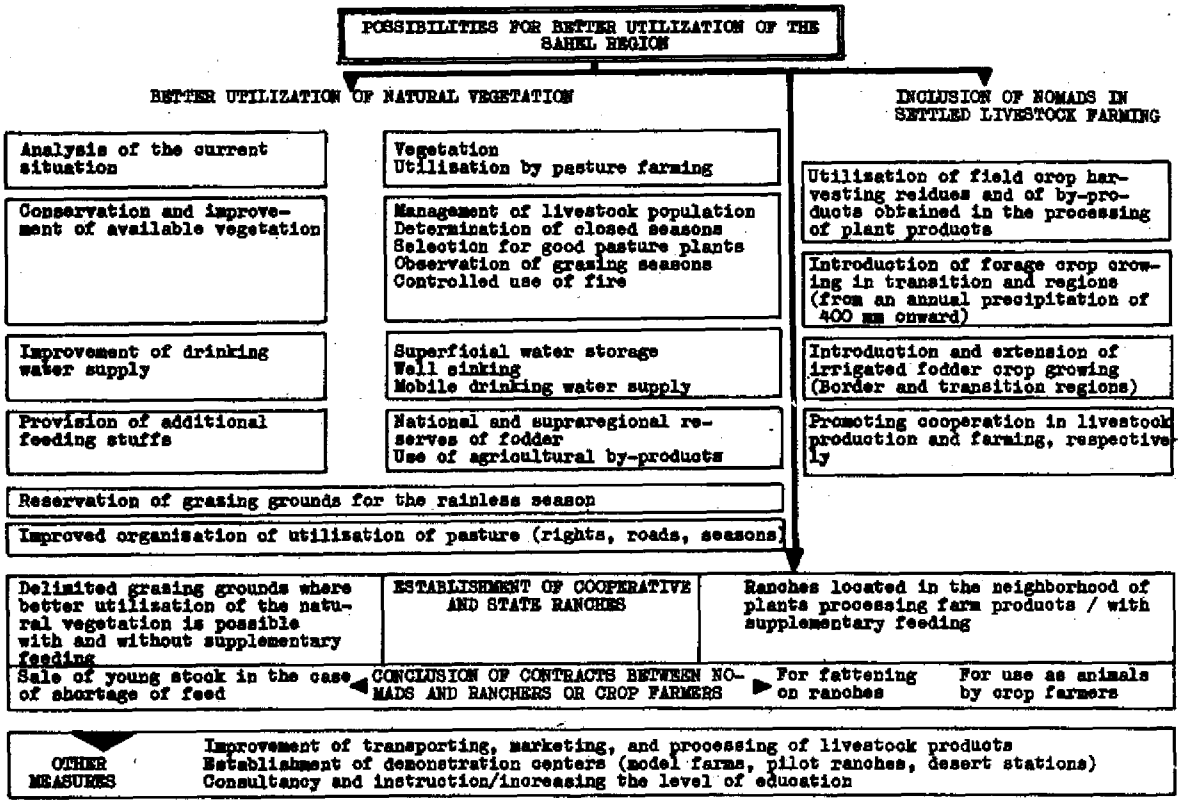

Fig. IV.1.9. Possibilities for better utilization of natural vegetation of the Sahel region (LEGEL, 1978)

