PRODUCTION SYSTEMS

Ecological zones

Livestock production systems are influenced by the annual rainfall and its effect on the main vegetational characteristics.
The arid zone, associated with pastoral production, includes all areas receiving less than 600 mm of rainfall per year. The zone has two major sub-zones. The first has less than 200 mm of rain per year and no agriculture at all is possible outside a few oases or other irrigable areas. Where rainfall is less than 100 mm per year, the natural vegetation is of the Saharan type. The second sub-zone has rainfall of 200-600 mm per year and is often called the Sahel zone in northern and western Africa. Some agriculture is possible but crop failures are frequent and yields are generally low as the coefficient of variation of rainfall is in the range 25-35 per cent.
In the semi-arid zone, rainfall is between 600 and 1000 mm per year. Livestock raising is usually intimately associated with crop production. Vegetation is of the south-Sahelian or north-Sudanian type in northern and western Africa. In eastern and southern Africa the lightly forested 'miombo' areas are part of this ecological zone. Rainfed millets *{Pennisetum, Eleusine, Digitaria,* etc.) are the principal cereal crops but these are replaced by sorghum and maize where rainfall is better and where year to year variation is less. Some cash crops such as cotton and groundnuts may be grown in the more favoured areas. The coefficient of rainfall variation is generally in the region of 20-25 per cent.
The sub-humid zone is a high potential area with rainfall of more than 1000 mm per year. The main vegetation is of the Sudanian and south-Sudanian types, large trees often being broad-leaved and deciduous. Sorghum and maize are the principal cereal crops, a number of cash crops are grown and some tuberous root crops appear as food staples towards the boundary of the humid zone.
The humid zone is characterized by an annual rainfall in excess of 1500 mm. Although a "dry" season may sometimes be recognised, rainfall usually exceeds evapotranspiration throughout the year except for a very short period. This zone is essentially found in coastal West Africa and some parts of central and central-west Africa. Livestock production in the humid zone is currently not very important as an economic activity but the potential is considered to be high providing that the problems of tsetse flies and trypanosomiasis can be overcome.
Highland areas are those with an altitude above sea-level of more than 1500 m. Rainfall is not taken into account in defining this zone. The major crops are cereals (tef *Eragrostis tef,* barley and wheat in Ethiopia, maize and sorghum elsewhere), pulses, and bananas or plantains. Livestock production is generally an important secondary activity on the small farms that are typical of this zone. In some areas extensive or intensive commercial, purely livestock operations have developed.
Large areas of seasonally flooded land or areas capable of being permanently irrigated can be considered as a quite separate ecological zone. On account of the possibilities of out-of-season conservation of fodder and the quantities of crop and agro-industrial by-products potentially available, these are important livestock producing areas.

Livestock production systems

In Africa, it is possible to distinguish two major types of production systems. These are the traditional systems and the modern ones. Some major characteristics of each group of systems are provided in Table 1. The two groups differ essentially in their use of the main factors of production, with traditional systems using mainly land and labour while modern systems also have large capital requirements and generally a lesser requirement for one or other of the remaining factors.

Two principal criteria serve to define traditional systems. The first is the degree of dependence of the household or the production unit on livestock or livestock products either for household income or for food supply. The second is the type of agriculture practised in association with livestock production. The distance and duration of movement (transhumance, migration) might also be used to define systems and it is recognised that this is an important aspect of management within a system. It is considered to be a secondary one, however, subordinate to the two major ones just discussed.

Rather arbitrary limits have been set to define the systems. A system in which more than 50 per cent of gross household revenue or more than 20 per cent of total household food energy derives directly from livestock is considered to be a pastoral one (Wilson, de Leeuw & de Haan, 1983). The term "derived from livestock" in relation to revenue would also include the value of any transport (donkeys carrying firewood, camels carrying salt, etc.) plus sales or exchange of manure plus income from any other minor functions.

