WEST AFRICAN PASTORAL PRODUCTION SYSTEMS

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FORWARD

This working paper was written as part of a three-year study of West African livestock economics undertaken by the Center for Research on Economic Development, University of Michigan, for the United States Agency for International Development under Contract AID/afr-c-1169. The study consisted of four eighteen-month field studies, two focusing on production and two on marketing, in addition to several investigations based on the existing data and literature. The geographic area of focus essentially involved the five member states of the Conseil de l'Entente, Ivory Coast, Togo, Benin, Niger, and Upper Volta, but also included, in a more general fashion, Mali and Nigeria. The following documents have been produced as a result of this study:

K. Shapiro, ed., Livestock Production and Marketing in the Entente States of West Africa: Summary Report. (This volume contains an overview by Shapiro plus separate summaries of each author's monograph.)

A. Ergas, ed., Livestock Production and Marketing in the Entente States of West Africa: Annotated Bibliography. (Included as part of the summary report.)

MONOGRAPHS:

Delgado, C., Livestock versus Foodgrain Production in Southeastern Upper Volta: A Resource Allocation Analysis.

Staatz, J., The Economics of Cattle and Meat Marketing in Ivory Coast.

Eddy, E., Labor and Land Use on Mixed Farms in the Pastoral Zone of Niger.

Herman, L., The Livestock and Meat Marketing System in Upper Volta: An Evaluation of Economic Efficiency.

WORKING PAPERS:

1. Ferguson, D., A Conceptual Framework for the Evaluation of Livestock Production Development Projects and Programs in Sub-Saharan West Africa.

2. Wardle, C., Promoting Cattle Fattening Amongst Peasants in Niger.

3. Swift, J., West African Pastoral Production Systems.

4. Sleeper, J., An Economic Analysis of the Role of Ox-Plowing and Cattle-Feeding in the Stratification of West African Livestock Production.

5. DeBoer, A. J., The Short Run and Long Run Position of Australian Beef Supplies and the Competitiveness of Australian Beef in International Trade.

6. Porter, R., The Uses of Economic Models in Analysis of the Cattle Sector.

These documents are available from the United States Agency for International Development, Bureau for Africa, Office of Development Resources (AFR/DR), New State Department Building, Washington, D.C. Some may be available from the Center for Research on Economic Development. The monographs and the summary report are also available in French.

Ann Arbor, Michigan
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Kenneth Shapiro
Project Director

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Introduction

This paper describes the main pastoral production systems in dry west Africa. The geographic scope is the area between the Sahara in the north and the Guinean vegetation zone in the south (ie. the area between approximately 100 and 1200 mm annual rainfall), from Senegal in the west to the Chad-Sudan frontier in the east. Some ecological and animal production data from neighbouring western Sudan is also referred to since environmental conditions there are similar. The paper is concerned with pastoral production systems only, here defined as the production systems of those groups of households for which pastoral activities, including where appropriate caravan transport earnings, provide more than half of total (subsistence and marketed) gross income, or where milk and milk products account for more than 20 percent of household food energy consumption. I first describe in broad terms the main west African pastoral economies, then analyse in greater detail the main economic characteristics of west African pastoral production.

1. WEST AFRICAN PASTORAL ECONOMIES

There is no adequate typology of west African pastoralism. Students of these and other pastoral societies have based their classifications on the degree of nomadism or fixity of residence (Ruthenberg 1971: 5,252), or on the geographical pattern of nomadic movement (Johnson 1969) These classifications are of limited use in the present context, since movement is a variable characteristic. Movement is an individual household strategy, and individual households in the course of their existence may become more

or less mobile, or even completely sedentary, according to ecological conditions such as drought, or according to wealth. Movement is also a contingent characteristic. People other than pastoralists are nomadic, for example hunter/gatherers, long distance traders or raiders and some fishermen, and their pattern of movement may resemble that of nomadic pastoralists, with whom they share no other important characteristic.

An attempt to refine this type of classification for the pastoralists of the Malian Gurma has been made by Gallais (1975a), who uses a matrix of degrees of mobility ranging from nomad to sedentary on one axis, and degrees of dependence on agriculture, ranging from pastoralists who live directly from herd products especially milk, to livestock-keeping cultivators on the other. But this is still descriptive, not analytic; it reveals little about how different pastoral economies work, how they differ from one another, and how they may react to future changes.

Here I use four variables - environment occupied, socio-cultural tradition, source of livelihood, and the degree to which production is marketed - to classify west African pastoral production systems.

1.1 ENVIRONMENT

Pastoral production in dry west Africa depends principally on natural vegetation, although where agriculture is possible crop residues form an important fodder supplement.

Natural unmanaged pastures are the largest category of usable land in dry west Africa. Table 1 shows land-use statistics for 8 west African countries: potential arable land is 11 percent of the area, permanent pasture is 25

percent. An unknown but considerable portion of the areas designated as "forest" and "other" is also grazed and browsed by domestic animals.

Rainfall

Inland west Africa has a hot dry climate with summer monsoon rains. The Intertropical Convergence Zone (ITCZ), a low pressure area between the tropical anticyclones either side of the equator, moves north and south with the seasons following the sun's displacement. In summer the ITCZ travels sufficiently far north to draw the moisture-laden oceanic trade winds of the southern hemisphere across the equator. These monsoon winds meet dry harmattan winds blowing from the north-east across the Sahara, and the line where the two opposing wind systems meet is known as the Intertropical Discontinuity (ITD). As the ITD moves north across the Sahel in late summer, rain falls behind it, often in short violent storms accompanied by strong winds and dust storms.

Because the northerly movement of the ITD is undisturbed by major mountain ranges, west Africa has a simple rainfall profile, with total precipitation increasing in intensity from north to south in broad parallel belts. Total annual rainfall ranges from 2,000 mm or more on the coast to the rare and seasonally irregular rainfall of the Sahara. In winter there is a long dry season, broken only in the central and northern Sahara by occasional winter showers from the Mediterranean weather system to the north, and on the Atlantic coast by northerly winds associated with the Azores anticyclone, which bring occasional heug rains. Apart from these and other small anomalies, west Africa's climate is thus very regular in its broad outlines, which can be arbitrarily defined as comprising four or five latitudinal weather zones, each 200-400 miles deep.

However, the regular zonation of West African climate

Table 1 Land-use in dry west Africa

Country	Total land area	Arable land	Permanent pasture	Forest	Other
	'000 ha				
Senegal	19 200	2 300	5 700	5 318	6 301
Mauritania	103 070	1 000	39 250	15 134	47 681
Mali	122 000	11 700	30 000	4 457	77 843
Niger	126 670	15 000	3 000	11 780	96 920
Chad	125 960	7 000	45 000	16 500	59 900
Upper Volta	27 380	5 315	13 755	4 101	4 187
Cameroun	46 944	6 750	8 300	30 000	1 909
Nigeria	92 377	25 300	20 720	31 069	15 288
Total	663 601	74 365	165 725	118 359	310 029
Percent	100	11.2	25.0	17.8	46.7

Source: FAO Production Yearbook 1974

conceals great variability of weather on the ground. The northward advance of the ITD depends on the balance between two separate pressure and weather systems, and is thus quite variable from year to year. In addition, in the drier areas rain falls mainly in violent but localised storms. As a result rainfall varies in three related ways:
(a) spatial variation. Daily rainfall at Niamey and at its airport about 5 kms away during 1953 showed a large difference, although the annual total varied much less (Cochemé and Franquin 1967: 36). Similarly, records from the catchment area feeding the wadi Seloumbo in Mauritania show annual totals which in 1957 varied from 117.6 to 223 mm in different parts of a 24 km^2 catchment (Toupet 1966: 52).
(b) spacing within the year. Rain is often erratically spaced within the year; in particular the onset of the main rains may vary by one or two months.
(c) interannual variation. Annual variability of rainfall from year to year increases with decreasing annual totals from south to north. Throughout most of the Sahel standard deviation from the mean is of the order of 20 to over 30 percent (Cochemé and Franquin 1967: 23-5). A 100-year series of rainfall figures from Saint Louis in Senegal demonstrates this variability (Bille 1974: 6-11). Mean rainfall in this period was 370 $\pm$ 45 mm. But in one year out of two rain was less than 225 mm. It appears that since high annual totals at individual stations may be the result of one or two storms, dry years are likely to be general to several stations, while wet years may not be.