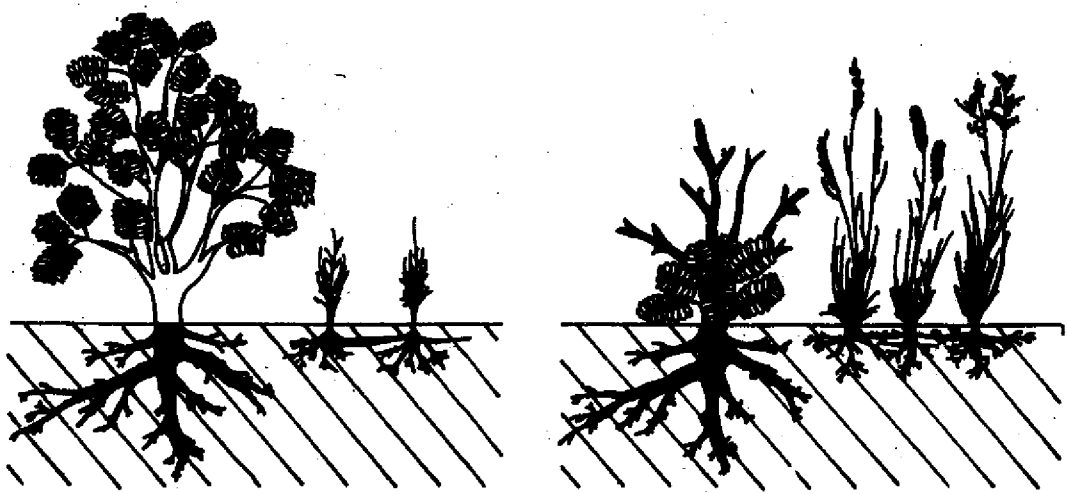

Fig. IV-1.10. Influence of controlled use of fire on the proportion of shrubs and grasses in savannas (HALTENORTH, 1973)

Optimum animal stocks

In general, the output obtained from a pasture depends on the number of animals per unit area (Table IV.1.15).

Table IV.1.15. The effect of stocking rate on the potential bodyweight of cattles (200-250 kg) kept on 100 ha of rangeland over a period of 100 days (calculated according to UN-Report Science and Technology for Development, 1963)

No. of grazing cattle on 100 ha range	Type of grazing	Percentage of TDN used for gains	Liveweight gain on the range	
			Total (kg)	per animal and day /(g)
17.5	Light under-grazing	31.8	630	370
25.0	Optimum grazing	45.5	900	360
32.5	Light over-grazing	29.6	600	190
42.5	Medium over-grazing	7.4	150	35
50.0	Heavy over-grazing	0.0	-180	- 35

In the case understocking fodder is available in excess, and the daily live weight gain per animal is higher compared to optimum and excessive stocking. Slight overstocking may be justifiable since the increase in live weight per unit area is only somewhat below that which is obtained on slightly understocked pastures. The maximum increase in the total weight is achieved with an optimum stock of animals. Here the proportion of the nutrients utilized for the live weight gain is the highest one with some 45 %. Live weight gains are hardly achieved in the case of medium overstocking. Similar conclusions can be drawn from Figure IV.1.11. On a poor natural pasture, a stock

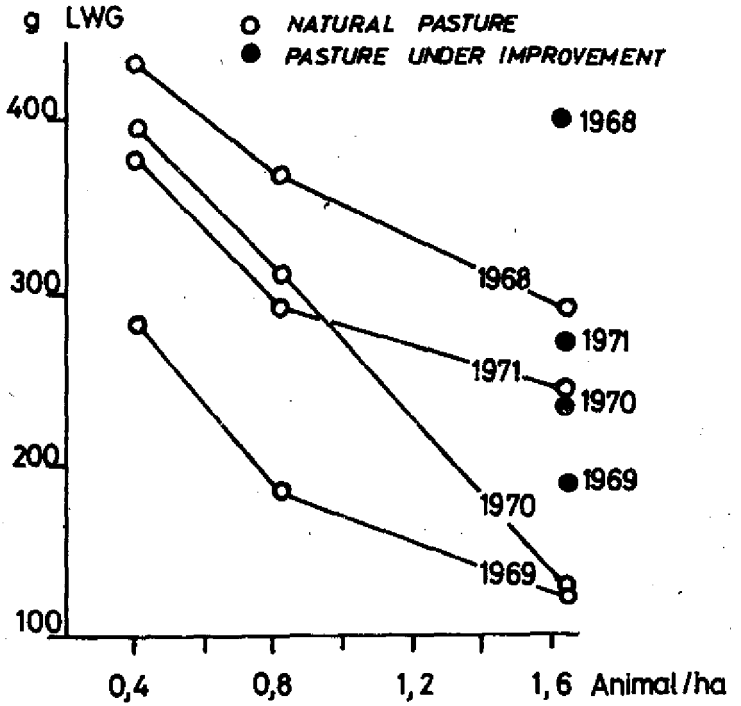

Fig.IX.1.11. Live weight gain of bullocks at stocking rates expressed in terms of animal/ha in Uganda. Lines are drawn connecting the gain from natural pasture in each year. The gain of improved pasture at 1.6 animals/ha are also marked (HARRINGTON and PRATCHETT, 1974)