An agro-pastoral system is one in which between 10 and 50 per cent of household revenue derives from livestock or livestock products. A third, agricultural, system be one in which revenue from livestock amounts to less than 10 per cent of the total. In the modern African context, one must not omit the urban or peri-urban systems. These last are assuming increasing importance in many countries and one may cite the cases of Nouakchott and Djibouti for camel dairies, Khartoum and Mogadishu for goat production, and Ethiopia and many west African regional centres where donkeys provide transport of domestic fuel and building materials.

Table 1 A classification of small ruminant production types and systems in tropical Africa

Type	System	Macro-management	Main production factors	Nutrient source
Traditional	Pastoral	Nomadic/Semi-sedentary	Land	Range
	Agro-pastoral	Transhumant/Sedentary	Land/Labour	Range/Crop by-products
	Agricultural	Sedentary	Labour/Land	Crop by-products/Household waste/Forage
	Urban	Sedentary	Labour	Household waste/Feed
Modern	Ranching	Sedentary	Land/Capital	Range/Forage
	Feedlot	Sedentary	Capital/Labour	Feed/Forage
	Dairy farm	Sedentary	Capital/Labour/Land	Feed/Forage
	Station	Sedentary	Land/Labour/Capital	Range/Forage/Feed

Within the pastoral system, three major sub-systems can be identified. The first is a pure system in which little or no agriculture is practised. Examples are the camel cultures of the northern Sahel and (at least until the 1960s) the Masai system in eastern Africa. In the pure system, mobility is often high, and long distances might be covered in search of grazing and water. The second pastoral sub-system is found in the semi-arid regions and is one in which livestock production is associated with dryland or rainfed agriculture. Examples of this system are many of the Fulani groups of West Africa, most Baqqara in Sudan, and the Wagogo in Tanzania. In the livestock-rainfed agriculture system, cattle, sheep and goats are often of equal importance and donkeys provide many of the needs of transport. Draught animal power (oxen, donkeys and occasionally horses) and the use of, or exchange of, manure are important elements of this major sub-system. The third pastoral sub-system is associated with oases or with large irrigated areas. Some Touareg groups, the Macina Fulani of the Niger inundation zone in Mali, a number of Nilotic tribes in southern Sudan and areas in Zambia and Mozambique provide examples of this sub-system.

In the agro-pastoral system, livestock are usually sedentary or, if movement is part of the management practice, it is generally restricted to short distances. The three major sub-systems here are those associated with rainfed subsistence agriculture, rainfed cash cropping, and large-scale permanent irrigation of cash crops.

Some examples from West Africa of these different production systems are provided in Table 2 (Wilson, de Leeuw & de Haan, 1983) and a more detailed analysis of Systems in the sub-humid zone of Côte d'Ivoire is shown in Table 3 (adapted from von Bassewitz, 1983).

Table 2 Characteristics of small ruminant production Systems in West Africa

Characteristic	Pastoral System			Agro-pastoral Systems		
	Pure	Associated with rainfed agriculture	Associated with irrigation	Associated with subsistence rainfed agriculture	Associated with irrigation	Associated with cash crop rainfed agriculture
Contribution of livestock to revenue (%)	95	90	60	25	15	10
Rainfall (mm/year)	<400	300-600	Variable	400-800	Variable	700-1400
Relations with agriculture	weak	some cultivation, exhange of manure	own fields cultivated	own fields cultivated, animal traction important, crop residues important		
Number of TLU/100 hal)	0.0 - 3.9	4.0 - 17.9	10.0 - 27.9	4.0 - 9.9	10.0 - 17.9	4.0 - 17.9
Carrying capacity						
people	very low	low/medium	high/very high	medium	high	medium
animals	low	low/medium	medium/high	low/medium	medium/high	medium/high
Ratio TLU:person	0.0 - 1.6	0.4 - 1.6	1.2 - 1.6	0.4.- 1.2	0.4 - 1.2	0.4 - 0.8
Mobility	high, no fixed base	medium/fixed base	high in wet season	Low and for short distances at main cultivation season		
Importance						
Mali	high	medium	medium/high	high	high	high
Mauritania	high	low	1ow/medium	medium	low	low
Niger	high	high	low/medium	medium	low	medium
Senegal	low	low	low/medium	high	low/medium	high
Burkina Faso	low	medium	low	high	low	medium/high