Vegetation zones

Following the main weather zones, the vegetation is zonally distributed from north to south from the specialised desert vegetation, with some relict Mediterranean species, of the Sahara (Quezel 1965) to the humid tropical forests of the west African coast. In the Sahara itself, some seasonal grazing is available to nomad herds from Aristida grasses

and had (Cornulaca monacantha) on sand dunes, Panicum grasses and Acacia bushes in wadi beds. The northern driest belt, just below the Sahara, has a steppe vegetation, with widely-scattered annual and perennial grasses, associations of various Aristida, Panicum and Cenchrus grasses with Acacia and Balanites thorn trees (Rattray 1960). Because grass cover is scattered, fire is rarely an important agent of environmental modification. This dry zone includes one rich set of natural ecosystems, the main river valleys (Gillet 1974); as flood water retreats it leaves rich pastures in the Senegal, Niger and Chari river valleys, especially the "burgu" (Echinochloa) pastures of the middle Niger flood zone. Further south, richer grassland associations including Cenchrus, Chloris, Eragrostis, Schoenefeldia and Aristida grasses become common, in association with trees and bushes including Commiphora, Boscia and Grewia. In these savannas, the density of grass cover allow periodic fires of great intensity (often lit by pastoralists to encourage new green growth for their animals) which reduce tree growth. Further south still, the dominant grass species become Andropogon, Hyparrhenia and Pennisetum, with such trees as Isoberlinia. In this zone of over 700 mm annual rainfall, cultivation and fire have considerably modified original conditions, and now maintain a "fire-cultivation" sub-climax vegetation. The transition in west Africa from desert to humid forest takes place gradually, with few sharp distinctions between different biogeographical zones. In the north, the dividing line between desert and steppe has been the object of much discussion (Schiffers 1973). Using the presence of different plant species and associations and their distribution in relation to soil conditions and water availability, Capot-Rey (1953) and Monod (1954) recognise a gradient from the typically "constricted" pattern of vegetation in the central Sahara, where plants are concentrated in wadi beds, to the typically "diffuse" pattern of steppe and savanna grasslands. Capot-Rey proposes the line of transition between the had bush (Cornulaca monacantha) and the cram-cram

grass (Cenchrus biflorus) as the dividing line between desert and steppe. This line appears to correspond closely to the 150 mm isohyet (Quezel 1965). South of this line, the Sahel is a 2,500 mile long belt of steppe vegetation along the southern edge of the Sahara from the Atlantic to Lake Chad. South of this, the vegetation zones are known as the "sudanic" (tall grass savanna with approximately 600-1200 mm annual rainfall), and the "guinean" (well wooded savanna, with over 1200 mm annual rainfall) (Morgan and Pugh 1969).

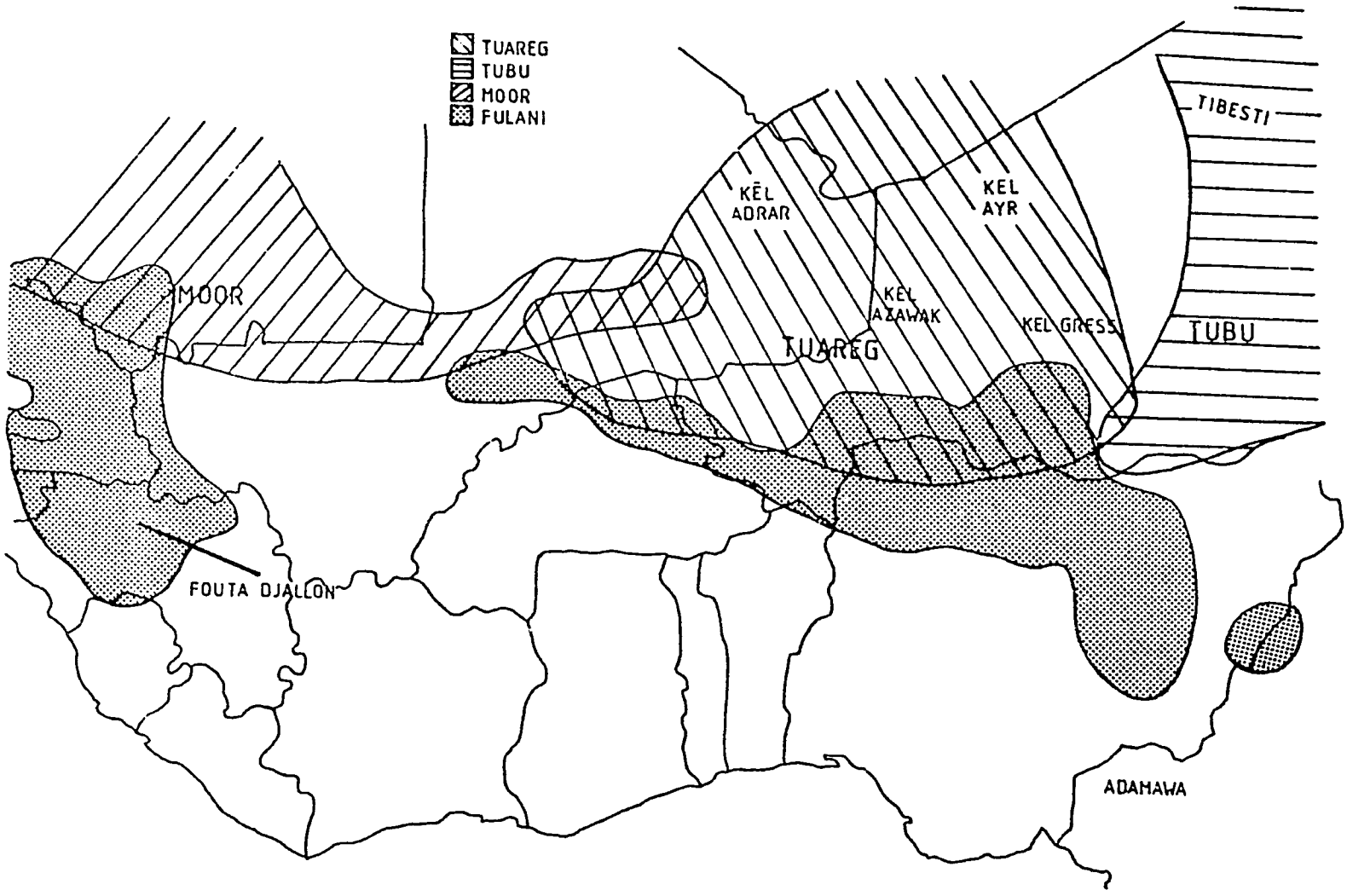
1.2 SOCIO-CULTURAL TRADITION

Distribution of the main pastoral societies

West African pastoral societies belong to four main traditional ethnic and political groupings, each occupying a relatively well-defined geographical area. These groups are the Moors, Twareg and Tubu in the north of the pastoral zone, and the Fulani in the south; there are also several smaller pastoral groups, especially Arabs in the east of the zone, scattered within the area occupied by the larger groupings. Figure 1 gives a rough idea of the distribution of the major groups.

In this section I describe these pastoral groups and estimate the numbers of people involved. The second of these tasks is difficult, due both to a lack of information and to the definitional problem caused by the partial overlap between ethnic and linguistic categories on the one hand, and livelihood patterns on the other. Thus "Twareg" is used here in the sense (which is the one used by the people themselves) of Kel Tamasheq, or Tamasheq-speakers, and includes people originally of non-Twareg origin, such as the ex-slaves, who are now culturally and linguistically Twareg. These Tamasheq-speakers are not all pastoral nomads; many, especially those of slave origin, are partly

FIGURE 1 Geographical Distribution of the Main Pastoral Societies in West Africa



or principally agriculturalists. Relative dependence on agriculture and pastoralism is highly variable: households may shift between agriculture and pastoralism according to their fortunes or the weather, and even those who are mainly farmers may derive a substantial part of their income from pastoralism. In the enumeration of major pastoral groupings that follows, an effort has been made to obtain a rough figure for the number of pastoralists, defined as members of households in which pastoral activities are the main source of subsistence and cash income. Thus the figures do not necessarily refer to nomads. It should be stressed that the available figures are out of date and imprecise and many ambiguities remain.

Several attempts have been made to estimate the total number of nomadic pastoralists in west Africa, and more especially in the Sahel. For the 6 Sahelian countries (Senegal, Mauritania, Mali, Upper Volta, Niger and Chad) there have been two recent estimates: that nomadic pastoralists constitute 10 percent of the total population of the countries concerned (25 million) and thus amount to 2.5 million (Caldwell 1975); and that they are one sixth of a total population (in 1970) of 23 million, that is to say 3.8 million (United Nations 1974). An estimate for five Sahelian countries, excluding Senegal, gave around 2 million, distributed as follows: Mauritania 980,000, Niger 650,000, Upper Volta 350,000, Mali 200,000 (Messiant 1975: 66). All these estimates are for nomads, although there is no standard definition of what a nomad is in this context. All the estimates exclude northern Nigeria and Cameroun, both of which have significant pastoral populations.

A different approach is to estimate the numbers by major traditional social groupings, in their geographical settings.

The Moors are a group of hierarchically-organised,

Arabic-speaking peoples occupying the Saharan and Sahelian pastures of Mauritania, and spreading into north Mali. Until the 1973 drought, nomadic pastoralists were thought to form 70 percent of the total population of Mauritania, and were estimated at between 500,000 and 980,000 people (Toupet 1963, Messiant 1975). As a result of the drought and the new mining economy of Mauritania however, this number may have been considerably reduced since 1974. In 1963, there were estimated to be 34,000 Moors in Mali (Unesco 1963: 22).

The Twareg, who speak a language of the Berber group, are distributed in seven main confederations (Nicolaisen 1963). A small number of Twareg live in the central Sahara, in Algeria, and Libya, probably amounting to 5 - 8,000 people.[1] The great majority of Twareg are Sahelians in Mali (c. 250,000), in Niger (c. 380,000, of whom a large number are mainly sedentary cultivators), and in Upper Volta (c. 43,000). making a total of 6 - 700,000 Sahelian Twareg, not all of whom are however nomadic pastoralists.[2]

Like the Moors, the Twareg are hierarchically organised; they previously included a large number of slaves, who are now mostly effectively free from their former masters and form independent agricultural or pastoral groups.