of 0.8 cattle per hectare was already too high during the four years of investigation. After the improvement of the pasture, double the number of cattle could be raised per hectare, and the same increase in live weight was achieved.

Table IV.1.10 shows reference values for pasture areas required for cattle on natural pastures in Africa in dependence on precipitation and altitude.

Table IV.1.16 Necessary grazing land of different regions of Africa in dependence on rainfall and altitude (completed according to RATTRAY, 1960)

Rainfall (mm)	Necessary grazing land per 1 cattle	
	Lowland below 1000 m (ha)	Highland over 1000 m (ha)
100 - 250	26 - 56	17.5 - 28.0
250 - 500	10 - 21	5.2 - 18.2
500 - 750	5 - 8	4.3 - 13.0
750 -1000	---	0.9 - 5.2
1000 -1500	3 - 6	0.4 - 4.0
Europe for comparison)	0.25 - 1	

Supplementary feeding

During the dry season, supplementary feeding is important for two reasons: (1) It prevents a reduction in live weight which later on can be compensated only by increased nutrient and energy inputs. (2) If used systematically to provide the required minimum of nutrients, it improves the utilization of the fodder energy by the animals.

Table IV.1.17 gives an example for the utilisation of pastures by sheep. In a similar test with fattening cattle to which dry pasture grass was available ad libitum, the daily live weight gain could be raised from 750 g to 1000 g per animal by adding about 1.5 kg of concentrate. The protein deficiency plays a special part almost invariably. In these cases the energy of the easily soluble carbohydrates and the crude fibres of the pasture fodder can be utilized insufficiently only. Table IV.1.18 shows a calculation model with respect to a protein supplementation by urea of tropical grasses fed to milk cows. With 200 g urea/cow, 15 kg of milk can be produced per animal daily when feeding only young tropical grasses.
The live weight development of cattle when two of the above measures are applied can be seen from Figure IV.1.12 With an improved natural pasture and supplementary feeding, the same live weight can be achieved in one third of the time that is required without improvement and supplementary feeding.

IV.1.4.3 Model for the development of pasture utilization

An example of the gradual improvement of the utilisation of natural pastures under semi-arid conditions is given in Figure IV.1.12
The aim is to bridge dry periods when fodder is scarce as they are typical of most of the natural pasture areas.
The first steps (Picture 1 - 6) include the passive adaptation to the dry season by external and internal fodder reserves on natural pastures.
The second step includes the active overcoming of the dry season by fodder preservation, additional purchases and fodder growing (Picture 7 - 9).
Pictures 1 - 9 are explained in the following.

Table IV.1.17 Effect of various supplements on the utilization of low-quality roughage by merino weaners in Australia (FAO, 1955)

Supplement	Linseed meal 88 g/day		Lucerne chaff 173 g/day		Concentrate mixture 114 g/day		Wheat + urea + Na_2SO_4 88+ 6.25+ 0.15 g/day		Control (no supplement)	
Number of sheep per group	40	38	40	40	39	40	40	40	24	24
Percentage protein content of roughage	3.5	2.4	3.5	2.4	3.5	2.4	3.5	2.4	3.5	2.4
Average quantity of roughage consumed per day (g)	549	481	445	350	499	390	454	386	427	350
Average bodyweight change over 167 days(g)	2497	1226	999	- 227	681	- 613	- 295	- 1771	- 3723	- 3178
Average wool production(g)	1703	1448	1416	1362	1476	1303	1448	1162	1108	949