Note: 1) TLU is a Tropical Livestock Unit of 250 kg live weight equivalent.
Without being able to provide precise figures, it is probable that in the arid zone 70 per cent of small ruminants are found in pure pastoral Systems and 30 per cent in agro-pastoral Systems. In the semi-arid zones the figures are reversed with 70 per cent of small ruminants in the agro-pastoral Systems. In the more humid areas, virtually ail small ruminants are in the agro-pastoral System with a small percentage being found in the agricultural and urban Systems.
The relative importance of the main domestic species varies across Systems. Camels are important only in the driest pastoral areas. Cattle are probably the main species in ail Systems when these are considered as a whole. In agro-pastoral Systems, goats are generaily more numerous than sheep although only recently is this fact being recognised by the official statistical services.

Table 3 Small ruminant production systems in Cote d'Ivoire

Criteria	System					
	Urban	Village				Pastoral
		Paid shepherd	Family shepherd	Not herded	Opportunistic	
Day management	Free ranging	Herded	Herded (except dry season)	Free ranging	Free ranging	Herded (except dry season)
Night management	Housed	Housed/penned			Free ranging	Penned
Supplementary feed	Regular (household waste, cut browse, bought by-products)	Regular by means of crop by-products			Occasional by-products	Rare
Mineral feed	Household salt	Household salt, mineral licks			Rare	Salt and licks
Selection and culling	Regular	Often practised			Not practised	Regular
Traditional health care	Regular	Occasionally practised			Not practised	Regular

Flocks are constituted by a great variety of processes. Major methods of acquiring animals include inheritance, gifts, dowry, exchange, leasing and natural increase. In the pure pastoral system, additional animals are bought with money obtained from caravan operations and from salaried employment. In agriculture-associated systems, the money from sales of crops surplus to subsistence is often invested in livestock. Where women may own livestock, they often obtain them by dowry or by income from sales of milk.

As an investment vehicle, small ruminants are often considered as the small change or credit account of a savings plan while cattle constitute the capital account. Many new entrants to the business of livestock production start with small ruminants. In addition, because of their greater resistance to drought conditions and their faster breeding cycle, small ruminants are the first type of animal to become available and be bought by people with a livestock tradition who, for some reason, have lost their stock.

MANAGEMENT

General practices

Until recently, it was widely considered that no management was practised in traditional herds and flocks. This attitude still prevails in some quarters but even a little thought will show its absurdity. Pastoralists are generally better managers than agro-pastoralists or crop farmers who depend only in small part on animals for their livelihood. Nomadism and transhumance are sophisticated responses to a resource which is always in short supply and often totally deficient. Smallholder fattening is equally a reaction to a long or short term excess of resources and often to a spatially and temporarily restricted demand for meat. These two examples are at the outer limits of a whole range of management practices found across the spectrum of ecological zones from extreme arid to very humid.

Table 4 provides some indications of the strategies ("macro-management") and tactics ("micro-management") of management of traditional owners in Africa. With few exceptions, the tendencies follow a logical pattern from dry to wet zones. These tendencies are: nomadism to fattening; free range grazing to totally confined animals; larger flocks in less favourable to smaller flocks in more favourable areas; and sheep in pastoral to goats in agro-pastoral systems. One of the exceptions is the example of highland central Africa (Table 5; Bizimungu, 1986) where goats are more important in the drier and less intensively cultivated areas. Large-scale modern management systems are generally found in the highland areas of Kenya and Zimbabwe but intensive modern feed lots are increasing in numbers in all areas.