The Twareg were originally organised in confederations in the main Saharan and north Sahelian mountain ranges: the Ahaggar, Ajjer, Malian Adrar and Ayr mountains in Niger. Twareg occupation of the central and southern Sahel dates from the mid-17th century in Mali and Niger as the existing Twareg confederations in the Adrar and Ayr broke up from internal

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1. Keenan (1977: 7) estimates there to be 5,000 Kel Ahaggar Twareg in Algeria; the Kel Ajjer in Algeria and Libya are in very small numbers.

2. National totals respectively from Gallais 1975a: 43; Dankoussou et al 1975; Courel and Pool 1975.

quarrels or were pushed out by new waves of Twareg from the north. This long history of successive southward movement of Twareg has carried them as far as, and in places well into, the agricultural zone.

In the eastern part of the west African pastoral zone the dominant cultural entity is the Tubu group of peoples, based originally on the Tibesti mountains but now found throughout Saharan and Sahelian Chad, as well as in eastern Niger and western Sudan. Originally Tubu society was based on a system of exogamous clans, with a specialist metal working and hunting caste, and a small number of pastoral and agricultural slaves. The Tibesti, like other Saharan and north Sahelian mountain ranges, served as a centre from which pastoral groups spread into the Sahelian zone, and which occasionally also served as a refuge in time of trouble. In the 18th and early 19th century dispersion southwards from the Tibesti became particularly active; in the mid-19th century the Sahel zone to the south of the Tibesti was also invaded by Arab nomadic pastoralists who had been defeated by the Turkish government in the Libyan Fezzan and Tripolitania (Chapelle 1957: 41-65). French conquest of north Chad, and the colonial peace that followed, led to a further dispersion of Tubu from the mountains into the surrounding plains.

In the 1950s it was estimated that the Tubu group as a whole amounted to about 195,000 people, who, apart from about 5,000 oasis dwellers, were mainly nomadic and trans-humant pastoralists (Chapelle 1957: 405-7). A later, more detailed estimate for Sahelian and Saharan populations of Chad (ie including Arabs and other groups as well as Tubu) was divided into semi-sedentary (people with a fixed dwelling they abandon for part of the year to take their animals elsewhere), semi-nomads (people with a mobile dwelling, who in the Sahel cultivate some crops and in the Sahara may

own date palms but not gardens, but whose main livelihood in both zones is pastoralism), and nomads (living in mobile dwellings, with no agriculture or date palms). The estimated populations in each category are as follows (calculated from Le Rouvreur 1962 passim):

Table 2 Chad: pastoral populations

	semi-sedentary	semi-nomad	nomad	total
Sahel zone	457,200	129,400	169,500	756,100
Saharan zone	18,300	10,250	25,600	54,150
Total	475,500	139,650	195,100	810,250

The Fulani are the major complex of west African cattle pastoralists. Fulani are found from the Atlantic east across the whole width of the Sudanic and north Guinean grasslands, as far as Chad and the Sudan. Within the Fula-speaking groups of peoples is a range of livelihood activities from the fully pastoral and nomadic Bororo, to fully settled agricultural and urban Fulani. But even for fully settled Fulani, cattle are important, and a part of household incomes usually comes from pastoral activities.

The Fulani occupation of almost the entire width of the west African savanna belt took place by the slow migration of cattle herds and farmers east from early Fulani settlements in north Senegal and the Futa Jallon mountains of Guinea. By the 16th century considerable numbers of Fulani were found as far east as the Adamawa

plateau of north Cameroun. Fulani power and territory was increased by the formation of powerful Islamic states in the 18th and 19th centuries, especially in the Futa Jallon, the Futa Toro in north Senegal, Macina in the inner Niger delta in Mali, and Sokoto in north Nigeria. These Fulani states were militant Islamic theocracies, characterised by an ethnic mix of tribute-paying rural inhabitants subordinated to Fulani rulers. A high degree of regulation of agricultural and pastoral land use was achieved in some of these states. The highly structured social and political organisation of these states contrasted with the simple and egalitarian organisation of the pastoral Fulani, who had previously and now continued to form minorities in larger agricultural societies. Some of the pastoral Fulani were integrated into the political framework of the new Fulani states. Others remained outside formal state structures, and, organised as migratory groups under elected leaders, continued to move north and east into land occupied by Twareg and by other pastoral groups. This dual process of state formation, especially rapid in the 19th century, and continued migratory drift of pastoral Fulani, led to the extension of Fulani cattle herding east across the Sudanic and north Guinea savanna, and north into the Sahel.

Estimates of the total Fulani population are usually around 6 million. Stenning's (1959: 1) estimate of their distribution by country in the early 1950s is given in table 3.

Table 3 Fulani populations in early 1950s

Country	Fulani population
Mauritania	12 000
Senegal	250 000
Mali	600 000
Dahomey	54 000
Guinea	720 000
Niger	269 000
Upper Volta & Ivory Coast	52 000
Chad & Central African Empire	no figures available
ex-French Cameroun	305 000
ex-British Cameroun & Nigeria	3 630 000
Gambia	58 700
Ghana	5 500
Guinea Bissau	36 500
Incomplete total	5 993 000

These figures are probably an underestimate. The number of Fulani in Upper Volta has recently been estimated at about 400,000 (Pool and Coulibaly 1977: 32), as compared to Stenning's figure of 52,000 for that country and Ivory Coast combined. Stenning gives no figures for Chad and Central African Empire, where numbers of pastoral Fulani are increasing, as they are in the Sudan, not mentioned by Stenning.

Gallais (1969) estimated the distribution of Fulani by rainfall zone (the Futa Jallon excepted), and showed them to occupy mainly the Sudanic vegetation zone. This distribution is given in table 4.

Table 4 Distribution of Fulani by rainfall zone

rainfall zone	percent of Fulani population
250-500 mm	6
500-750 mm	22
750-1000 mm	38
1000-1250 mm	17
1250 mm +	12

The proportion of Fulani who are primarily pastoral or nomadic is not known. In Niger there are between 50,000 and 67,000 nomadic Fulani, which is about one third of the total Fulani population; in addition there are a considerably number of semi-nomads, among whom several members of the household migrate for most of the year, only returning to the village at harvest time (Dupire 1962: 38 and 1970: 16). The proportion of mainly pastoral to mainly agricultural Fulani does not appear to have been estimated in any of the published sources.

The total number of people belonging to the three major traditional Sahelian pastoral societies amounts to 2 - 2.5 million; this does not include any Fulani. If around half of the Fulani living north of the 1250 mm rainfall line fall within the definition of pastoralist used here (people for whom pastoral activities are the main source of subsistence and cash income), the total number of pastoralists in the Sahel and Sudanic zone is between 4 and 5 million. This is higher than the overall estimates cited at the start of this section, but it should be noted that the estimate here includes Nigeria and Cameroun, which are excluded from the others; it also refers to pastoralists,

who are not necessarily all nomads, while the other figures refer to nomads only.

Tne geographical distribution of the four main pastoral groupings is the result of centuries of migration, land occupation and conflict. As described above, the most important of these migrations during recent centuries was the southward movement of Saharan and north Sahelian groups (Moors, Twareg and Tubu), and a vast movement east and north by the Fulani. The French conquest of the central and western parts of west Africa hastened these processes, and had several important consequences for the distribution of the main pastoral groups. In the first place the colonial peace imposed on the area led to a wider dispersion of several pastoral societies which had previously kept closely grouped for protection against raiding, which was still common until the 1920s and 1930s. In particular, this enabled Twareg and Tubu groups from the north Sahelian mountains to disperse more widely in the Sahelian plains to the south, adding to the historical process of southward migration already well under way.

In Twareg areas of the Sahel and north Sudanic zone, liberated Twareg slaves, known as Buzu or Bella, began to form independent herding and farming groups which moved further south even than the advance of the Twareg, in order to escape their exactions.

The same peace enabled the Fulani to continue and expand their movement north from the Sudanic savanna into the drier Sahelian steppes. This convergent migration into the central Sahelian grasslands by Twareg, Tubu, Arabs and even Moors from the north, and by Fulani from the south, was speeded up by the efforts at pastoral development practiced by governments after the 1930s and especially in the 1950s and 1960s. Several elements contributed. Most important

was the provision of new water supplies. Water is the key to access to dry season pasture, and prior to colonial administration most pastoral water supplies other than surface rainwater pools and rivers had been wells privately owned by individual households, small groups or clans. The new government wells could not be privately appropriated in this way and little attempt was made to regulate access to them. As a result, the new wells, especially the high capacity boreholes, spearheaded the occupation by large numbers of newcomers of pasture previously unused or used by a small number of households only. This further contributed to the northward expansion of the Fulani, and to a blurring of previously quite well defined grazing areas customarily used by particular groups.

1.3 LIVELIHOODS

The pastoral production systems of concern here are all characterised by the herding of domestic animals, but their degree of dependence on pastoral products, both for household food supply and for income, varies greatly. Many of these households have other production activities, including agriculture, collecting and hunting, or caravan trading.

Dubie (1953: 117) distinguishes four main types of Moor pastoralism (goats are found in all of them):
(a) In the north of Mauritania are camel pastoralists who are among the most nomadic people known; their extreme mobility enables their camels to use pastures in two different climate systems: Sahelian summer rainfall pastures in the south, and Mediterranean winter rainfall pastures in the north.
(b) The inhabitants of the mountains of the Adrar and the Tagant live from cereal cultivation and dates, combined with sheep pastoralism which needs only small scale nomadism.