Table IV.1.18 Supply of protein demand of milk cows feeding tropical grasses and urea (non-protein-nitrogen) as supplement.
(Basis of calculation: 200 g urea = 50 % of the protein requirement, 15 kg milk (4 % fat)/cow/day, 450 kg bodyweight, protein-concentration = 84 g DCP/kg dry matter, energy concentration = 755 TDN/kg dry matter)

Tropical grasses	PC[1] of grass ration is sufficient for... kg milk production	Necessary supplementation		Urea in percent of the protein requirement
		Concentrate (kg)	Urea (NPC) (g)	
Elefant grass				
old	6	1.0	210	50
young	10	-	150	33
Para grass				
old	9	-	180	40
young	9	-	180	40
Jaragua grass				
old	1	3.5	210	50
young	9	-	180	40
Molasse grass				
old	22	3.0	210	50
young	11	-	120	25
Guinea grass				
old	66	1.0	210	50
young	13	-	60	15

[1] PC = Protein-concentration

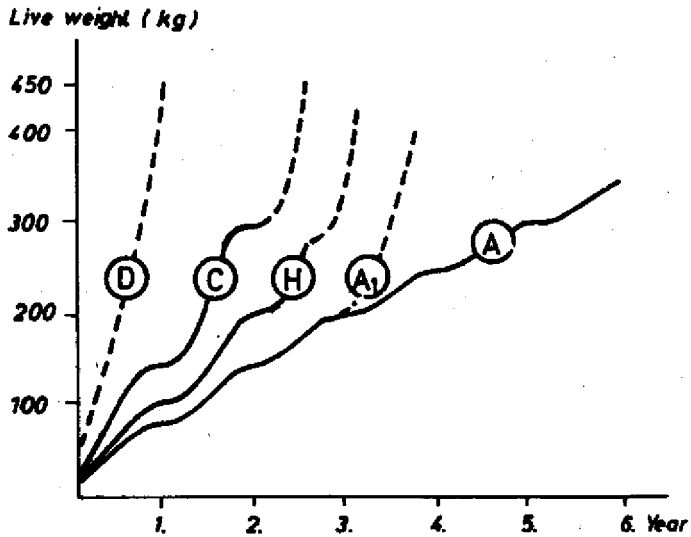

Fig.IV.112 Live weight development of cattle at natural Pasture(A), natural pasture with suppl.feeding(A_1), improved natural pasture with suppl.feeding(B,C) and under intensive fattening conditions (D) / (AURIOL, 1974)

Picture 1: Nomadic pasture farming

The stock breeders have not settled yet. Such conditions are found in extremely dry regions where the road system is poor. This applies to the economic systems of the Syrian steppe Bedouins, of the Kurdes, of the Berber tribes or of the tribes in the mountainous regions of Central Asia.

The Massai, the Fulbe or the Somali in East Africa, can be designated as semi-nomades. These peoples migrate over long distances in search of fodder. This economic system preferably developes where the vegetation cycle differs within the course of a year from one region to the other due to mountain chains, mountains and valleys or the seasonal rainy or dry periods. Whereas the mountain nomades (e.g. in Ethiopia) migrate between lowlands