Table 4 Ecology and management of goats and sheep in semi-arid Africa

Climatic regime (rainfall) mm		Country/ Ethnic group	"Macro" management	"Micro" management				Size of flock/ herding group	
				Sheep		Goats		Sheep	Goats
				Day	Night	Day	Night		
Arid	(200)	Mauritania/Moor	Nomadic	↑↑	Open camp	↑↑	Open camp	100-500	30- 80
					Penned				
		Ethiopia/Afar			Open camp		Penned		
		Sudan/Kababish					Open camp		
		Mali/Touareg		Loose flock	Open camp	Loose flock	Open camp		
	(300)	Niger/Touareg	Transhuman t	↓↓	↓↓	↓↓	↓↓		
		Chad/Zhagawa			Penned			200-250	40
		Kenya/Turkana					Penned		
Semi-arid	(400)	Ethiopia/Afar			Penned		Penned	50-150	30-100
		Sudan/Baqqara	Semi-sedentary	Tight flock	Penned		Penned/tied	20-60	20- 80
	(500)	Mali/Fulani		Loose flock	Open camp		Penned/tied	200-500	
		Kenya/Masai		Tight flock	Penned	Tight flock	Penned	20-80	40-120
	(600)	Sudan/Daju etc.	Sedentary	Tight flock	Penned	Dry season not herded	Tied	5- 10	5- 40
		Mali/Bambara		Tight flock	Penned/tied	Crop season tight flock	Tied	0- 10	2- 20
		West Africa/"Mouton de Case"	Stall-feeding	Tied	Tied			1- 5	
		Kenya/"Thenges"				Tied	Tied		1- 5

Highlands		Kenya/Large scale farms	Extensive paddocks	Padcfock			500-1000	

Ownership patterns

Patterns of ownership in traditional systems differ widely and are often difficult to understand, especially for someone not a member of the owning group. The ramifications of the numerous African extended family systems, the practices involving "stock friends", loans and flock splitting, and sub-letting the flock to a professional herder usually of a different tribe, all lead to a rather vague idea of who owns which animal. Under these conditions, "ownership" changes many times during the life of an animal. Nonetheless, it is generally true that individual or family ownership is greatest in the dry areas. In West Africa and in Sudan, this essentially means that flock sizes and numbers owned decrease from north to south. In Ethiopia and Kenya, flock sizes decrease with altitude. These trends reflect the systems' differences which change from pastoral in the dry areas to agro-pastoral or agricultural in the better endowed zones.

Table 5 Biophysical characteristics and livestock ownership patterns in highland central Africa

Region and Country	Altitude (m)	Rainfall (mm)	Temperature (°c)	Number of			
				Families	Cattle	Sheep	Goats
Bugorhe, Zaire	2000	1500	<20	483	222	814	940
Giheta, Burundi	1700	1200	20	552	146	821	1232
Gashora, Rwanda	1300	1000	21	445	97	177	1682

Perhaps of more importance, even though the change has been less well recorded, are the increasing numbers of goats and the increasing numbers of people who keep goats as management systems become sedentary. Goats are generally more prolific than sheep and are possibly easier to manage for people with little experience of animals because they are capable of foraging more widely and on more vegetation types. Table 7 (Mosi et al, 1982) are shown ownership patterns in the humid zone of south-west Nigeria while Table 8 provides additional data for Chad and Kenya.

Table 6 Ownership patterns of sheep and goats in the agro-pastoral area in central Mali

Parameter	Irrigated rice sub-system		Rainfed millet sub-system	
	Goats	Sheep	Goats	Sheep
Number of owners studied	27		16	
Number owning sheep or goats	26	15	16	9
Number owning	12		7	

goats but not sheep				
Number owning sheep but not goats	1		0	
Mean flock size[1)]	9.0	6.4	38.2	7.1
+ s.d.	6.03	13.51	27.75	14.81
Mean flock size[2)]	9.3	11.5	38.2	12.6
+ s.d.	5.87	17.0	27.75	18.27
Range in flock size	0-23	0-64	2-91	0-58

Notes: 1) of all owners i.e. irrespective of whether the holding of one species of stock is nil

2) of only those flocks in which animals are held, i.e. nil holdings excluded

During the last few years (although again official statistics do not yet show this), it is probable that the goat population has increased absolutely and relatively more quickly than the sheep one. This is probably due to the generally higher reproductive rate of goats and their less demanding dietary requirements.