(c) In middle Mauritania cattle, sheep and camels are herded in a typically north Sahelian pattern, with movements of 100-200 km north in the wet season and south in the dry.
(d) In south Mauritania there is semi-sedentary cattle and sheep herding, combined with millet cultivation and collection of gum arabic.

Agriculture in these traditional Moor societies was carried out mainly by servile labourers who paid a part of the harvest to their master as a tribute or tax. At the southern limit of Moor pastoralism, there were formalised exchanges between Moor pastoralists and sedentary agriculturists by which the animals manured the fields in the dry season in return for stubble grazing, and milk or salt were bartered against millet or cloth (Meillassoux 1975). Many Moor pastoralists also did extensive trading; in the south cattle were taken to the urban markets of Senegal and Mali, in the north salt and other Saharan caravan goods were carried from north Africa. It is however not clear from published accounts how much of this traditional Moor pastoral economy survives.

A budget for a well-off Moor pastoral household in the 1940s is given by Dubie (1953: 152). This is discussed in greater detail in section 1.4 below, where estimates of milk and meat production are made. Using these estimates and Dubie's own figures, it is possible to calculate the share of household income from pastoral sources (milk, meat, sale of live animals and camel transport earnings but excluding artisan production, trade and gum collection), and the direct contribution of pastoral products to household food consumption. These are shown in table 5 which illustrates the great predominance of pastoral products in household income and food supply.

Table 5 Household dependence on pastoralism, Moor (1940s).

	percent of total
Household income:	
- share of household income accruing from pastoral activities[1]	84
Composition of household food consumption:[2]	
- milk	76
- meat	4
- millet	20

Notes:

1. Valued in local currency; see section 1.4.
2. Valued in kcal.

The Twareg show similar changes in economic activity from north to south. Goats are ubiquitous. In the north Sahel, between about 100-250 mm rainfall, camels predominate, together with sheep in many places, especially where markets are available, including markets in the central and north Sahara. Nomadism here tends to take the form of movement away from and back to a dry season well. Many northern Twareg use their camels for extensive caravaneering of salt and other Saharan goods both north and south of the Sahara.

South of the 250-300 mm rainfall line cattle replace camels as the main large animals as a result both of ecological factors (there is more grass for cattle, and camels do not like the marshy conditions found in some places during the rains) and economic ones (cattle have a ready market, camels less so). These areas overlap, so that in the north Sahel diversified pastoralism using all four species, or any combination of them, is possible.

In the Twareg areas of Mali and Niger, south of around 350 mm annual rainfall, pastoralism coexists with agriculture. Cattle are the main animals herded here and they require a constant guard when they are near crops to stop damage. Herds are generally sent north in the rains and return south to graze the stubble after harvest. In these southern areas where agriculture is possible, it used to be done by servile labourers on behalf of the Twareg. The liberation of slaves and the creation of new social groups of Twareg ex-slaves has increased the amount of land cultivated, as has the settlement of some pastoral Twareg groups.

The only detailed published study of Twareg household incomes and consumption is from central Niger (Niger 1966: 167-170), where pastoral activities are responsible for 80 percent of household income. Pastoral products are also the main source of household food consumption, although when some agriculture is added to pastoral activities, the share of food from a pastoral origin falls rapidly, as table 6 shows.

Table 6 Household dependence on pastoralism, Twareg, Niger (1963)

	purely pastoral households	households with some agriculture
Household income:	percent of total	
- share of household income accruing from pastoral activities	80	
Composition of household food consumption:		
- milk	51	33
- meat	3	2
- millet	47	65

Note: Valuation as in table 5

Among the Tubu and Arab pastoral economies of Chad there is similar gradient in species herded, from camels in the north, being replaced by cattle south of around 16° N; sheep and goats are found almost everywhere, and goats live in the remotest parts of the Tibesti mountains in the full Sahara. The camels of the north not only provide milk, but are also used a great deal for caravaneering (Le Rouvreur 1962: 42). In northern Chad, agriculture is restricted to oasis cultivation, until recently by a servile population, of date palms, wheat and millet. In the southern Sahelian zone many of the inhabitants are semi-sedentary, combining millet cultivation and cattle pastoralism.

Le Rouvreur (1962: 410-411) gives an estimated budget for a mediumly-wealthy Annakaza (Tubu) camel herding household in northern Chad. This budget illustrates a paradoxical situation common in some Saharan and north Sahelian pastoral economies, where date cultivation by sedentary servile labour (which may be considered as an agricultural rent to the pastoral household) accounts for a large share both of household income and food supply. In fact, by the criteria used here (pastoral households are defined as those in which pastoral activities, including caravan transport earnings, provide more than half total gross income, or in which milk products account for more than 20 percent of household food energy consumption), this household is only just a pastoral one: pastoral products (milk and sale of camel calves) are responsible for only 38 percent of total household income, and milk for 22 percent of household consumption, while dates are the source of 62 percent of income and 43 percent of consumption. A different estimate of Annakaza household food consumption for the same years is given by Capot-Rey (1963: 91); this is much nearer the food consumption patterns of other pastoral societies.

Table 7 Household dependence on pastoralism, Annakaza (Tubu) north Chad (1950s).

	Capot-Rey	Le Rouvreur
	percent of total	
Household income:		
- share of household income accruing from pastoral activities		38
Composition of household food consumption:		
- milk	48	22
- meat	-	-
- millet	24	35
- dates	28	43

Note: Valuation as in table 5

For some Tubu groups, caravan trading was until recently an important source of income. Le Rouvreur gives an example of a caravan in the hot season (when profits are particularly high). The caravan, composed of 8 adults, 5 of them women, with 14 camels, carried salt, natron and dates on its southward trip and millet, a sheep, chickens, tea, sugar and cloth on its return north. The round trip lasted 3 months and the gross return was 25 times the funds invested at the outset. Elsewhere in northern Chad a camel can, in a single caravan trip, earn its own purchase price (Le Rouvreur 1962: 331, 412).

The Fulani economies of west Africa combine principally cattle pastoralism with agriculture and other activities in a variety of ways. The number of fully nomadic Fulani is quite small; in Niger it is estimated to be about one third of the total Fulani population, and it is probably smaller in the other countries. In addition to fully nomadic Fulani, Dupire

(1962: 37-39) distinguishes semi-nomads, among whom the young men and some married couples nomadise for much of the year returning to the village only at harvest, and sedentaries, all of whom live permanently in agricultural villages, employing salaried herdsmen to take care of their animals. The semi-sedentary economy appears to be an unsatisfactory compromise forced on nomadic households by loss of animals, and is usually succeeded by a return to full nomadism or by a further change to complete sedentarisation. In some conditions fully sedentary Fulani accumulate large herds and become nomads. But more recently it has been argued that the process of sedentarisation in western Niger is often irreversible; even if the new sedentary household acquires a large herd it will probably employ a herdsman to look after it (Sidikou 1974: 189-90).

In Niger and other areas where Fulani practice both agriculture and pastoralism, the two activities are often not well integrated, and the herds have to be sent away during much of the agricultural season so as to avoid crop damage; the only combination of the two activities is when the cattle graze stubble and manure the fields after harvest. In the inner Niger delta in Mali however, a well-integrated agro-pastoral system has been developed since the 19th century, which has allowed a considerable increase in population density in the delta.

Two sets of household budgets are available to give an idea of Fulani income and food consumption patterns. These are from central Niger (Niger 1966: 159-161) and the inner Niger river delta in Mali (Gallais 1967: 403-4). The Niger Fulani household income came almost entirely from pastoral sources (milk, meat, live animals, skins, butter), while in the inner Niger river delta, where the specimen household also farmed and traded, only slightly over half of household income was from pastoral sources. In both the groups combining some agriculture with pastoralism, cereals formed three-quarters

and milk one quarter of household food consumption. The pattern of household food consumption in these two Fulani economies is shown in table 8.

Table 8 Household dependence on pastoralism, Fulani, Niger and Mali

	Niger (1963)		Mali, inner Niger river delta (1958)
	purely pastoral households	households with some agriculture	
	percent of total		
Household income:			
- share of household income from pastoral activities		96	57
Composition of household food consumption:			
- milk	39	24	25
- meat	2	2	-
- cereals	58	74	75

Note: Valuations as in table 5.

The broad pattern of west African pastoral production systems appears from this summary of the livelihood patterns of the main ethnic groups. In the pastoral societies of the north, camels and goats are the main species herded, sometimes with sheep. This type of herding economy is or was combined in places with oasis agriculture (dates, wheat, millet), which often used to be carried out by a tributary population on behalf of nomadic pastoral masters. Caravan trading is an important source of income for some households. The degree of direct household dependence on pastoralism in these economies varies widely. In the Moor society for which data are available, over 80 percent of household income came from

pastoral activities, and milk formed three quarters of household food supply. In one Tubu example however, pastoralism provided only just over one third of household income and milk was less than a quarter of household food, while dates were the source of over 60 percent of income and 40 percent of food consumption. These examples are from the 1940s and 1950s however, and conditions may have changed substantially in the intervening years.

In the south of the zone, cattle are the most important species, herded principally by nomadic and semi-nomadic Fulani, in combination with goats and sheep. This pastoralism is often combined with extensive village agriculture; although integration of the two types of production is unequal, some agricultural use is normally made of manure. The figures for household income and food consumption indicate that over half of household income accrues from pastoral activities and that the share of milk in household food supply is around one quarter, with cereals forming around three quarters.