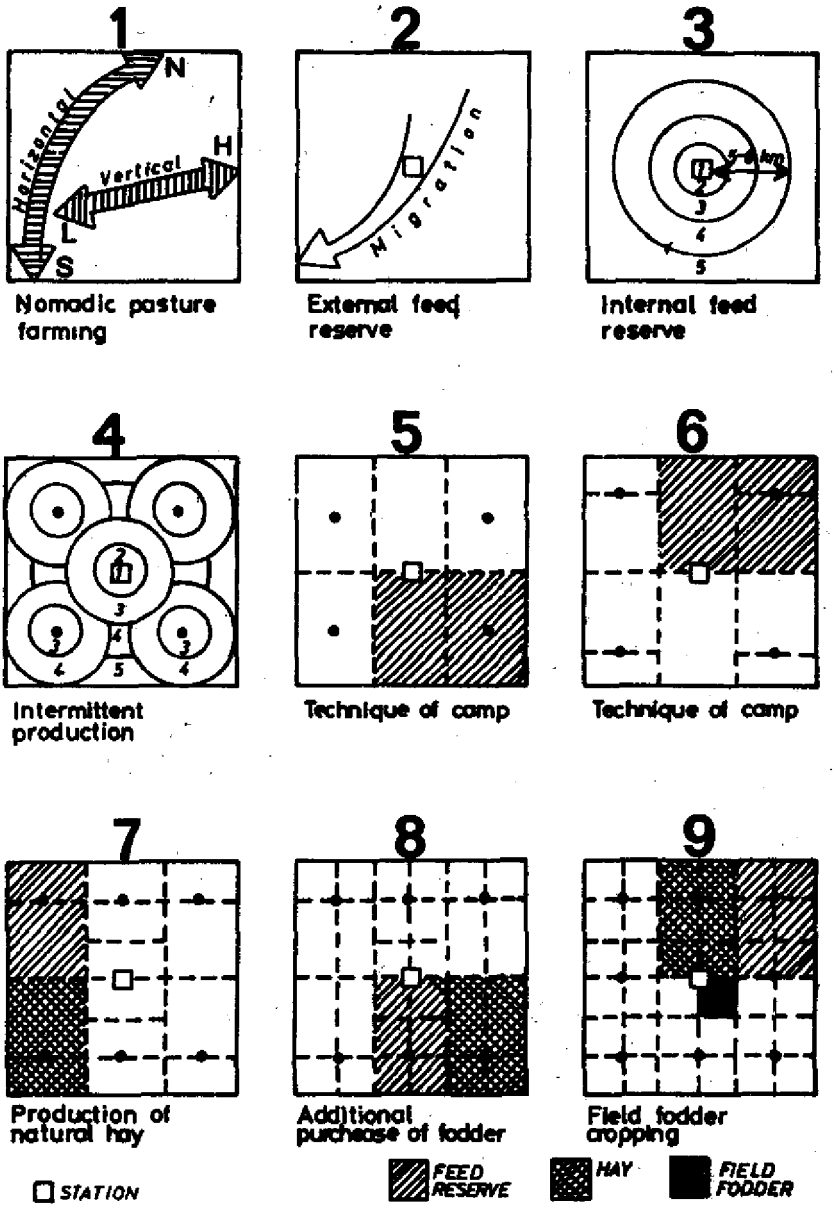

Fig. IV.1.3 Model of gradual improvement of utilisation of natural pastures (ANDREA, 1966)
-Pictures 1-9 are explained in the text -

and high-laying areas the flat land nomades (e.g. in the Sahel zone) cover large distances.

Picture 2: External feed reserve

When the nomades become sedentary they are given land for farming. They continue, however, to use large areas (which are state-owned) nomadically as pastures. During the dry season, these areas are available as reserve pastures (standing hay).

Picture 3: Internal feed reserve

As more and more nomades settle down and livestock farming is intensified ever more natural pastures are shared out to them and the right to use is granted for ever larger areas. In dependence on the socio-economic structure, there are different types of utilization (semi-nomadic utilization by individual tribes or families up to pasture farming in state farms and ranches).
The areas have been parcelled out but the pastures have not yet been subdivided by fences within the farms or ranches. It is assumed that there is only one watering point available near a farm or ranch. Different vegetation zones develop around this centre. Near the watering point, there is only bare ground because the tread of the animals and their excrements destroy all vegetation. In the 2nd zone, too, vegetation is scattered and consists mainly of inferior weeds. Even the 3rd zone, though at a greater distance from the watering point, is pastured excessively and there are still many weeds, although the vegetation is denser here and contains some valuable grasses. Only the 4th zone has an almost normal vegetation, a better pasture sward with only few weeds and many valuable grasses. However, at a distance of five to eight kilometres from the station, this zone generally forms

the external ring of those areas which can be reached by the animals from the watering point. The 5th zone is not used in the rainy season when there is enough fodder available because the distance from the watering point to be covered is too great. For this reason, the vegetation found here is hardly influenced by the productive livestock. This 5th zone is a fodder reserve for the dry season when there is not enough fodder available at least to the external tropics where the dry season is in the winter when the animals do not need to go to the watering point so often and the calves and lambs are strong enough to migrate with the herd and a wider radius can be grazed. Extensive pasture farming depends on such internal fodder reserves the more, the more unequal the precipitation is distributed over the years and the longer the dry seasons.