Table 7 Patterns of small ruminant ownership in the humid zone of south-west Nigeria

Item	Forest	Derived Savanna
Percentage of farmers owning small ruminants	73.0	20.0
Mean flock sizes		
Goats only	2.8	3.7
Sheep only	2.0	0.0
Mixed flocks	5.1	5.3

When calculated on the same basis of unit weight or unit metabolic weight, goats are usually less productive than sheep in terms of meat but their better milk yield makes them a more attractive proposition to livestock owners who keep only a few animals. In traditional systems, it is probable that goats will continue to expand in relation to sheep for the foreseeable future. In modern systems there is still some resistance to goats, especially in Kenya, but even here the attitude is changing and meat goats and Angoras for mohair production are beginning to make their appearance.

Table 8 Livestock ownership (numbers per household) in agro-pastoral and pastoral societies in Kenya and Chad

Species	Kenya		Chad		
	Masai pastoral	Karapokot agro-pastoral	Zioud pastoral	Salamat agro-pastoral	Gondeye-Tchein agro-pastoral
Cattle	157.3	11.8	36.4	133.3	2.1
Sheep	44.0	5.4	43.5	2.0	1.3
Goats	83.1	13.6	45.0	46.3	4.7

Flock structures

In earlier times, "prestige" and "perverse supply" were terms often used, usually in a derogatory manner, to describe the behaviour of traditional owners in relation to their animals. African livestock owners are undoubtedly conservative but it is doubtful if they are more so than their counterparts in Europe, the Americas and Australia. Their reasons for keeping stock are rarely irrational and are related to their particular needs either in the long or in the short term. This hypothesis can be supported in regard to the age and sex structure of flocks. Whatever the major objective of the keeping of sheep and goats, there is always a preponderance of females in the flocks while minor differences in sex and age structure are maintained. It needs to be emphasized that almost all animals in the flocks are "productive" whether that production consists of giving birth to young, providing wool or hair, producing milk, or simply undergoing the process of growth to a size at which another product becomes the principal one.

Table 9 provides some examples of flock structure related to production objectives. With the exception of the Afar of Ethiopia (the Afar in Djibouti have a similar strategy) and the case of pelt production in Botswana, all flocks have 70 to 75 per cent of the total as females and about 55 per cent of the flock is comprised of females of breeding age. In five ethnic groups in Mali covering the whole range of systems, females ($x \pm s.d.$) accounted for 74.7 + 3.07 per cent of the flock and breeding females 54.3 ± 2.43 per cent. Contrary to another article of conventional wisdom, there are very few old females in the flocks: in large pastoral flocks, this class of animal is rarely in excess of 5 per cent and in small agro-pastoral flocks it is never more than 10 per cent.

Table 9 Flock structures in relation to management objectives (as per cent of animals)

Region/ Ethnic group	Sheep					Goats				
	Use	Males		Females		Use	Males		Females	
		Total	Castrated	Total	Breeding		Total	Castrated	Total	Breeding
Mauritania/Moor	Meat/Hair	22.9	6.2	78.1	58.6	Milk/Meat	20.2	1.2	79.8	55.1
Mali/Fulani	Meat/Wool	25.5	11.3	74.5	55.9	-	-	-	-	-
Chad/"Arab"	Meat/Milk	26.7	"few"	73.3	53.7	Milk/Meat	28.3	"few"	71.7	48.1
Sudan/Baqqara	Meat	22.2	0.0	77.8	57.7	Milk/Meat	23.6	0.0	76.4	51.2
Kenya/Masai	Meat/Fat	31.4	15.4	68.6	54.2	Meat/Fat/Milk	33.8	10.3	66.2	48.3
Botswana/Tswana	Pelt	13.2	0.6	86.8	64.5	-	-	-	-	-
Ethiopia/Afar	Milk	7.8	0.0	92.2	61.4	Milk	3.3	0.0	96.7	65.5