There is a broad zone of contact between these two pastoral types, where cattle herding Fulani from the south overlap with camel and cattle herding Moors, Twareg and Arabs from the north. The share of pastoral products in household incomes in this area is very high (80 to 96 percent for Twareg and Fulani in Niger); the share of pastoral products in household food supply is variable, milk forming 50 percent of Twareg and 40 percent of Fulani diets, with millet making up the difference. Meat forms a very small part of the diet of all the pastoral societies for which data are available.

1.4 DEGREE OF COMMERCIALISATION OF PASTORAL PRODUCTION

A fourth important variable in classifying west African pastoral production systems is the extent to which the

different pastoral groups are involved in market exchange. Ruthenberg's (1971: 5) classification provides a terminology: subsistence operations are those where sales are less than 25 percent of gross returns; in partly commercialised operations, sales are less than 50 percent, and in semi-commercialised ones 50 to 75 percent of gross returns; where sales are more than 75 percent of gross returns, the operation is highly commercialised.

There is an important difference between pastoral and agricultural economies in this respect. In a pastoral economy, each year the herds and flocks produce young male animals, and females whose reproductive span is over. Only a few of the young males are needed for reproductive purposes, and except where they are used for transport or for traction, these males, and females whose reproductive span is over, may be disposed of without affecting the reproductive capacity of the herd. This surplus exists in all herds, however small. Its size is determined by circumstances generally beyond the control of the herdsman: the size of the breeding herd, and the ecological conditions of the year. Households can eat these surplus animals, or they can barter or sell them for cereals; wherever pastoralists have been in contact with farmers or markets, it seems likely that they could obtain more food energy by exchanging their surplus animals for cereals than by eating them. The few published figures confirm this for west Africa, and show that the food energy terms of trade (the ratio between the food energy value of an animal eaten and food energy value of the millet that could be obtained by selling the same animal at current market prices) are positive although very variable. These figures are shown in table 9.

Table 9 Food energy terms of trade, beef to millet

Place	Date	$\frac{\text{millet kcal}}{\text{beef kcal}}$[1]	Source
Mali			
- inner Niger delta	1958	16	Gallais 1967: 401-411
Niger			
- Tahwa	1963	2.3	Niger 1966: 159
- Ader	1930s	8)	Bonte 1973: 95-6
	1960s	5)	
- Western Niger	1968-70	4 - 8	Sidikou 1974: 195-7
- Tahwa	1967-75	3.7-10.4	FAO 1977: 362
Chad			
- several Sahelian markets[2]	1957-8	2.6-4.6	Le Rouvreur 1962

Notes: 1. Calculated assuming a dressed weight of an ox of 120 kg, (150 kg in the inner Niger delta), and energy values of 330 kcal/100 g millet, and 237 kcal/100 g beef.
2. Markets of Moussoro, Am Zoer, Abéché, Nokou, Kunjuru.

The best exchange is in the rich inner Niger delta, the least good in the remote markets of pastoral zone of Chad, but in all cases the ratio is positive; from the point of view of food energy value it would always be better for a pastoral household to exchange its surplus cattle against millet rather than eating them, since it can get between 2 and 16 times more food energy this way.

For this reason it is to be expected that west African pastoralists will market more of their production than do farmers in the same zone. There are very few published figures to test this, and there are doubts about the adequacy of those that do exist, especially in calculating the total

physical output of milk and in pricing, but it is worth reviewing the evidence.

Dubie (1953: 152) gives a representative budget of a well-off Moor household in the 1940s, which owns 200-250 sheep, 50 cattle and 30-40 camels. Approximate potential annual offtake rates from such a herd would theoretically be 20-25 percent for sheep, 10 percent for cattle and 6 percent for camels.[1] In fact sales during the year are estimated by Dubie at 35 sheep (15 percent of the flock), 1 bullock (2 percent) and no camels. There is no record of the household's own consumption of animals, but this is likely to be several sheep, bringing the sheep offtake rate up to around 20 percent, which is in line with the expected potential rate of offtake. Household slaughter of cattle is less likely, so it appears that the cattle herd exploitation is below the potential 10 percent. There are no sales from the camel herd, but the household has a small income from camel transport. All the milk is apparently consumed by the household (of 10 people), which lives almost exclusively on milk for 8 months of the year.

Although no estimate of milk production or value is given by Dubie, it is possible to estimate it. The household of 5 adults and 5 children lives almost exclusively on milk for 8 months. With daily food energy requirements of 2350 kcal per adult and 2000 kcal per child, minimum household requirements, and thus herd production, in this period are 6525 litres (21,750 kcal daily for 240 days divided by 800 kcal/litre composite energy value for camel, cattle and sheep milk). If milk production during the other months is 1000 litres, total annual milk production is 7500 litres.

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1. These are discussed below. In an economy where camel transport is important, the camel offtake rate would be much lower, possibly negligeable.

Valuing this milk production is difficult, since there are few published prices of milk and they vary widely in space and in time.[1] For the purposes of calculation I have used the conservative assumption that milk is bartered weight for weight with millet (a not uncommon practice in pastoral areas in fact), and have used this to establish milk prices from millet prices. In general this practice will underestimate the value of milk, although not always so.

Milk production in the Moor household described by Dubie can be estimated in this way by reference to the price of millet, given by Dubie as 1200 F for 480 kg, or 2.5 F/kg. If milk exchanges for millet at equal weights, the value of total subsistence production of 7500 litres is 18750 F.

The household is also assumed to eat 5 sheep during the year. These are valued at market price. The possible growth in cattle and camel herds and sheep flocks during the year is not estimated. Marketed output is taken from Dubie's figures. Total household production during the year is given in table 10.

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1. In 1958 in the inner Niger delta in Mali, a rich agricultural area, milk cost five times as much as the same weight of millet (Gallais 1967: 403-4). In fully pastoral areas the rate of exchange is usually less good. In north Chad and Mali in the 1930s and 1950s milk appears to have been 2.3 - 3.5 times as expensive as the same weight of millet. In the pastoral zone of Niger, milk cost around 0.8 times as much as millet in 1963 (Niger 1966: 159); in 1974/5 the price of milk was estimated to vary between 0.6 and 3.4 times as much as the same weight of millet (FAO 1977: 242-363).

Table 10 Annual production of a well-off Moor pastoral household (1940s)

	Value (F)
Subsistence production:	
- 7500 litres of milk	18,750
- 5 sheep	750
Marketed production:	
- animal sales: 35 sheep	5,250
2 donkeys + 1 bullock	1,300
- camel transport earnings	600
- artisan products	1,000
- trade, transport, gum collection etc	4,000
Gross return	31,650
Marketed production as % of gross return	38 percent

It appears that this Moor pastoral household is a partly commercialised one in that 38 percent of its gross revenue comes from market transactions. It is difficult on the evidence given by Dubie to know how representative this household is of Moor pastoral households generally. Poorer households than this, which are probably in a great majority given the unequal distribution of animals in traditional Moor pastoral society, might have a smaller share of revenue from market activities. On the other hand, households with any substantial caravan activity would have a larger commercial income.

From Chad, Le Rouvreur (1962: 410-411) gives a similar sample budget for a household of Annakaza (Tubu complex) camel herders of medium wealth. Valued in the same way as the Moor household, (ie milk is given the same price as an equivalent weight of millet) their total production is given in table 11.

Table 11 Annual production of a mediumly wealthy Annakaza pastoral household, north Chad (1950s)

	Value (CFA)
Subsistence production:	
- 1500 litres of milk	22,500
- 700 kg dates	42,000
Marketed production:	
- 300 kg dates	18,000
- 3 camel calves	12,000
- camel transport earnings	3,000
Gross return	97,500
Marketed production as % of gross return	34 percent

This household again falls within the category of partly commercialised operations according to Ruthenberg's terminology. Again, it is not clear how representative this household is. Certainly were it to undertake any caravan trading, its cash income would form a very much greater part of the total.

For Twareg and Fulani economies there are two sets of usable published figures. The first comes from the sample budgetary survey carried out in Niger in 1963 among Twareg and Fulani households (Niger 1966: 155-170). This survey included both pastoralists and households which obtained a large part of their livelihood from agriculture. In these calculations milk is valued a little lower in relation to millet than in the previous budgets (milk is 10 F CFA/litre, millet 12 F CFA/kg). The household budgets for the two groups are summarised in table 12.

Table 12 Annual production of Twareg and Fulani households, Niger (1963)

	Annual household production (CFA)	
	Fulani	Twareg
Subsistence production:		
- milk	15,042	20,832
- millet	1,435	8,316
- meat	736	840
Bartered production:		
- milk	276	-
- live animals	2,093	4,326
- other	23	147
Marketed production:		
- live animals	15,180	17,220
- butter	207	-
- skins	184	-
- handcrafts	-	840
- millet	-	504
- trade	-	252
- other	69	504
Gross return	35,245	53,781
Marketed and bartered production as % of gross return	51 percent	44 percent

If, as seems likely, subsistence production has been underestimated in these figures, both Twareg and Fulani fall within the category of partly commercialised operations, with the Fulani slightly more dependent on the market than the Twareg.[1] In both economies sale of live animals is by far

1. If milk is valued as in the previous budgets, as worth its weight in millet, marketed and bartered production in the Fulani and Twareg budgets becomes 47 and 41 percent of gross returns respectively.

the most important market transaction, accounting for 96 percent of Fulani and 91 percent of Twareg market and barter revenue.