Picture 4: Intermittent production

Better utilization of pastures is achieved by sinking additional wells. There are three aspects which enhance the animal output:

1. The way to the watering point becomes shorter. The animals consume less nutrients here which can be transformed into meat and wool outputs etc.
2. Now the complete vegetationless zone 1 disappears. Around the less frequented secondary watering points even the almost worthless zone 2 disappears.
3. The vegetation zones 5 (Picture 3) which could hardly be used before disappear because now all areas can be grazed also during the rainy season.

The vegetation of the farm or ranch becomes more uniform and more productive during the rainy season so that the livestock can be increased. However, the fodder situation has become worse during the dry season because, apart from the regional and external fodder reserves, the internal fodder reserves are also exhausted. This increases

the risks in the extensive pasture farming considerably. The increase in yield is thus obtained partly at the expense of a safe output. At this stage of development, the livestock suffers from hunger mainly during the dry season. Not only is no meat produced during the dry season, but weight losses are put up with which must be compensated for during the rainy season.
As a result of such an intermittent production the animals are ready for slaughter only after four or five years.

Picture 5 and 6: Technique of camp

This permits controlled pasture farming and thus better use is made of the soil and the soil fertility is preserved. Now different pasture qualities can be assigned to the individual animal species, types of utilization and age groups to suit differentiated requirements. Spare or save camps are set up in annual rotation for the dry season and should comprise at least one third of the total number and are not grazed during the rainy season. They are available to the livestock only when not enough fodder is available elsewhere. During the dry season, the animals practically feed on bad hay and good standing straw, respectively.

This bridging over of deficiency periods helps to protect the livestock from weight losses during the dry season. Often there are slight weight gains so that cattle need only about three years to become ready for slaughter. The proportion of productive fodder is increased.

Picture 7: Production of natural hay

Picture 7 differs from Picture 6 quantitatively in that the number of watering points has been increased from 5 to 7 and the number of camps from 10 to 16 in the

course of intensification and qualitatively in that natural hay is obtained to a limited extent.
On half of the areas excluded from pasturing during the rainy season the grass is now cut. In dry climates the hay retains its quality for a long time. It is stored in small kraals to which the livestock has access only during the dry season. The hay in the clamp is richer in nutrients and more concentrated than the "standing hay" because the cutting can be carried out at a time when the nutrients have not yet migrated from the stalks and leaves to the roots or seeds.

In the process of improving the forage farming, the production of natural hay is the first step to overcome the periods when fodder is scarce.

Picture 8: Additional purchase of fodder

In Picture 8, the number of camps has been rised to 28, and the camp method has been further developed. Apart from spare camps and natural hay production the additional purchase of fodder helps to overcome periods when fodder is scarce. At this stage of development, purchase of additional fodder for the dry season have become economical as a second measure for overcoming periods when little fodder is available. Since due to the insufficient degree of concentration of the growing fodder the extensive pasture farming alone cannot bring about high-quality animals for slaughter, final fattening is connected with higher concentrations during the dry season to achieve higher quality-grades.

Picture 9: Arable fodder cropping

Finally, the number of camps has been increased again to 36 in Picture 10. The basic difference between Picture 9 and Picture 8 is that now a third step is taken to over-

come the periods of poor fodder supplies; arable fodder cropping using irrigation near the base. The water for this comes from the main well which is no longer used for watering alone. This arable fodder cropping requires an extreme expenditure of labour. Picture 9 shows the final stage of extensive pasture farming which forms the transition to the forms of intensive pasture farming.

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