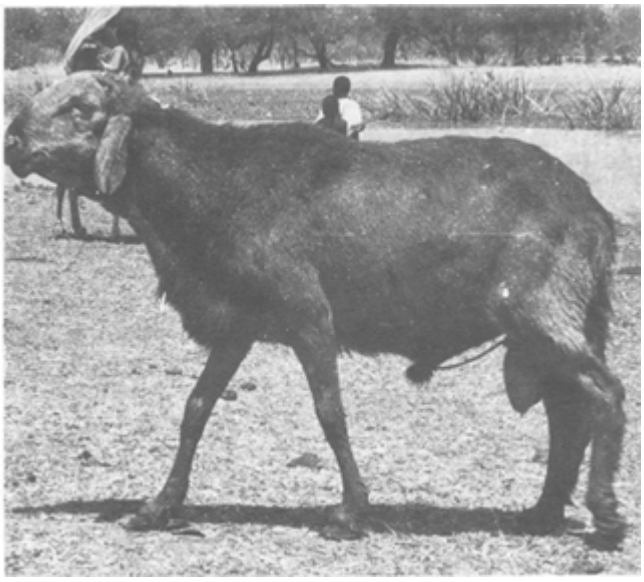

Figure 7 A Sudan Desert ram in Southern Darfur with a 'Kunan' to prevent breeding

Figure 8 Leather apron to restrict breeding on a Masai buck in a Kenya flock

The major management practice used to obtain this stability of structure is the early culling of males not required for other productive functions. Such young males are sold or slaughtered for home consumption. The numbers of males of breeding age and whose function is reported as "reproduction" are usually, and strictly speaking, in excess of those required: numbers are not excessively high, however, in view of the insurance required against sterile and temporarily infertile males. Other mature males fulfil a productive function whether this is the provision of wool for Macina Fulani, hair for Moors, or fat for Masai. In the humid zones, proportions of females may exceed 80 per cent in the derived savanna areas and 85 per cent in true forest areas. insurance required against sterile and temporarily infertile males. Other mature males fulfil a productive function whether this is the provision of wool for Macina Fulani, hair for Moors, or fat for Masai. In the

humid zones, proportions of females may ex- ceed 80 per cent in the derived savanna areas and 85 per cent in true forest areas.
Stratification of flocks is not common in traditional societies. Where breeding control is required it is achieved by a variety of means including the 'kunan' (Figure 7) in northern and western Africa and an apron (Figure 8) in eastern Africa. In some ethnic groups where small ruminants are the principal animal wealth, there exist sophisticated Stratification patterns, one example for the Macina Fulani being provided in Table 10.

Table 10 Stratification of Macina flocks in Mali, with demographic characteristics of each

Name of unit	Group size	Use	Composition			Notes
			General	Males	Females	
Beydi	Generally small	Nurse flock	Newly lambed females, advanced pregnancy, weak and aged animals	26	74	Kept in village. Herded by infants. Regular movements of animals into and out of group
Tarancaradji	Medium	Sale/slaughter	Largely male, generally young, with some older females	60	40	Kept in village, generally not herded
Njarniri	Small	Slaughter	Overwhelmingly male	95	5	Individually tied and zero grazed. Responsibility of women
Bucal	Medium	Milk	Predominantly female	25	75	Individual ownership, commonly grazed on reserved pastures by family labour in rotation. Household milk supply. Most of village goats are in this group.
Bendi						Similar to Bucal. Term used mainly by hair sheep owners
Horey	Large	Wool/meat	Predominantly female	24	76	Main flocks which transhume. Reserve for constitution of other groups as required. Milked by herders for own use.