A specimen budget for a Fulani household in the inner Niger delta in 1958 is given by Gallais (1967: 403-4). This is for a small (4 people) "modern" Fulani household living both from pastoral and agricultural production, and involved in Kola nut trading. The budget is as follows:

Table 13 Annual production of a Fulani household, inner Niger delta, Mali (1958)

	Value (F)
Subsistence production:	
- 1102.5 litres milk	44,100
- 1230 kg paddy	14,760
Marketed production:	
- 37.5 litres milk	1,500
- one ox	14,000
- kola nut trading profit	30,000
Gross return	104,360
Marketed production as percentage of gross return	44 percent

This household also falls in the partly commercialised category. Subsistence production is probably considerably underestimated in this budget as in others (for example, although the value attributed to subsistence milk production is high, the quantity is underestimated, since no allowance is made for milk production by the main cattle herd while on transhumance out of the delta; no allowance is made for meat consumption by the household, or for growth in the herd), but even if the value of subsistence milk production

is doubled, marketed share of gross revenue is still over 30 percent.[1] Gallais concludes (1967: 406) that in the inner Niger delta pastoral incomes are much higher than agricultural ones, and that a much greater proportion of pastoral than of agricultural incomes comes from market transactions.

Although it should be interpreted with caution, since subsistence production is very probably underestimated, the evidence from these budgets indicates that the pastoral economies for which data are available are all involved in market and barter transactions to an appreciable degree. They appear to fall within or very close to the category of partly commercialised operations in which sales (and barter exchanges) account for 25 to 50 percent of gross returns. The figures for Moor and Tubu households are at the lower end of this scale, indicating that in the 1940s and 1950s these economies were probably close to the subsistence range in which less than 25 percent of gross returns comes from sales. In these Saharan and north Sahelian economies, households involved in caravan trading would have had a much larger proportion of their returns through the market. The Twareg and Fulani figures (which are from the end of the 1950s and early 1960s) are close to the upper end of the partly commercialised range. Changes since these figures were gathered are likely to have moved all the pastoral economies of west Africa towards a greater commercialisation of production.

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1. Gallais gives another Fulani household budget from the inner Niger delta, that of a large traditional household which is not involved in kola trading and lives principally from its herds; in this budget the marketed share of revenue is 77 percent, leading Gallais to conclude that the traditional Fulani pastoral economy is a highly commercialised one. Unfortunately the value of milk production from this household appears to be seriously underestimated, and the budget is unusable. The same is true of a Fulani pastoral household budget reported from an unpublished source by Dupire (1962: 133). According to this budget, 7 cattle out of a herd of 30 are sold in a year, a commercial offtake of 23 percent (and this does not include household slaughter or non-market exchange); this is twice the likely sustainable offtake rate for Fulani Bororo cattle, and, if correct, would lead rapidly to the run-

1.5 CONCLUSIONS

The four variables discussed above - environment, socio-cultural tradition, source of livelihood and degree to which household production is marketed - enable west African pastoral economies to be classified into four main categories.

1. Saharan and north Sahelian camel economies

These occupy the very dry northern regions, with erratic rainfall and vegetation. Ethnically they include many of the Moor, and some of the Twareg and Tubu groups; many of the pastoral economies in this category are or were until recently based around the Saharan and north Sahelian mountain ranges and in the plains immediately surrounding them, but they have spread out in a long historical process of southward movement, much speeded up by the events of the 20th century. The social structure of such groups is generally hierarchic, with a rigid class structure incorporating a servile class of pastoral, agricultural or domestic labourers. Camels are the most characteristic animal herded, goats are ubiquitous, and some groups also herd sheep. These pastoral activities are often associated with long-distance caravan trading (salt, cloth, foodstuffs, animals), and with oasis agriculture (dates, wheat, some millet); the latter was however traditionally carried out by a servile population rather than by pastoralists. Where there is no oasis agriculture or caravaneering, a high proportion of household income is from pastoral activities, and pastoral products form a high proportion (between half and three quarters) of household food consumption. However where the household has an associated servile labour force cultivating oasis gardens, agricultural products may form a high proportion of both total household income and household food supply. A relatively low proportion (around one third in the 1950s-1960s) of household gross income is from sales or barter; however where the household practices caravan trading there is a much greater proportion of market income due to the great profitability of this type of enterprise.

2. Sahelian multi-species pastoral economies

These occupy the main band of the Sahel, and are especially of Twareg origin, with some Tubu and other ethnic groups in north central Chad. Like the north Sahelian camel economies, there is generally a hierarchic social structure, with until recently a servile class working at pastoral and domestic tasks. There are now new multi-species pastoral groups composed of former slaves. Ownership of any combination or all of the 4 species is possible. Camels are common in the north, where this type of pastoral economy overlaps the camel economies; in the south, cattle are common and this type overlaps the south Sudanic agro-pastoral economies. These multi-species economies either rely on pastoralism to the exclusion of agriculture, or cultivate millet in the south of the zone. There is some caravan trading, although on a smaller scale than in the north Sahelian camel economies. A high proportion of household income comes from pastoralism, and pastoral products form a relatively high proportion of household food supply (ranging from about one third in households which practice some agriculture, to over one half in those that do not). Slightly less than one half of household gross income comes from sales.

3. Sahelian and north Sudanic cattle economies

These are found in the south Sahelian and north Sudanic zone, and are mainly composed of Fulani cattle herders, although there are similar Arabic-speaking cattle herders in Chad. The Fulani are characterised by an egalitarian social organisation, with animals being herded by their owners. In some of these economies there is no agriculture at all, in others there is extensive rainfed cultivation of millet. There is little trading, and no caravaneering. A large proportion of household income comes from pastoralism. In purely pastoral households, milk and meat form 40 to 50 percent of household food consumption; this drops to around a quarter in households practising some agriculture however. Between 40 and 50 percent of gross household income comes from sales.

4. Sudanic agro-pastoral economies

These occupy the high and relatively reliable rainfall south Sudanic and north Guinean vegetation zones, and are also found in the rich environments of the main river valleys, especially the inner Niger delta in Mali. These economies are most typically Fulani, who in several areas are anciently organised into states with a hierarchic social structure; in places this has made possible a high degree of organisation of land-use and a close integration of pastoralism and agriculture. There is some class-based division of labour; servile labour is used mainly for agriculture, and where animals are not supervised by their owners, Fulani specialists are usually engaged for this work. Cattle are the commonest and most important animal herded, and goats are also common; some Fulani groups herd sheep, and there are some groups that have specialised in sheep herding. There is some trading, but it is generally small-scale trading in such items as kola nuts; there is no long-distance caravan trading. A relatively high proportion of household income may come from pastoralism, but cereals provide a large proportion (around three quarters) of household food consumption. Household production is partly commercialised, with 40 to 50 percent of gross income resulting from sales; this is a higher figure than in neighbouring fully agricultural societies.

There are many overlaps between these four basic types of west African pastoral economy, and in some areas, such as the Senegal valley, northern Upper Volta and northern Cameroun, two types are often found side by side occupying the same environment.

2. PASTORAL PRODUCTION

All types of pastoral production systems combine four main factors of production: land, technology, herds and labour.

2.1 LAND

The contribution of land to pastoral production depends on two main variables: (a) the ecological value of land as an input to production; it is in fact not land but the vegetation that grows on it that provides the input, by making food energy available to domestic animals; (b) the ways access by grazing animals to the vegetation is regulated.

2.1.1 Vegetation

The general determinants of primary production in dry west Africa were discussed earlier. Total annual primary production increases from north to south in rough proportion to total annual rainfall. There are important variations in plant production however, and in the south of the zone crop residues become an important source of animal feed.

Seasonal variations in primary production

Throughout dry west Africa there are major seasonal changes in the quantity and quality of vegetation. During the short growing period, which corresponds roughly to the rains from June or July to September, most grasses are green, with high water and low cellulose content; this changes during the cold and hot seasons when leaves, fruits and seed pods of some trees become a major source of animal food.

In the Sudanic ecological zone of northern Nigeria, herbage production increases from 50 kg dry matter/ha in May at the end of the dry season, to 1500 kg dm/ha in October/ November. In the northern Guinea vegetation zone to the south, increases are similar as table 14 shows. Quality varies also: crude protein content of the grass cover drops from a high of 12-14 percent in the early rains to 2-3 percent in standing forage in the dry season (Van Raay 1975: 84-5).

Table 14 Cumulative yields and nutritive value of upland savanna in Northern Nigeria, 1967-9

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec-May
Katsina survey area; Sudanic savanna								
Dry matter (kg/ha)	50	200	400	600	800	1200	1500	1000
Avg. crude protein content (% dry matter)	14	14	12	7	6	5	3	2
Zaria survey area; northern Guinea savanna.								
Dry matter (kg/ha)	300	700	1000	2500	2500	3000	3500	300
Avg. crude protein content (%dm)	12	12	7	6	5	5	4.8	3

Source: Van Raay 1975: 85.

Plant production varies with soil and with surface topography. Especially important are seasonally waterlogged depressions, which produce green vegetation over a longer period or in different seasons than drier areas. In northern Nigeria these fadama depressions produce 3500 - 7500 kg dm/ha, with a crude protein content of 3-6 percent.

Because of the short grazing season, browse is an important component of the diet of domestic animals throughout dry West Africa. Browse provides a high value food supplement which is eaten throughout the year, but has particular importance in the dry season when other food is scarce. In this season many trees and shrubs produce shoots, leaves or seedpods high in nutrients. In Katsina province of northern Nigeria over 20 browse species are consumed, and crude protein content is high (Van Raay 1975: 88). This

high quality is especially important since it appears to be pasture quality rather than quantity which limits animal production in this area. Research in progress in Mali similarly emphasizes forage quality as a constraint on cattle production; only by highly selective grazing, which is helped by herdsmen's choice of suitable areas, can cattle obtain a diet of adequate quality to maintain their weight during the dry season (Breman et al 1978).

Similar results were found in comparable but drier ecological conditions in Darfur in the western Sudan (Sudan 1974: 64-5). Here browse forms the major component of animal diet from January to June. Leaves and fruits, both of which are high in protein, are produced at times of year when grass protein is low; leaves are often produced before the rains break, in response to changes in humidity and temperature.

A number of environmental and management factors influence the use of natural pasture. The relative palatability of plants may affect the readiness with which they are eaten when vegetation is abundant, but when there is little to eat even normally unpalatable species are usually taken. Competition from other herbivores is not very great. There are relatively few large wild animals in the area any more, although termites and other small animals may take a part; in the Ferlo savanna in north Senegal (200-300 mm annual rainfall) one-third of yearly grass seed production is eaten by small animals (Bille and Poupon 1974).

Fire is a more important influence. Fire is uncommon in the sparse steppe vegetation of the Sahel, but where grass production during the period of vegetative growth exceeds 1 ton/ha dry matter, fires become common. In northern Nigeria, for example, Fulani fire the bush before

moving south in the dry season to ensure good regrowth on their return north in April and May (Van Raay 1975: 55).

Annual variations in plant production

In addition to seasonal variations, plant production varies considerably from year to year as a result of rainfall variations. In the dry areas of west Africa, primary production of plant material by photosynthesis is limited mainly by water available, and in areas of less than 600-700 mm annual rainfall, net primary production over broad areas is closely positively correlated with total annual precipitation. As a broad generalisation it is estimated that in the Sahel and Sudanic zones, each 1 mm of rain produces 1 kg/ha of consumable dry matter of vegetation (Le Houérou and Hoste 1977). So annual rainfall variations on a large scale lead to important changes in total primary production.

Bille (1974) measured soil water values and active growth period of the vegetation directly, and estimated that the "period of useful rainfall" started at the moment when approximately 60 mm of rain had fallen in 15 days, or 30 to 60 mm in a shorter time. This was enough for germination to start. This threshold varied in the Ferlo area of northern Senegal between the end of July and early August. Active growth of plants continued as long as monthly rainfall exceeded 40 mm, and continued until 10 days after the last major rainfall. This period of useful rainfall varied normally from 50 to 110 days per year, and plant production varied in proportion. In low rainfall years herbaceous plants shortened their vegetative cycle and took dwarf forms in order to conserve reserves of seed formation. Trees came into leaf later, leaf production was much reduced and leaves fell earlier. Fewer trees bore fruits or seeds, and when conditions become extreme, as in 1972, many trees died, although mortality rates varied widely according to species, location and age. In the exceptionally dry year of 1972

above ground primary production was practically nil. These variations and the consequent annual variations in carrying capacity for cattle are shown in table 15.

Table 15 Variation in plant production and theoretical carrying capacity for cattle in north Senegal

	Period of useful rainfall (days)	Above ground plant production (kg dm/ha)	Theoretical carrying capacity for cattle (head of cattle/ 1000 ha)
Normal good year	110	1300	187
Normal bad year	50	590	87
1972	0	0	0

Source: First two columns, Bille 1974; third column, Swift 1977.

After a dry year or years, plant production is able to recover rapidly, however. Grass seeds retain their germinative power for at least two years and probably longer, and research in the Ferlo indicates that only a small part of total seed production (3.3 kg/ha out of total production of 30.6 kg/dm/ha - i.e. 11 percent) is needed to ensure regrowth of the annual grass cover (Bille and Poupon 1974: 48).

Crop residues

Wherever agriculture is possible in west Africa, livestock also feed on crop residues. In the northern Sahel the only cultivation is in small oasis gardens using traditional irrigation methods, and this does not provide usable residues. Further south, the main subsistence crops are millet and sorghum, which need approximately 400-500 mm annual rainfall, although there are some very short cycle millets which can grow with as little as 200 mm. As a result, the northern limit of millet cultivation varies

between 500 mm and 220 mm mean annual rainfall, depending on soil conditions and surface drainage, while sorghum can be grown down to rainfalls of about 400 mm. Table 16 shows the zonation of possible cultivations in terms of rainfall from north to south across west Africa.

Table 16 Zonation of possible cultivation in terms of rainfall

Mean annual rainfall (mm)	Cultivations	
	Main	Secondary
250		Millet S
350	Millet S Cowpea	Cowpea
550	Millet M Sorghum S - M Groundnut S - M	Millet S Sorghum S Cowpea
800	Millet M - L Sorghum M - L Cotton	Millet Sorghum Cowpea Maize S
1000	Sorghum L Maize L Millet L Groundnut L Cotton	Millet S Sorghum S Cowpea Maize S Tubers

Source: Cochemé and Franquin 1967: 19

Note: S, M, L indicate short, medium, or long cycle.

A wide variety of crops, including maize, rice and tomatoes, are also grown in the bed of the Niger and Senegal rivers as flood-retreat crops when seasonal high water levels receed.

Animals feed on the residues of many of these crops as

part of arrangements between pastoralist and farmer who is aware of the value of having his fields manured. Animals may be simply grazed on fields, manuring them as they pass, breaking up the topsoil and mixing in part of the residues, or they may be corralled at night on one part of the field for periods from several days up to two months; droppings may also be collected from elsewhere in an effort to manure intensively. Van Raay (1975: 57-60) shows that these practices, especially the second, lead to considerable increases in organic carbon in the soil.

In northern Nigerian savannas, millet residues are of little value to livestock, because intercropping means that millet stalks cannot be grazed until the other crops have been harvested several months later, by which time they have decayed; cassava is likewise of little value because it is fenced, produces few residues, which are in any case poisonous. The other main crops, sorghum (guineacorn), cotton, groundnut and cowpea, all supply usable residues (Van Raay 1975: 88-95). Table 17 shows the yields and nutritional values.

Table 17 Yields and nutritional value of crop residues in Katsina

Residue	Mean yield (kg dm/ha)	Mean crude protein content (% of dm)
Sorghum	1738	2.2
Cotton	280	8.0
Groundnut	515	9.2
Cowpea	258	10.0

Source: Van Raay 1975: 95.

Using the various potential sources of livestock feed, Van Raay established a schedule of potential grazing days for the total livestock population in Katsina province. This is shown in table 18. Although this is a theoretical calculation only, it does indicate the potential relative

importance of the various sorts of vegetation for feeding livestock. The figures also show that even in the relatively densely populated Katsina province there is apparently an ample supply of fodder. Although it is likely that the actual utilisation rate by livestock, especially of crop residues, is much lower than the theoretical potential, the great importance of crop residues is clear: together they amount to 33 percent of potential grazing, with sorghum alone responsible for 27 percent of potential grazing days. Access to crop residues is thus responsible for greatly increased livestock production potential.

Table 18 Fodder potentials in Katsina Province

Land	Estimated fodder totals (1000 tons dm)	Potential grazing days of total livestock population per annum
forest	344	57
unreserved forest	77	13
residual, ie savanna	1506	251
sorghum	766	128
cotton	36	6
groundnut	86	14
cowpea	77	13
total	2892	482

Source: Van Raay 1975: 99

Seasonal variations in total fodder supply were also calculated as a fodder supply index by scoring each type of fodder each month. The result is shown in figure 2.

In Darfur a similar pattern of seasonal changes in the main sources of livestock feed was recorded, as table 19 shows.

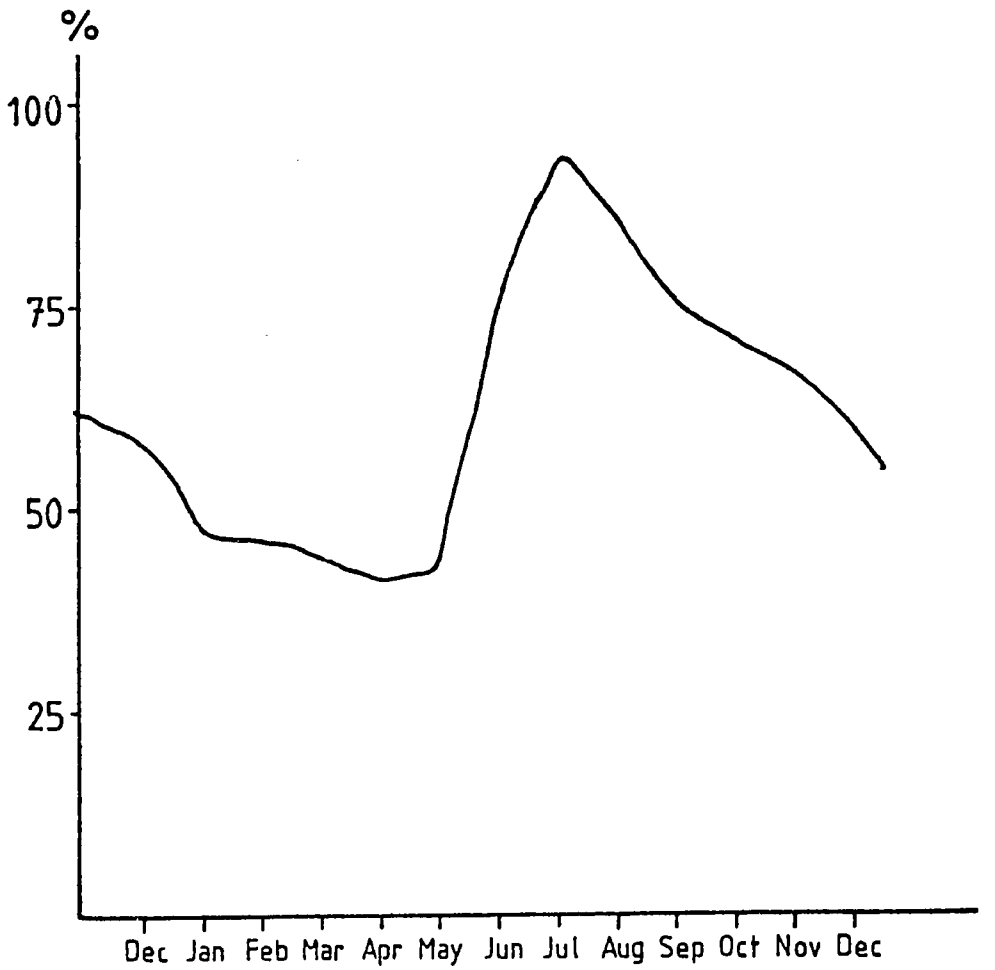
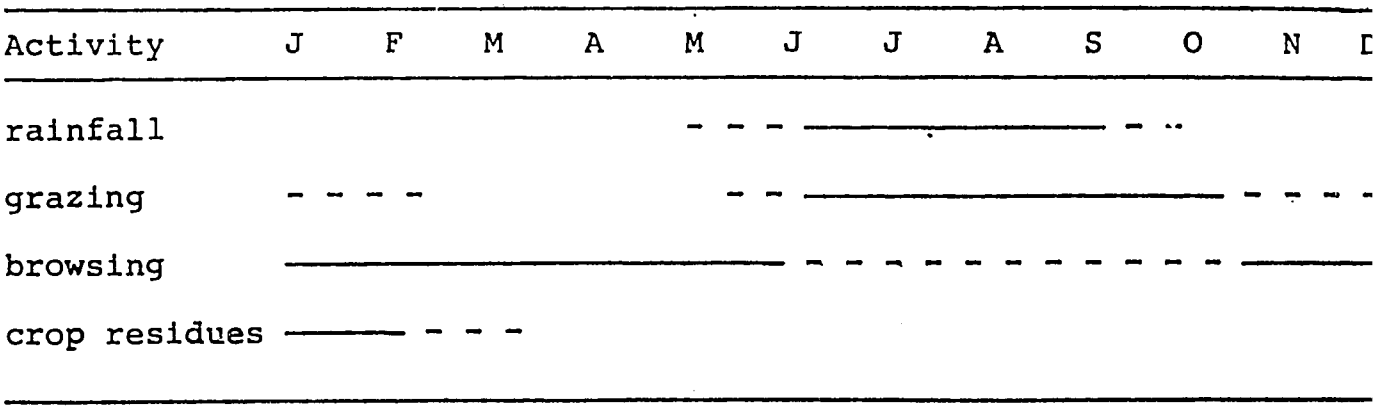


FIGURE 2 Fodder Supply Potential in Northern Nigeria (% of best score)
from Van Raay 1975:104

Table 19 Seasonal fodder availability in souther Darfur



Source: Sudan 1974: 64

Annual variations in crop residues are obviously considerable. Since rainfed crops require more water, better spaced, than pasture, annual variations in rainfall or in periods of soil water availability are likely to cause large fluctuations in the quantity of millet, sorghum and other residues available to livestock.

To summarise, total plant food available to animals increases from north to south in close correlation with total annual rainfall. The sharp seasonal concentration of rainfall causes a similar seasonal peak in grass growth and availability. This is offset to an important extent by browse, which, because it produces high quality feed (especially leaves and fruits) at a time of year when grass is scarce, is an important component of all animals' diets. South of about the 500 mm rainfall line, crop residues likewise become an important component of animal diets, also available at a time when grass is scarce. However the close correlation between rainfall and plant (and crop) production, means that the considerable annual variations in rainfall are reflected in considerable annual variation in the total feed available to animals.

2.1.2 Access to pasture

Traditional systems

Access to pasture (used here to include all plants whether grazed or browsed), to agricultural land and crop residues, rights to water, salt licks, trees or wild food plants and wild animals are regulated by various mechanisms in different pastoral societies in west Africa. Seasonal and annual variations in plant growth make collective use of pastures inevitable in the dry zone, and pasture land is generally held communally. This does not however necessarily mean that access is uncontrolled, only that pasture use is regulated at the level of a specified collectivity rather than at the level of individual landowners. Access may be controlled either through institutions defining which social or political group has pasture rights, or through ownership or control of the water sources without which grazing is not possible for much of the year. The main traditional sanction used to enforce these rules, where they existed, was, and to a limited extent remains, the threat of force. In most cases where access was once institutionally organised, the institutions have been weak in living memory.

Before considering institutional regulation of access to pasture, it is necessary to mention briefly one non-institutional way in which access to pasture and other environmental resources is controlled. Pasture is not used directly, but indirectly through grazing and browsing by domestic animals. Where land is communally held, each household's effective share of pasture depends on the animals it has available to graze. Differential appropriation takes place: (a) Where the number of animals owned or managed varies between households, in which case large herds have access to more pasture than households with small herds. (b) Where households own or manage different species of animals and each species has particular feeding preferences or a particular ecological niche; in this case households owning a particular species have access to resources denied

to households which do not own that species. In some cases the ownership of a particular species depends on the household's class position. This was for example the case in the Ahaggar mountains. Only "noble" Twareg traditionally owned camels, which occupy a distinctive ecological niche; this meant that the camels were herded at some distance from the Ahaggar itself in the Tamesna pastures to the south. Ownership of camels is still socially quite restricted in most Twareg societies which means that many households are denied access to the types of vegetation (principally browse) eaten by camels. Some Fulani clans herd mainly sheep, which restricts the types of vegetation to which the household has access by comparison with households herding cattle. In fact, since different species have different ecological requirements, the exact composition of household herds and flocks determines their effective use of vegetation. For example, watering intervals of different species determine the area around dry season water points to which they have access. An indication of these differences for Twareg in northern Mali is given in table 20.

But the main determinant of access to pasture is the institutional framework relating particular groups of people to a particular area of land. There are two broad categories of territorial organisation of pastoral societies in dry west Africa.

In the first place there are territorial systems based on lineage or class organisation, whereby membership of a specified social grouping confers use rights to pasture in the territory of that group. This category is characteristic of the hierarchic societies of the Moors and Twareg, and those agro-pastoral Fulani who have a hierarchic social organisation; traces are also found among the Tubu of northern Chad. The control and allocation of land rights

by the senior status group or individual in these hierarchic societies is often used to justify tribute payments from lower status groups in return for pasture allocation.

Table 20 Watering interval, normal grazing radius and area of pasture available in the dry season, Kel Adrar Twareg, north Mali

Species	Watering interval (days)	Normal grazing radius (km)	Potential pasture area (km^2)
camels	5	35	3,850
cattle	3	25	1,960
sheep	3	20	1,260
goats	2	15	710

Source: Swift 1979

In the Moor Emirates of the Adrar, Trarza and Brakna, noble hassan tribes and clans control the pasture lands, and use this to justify payment of a tribute by vassal groups. In addition there are tributary relationships between individual noble and vassal families, the latter generally outside the Emirate, allowing them access to pasture (Bonte et al 1978). It has been suggested that a first-come-first-served system also operates within this broad political allocation of pasture. In the Mauritanian Sahel a newcomer is not allowed to dig a well within a radius of 5-15 km around an existing well without the agreement of the owners of that well (Bataillon 1963: 33).

Among the Twareg there apparently was a system of pasture appropriation based on clan and class affiliation, and this still operates to a certain extent in areas where traditional Twareg social organisation is strong. The

system was until recently seen in clearest form in the Ahaggar mountains in the central Sahara. Here clans are territorial units (Nicolaisen 1963: 148-9; Bourgeot 1975: 267). The dominant noble clans have large territories, which are subdivided into clearly delimited territories of vassal clans. Noble clans can graze their animals anywhere in their own territories and are not bound by the subdivisions which limit grazing by vassal clans. The territories of vassal clans may be further divided into sub-areas, the right to which is vested in individual tenants, who are frequently section leaders. An annual rent for these is paid in kind to the Amenokal or confederation leader, and in return tenants are given the right to forbid grazing in their area or part of it so that plants will germinate and fully develop; tenants are also given the right to half the feral donkeys caught for domestication, the right to part of all the wild Barbary sheep hunted there, and the right to dues from the crops of every garden in the area. This system of rights and obligations regarding land appears to have fallen into partial disuse however, since already in the late 1950s camps of foreign clans were often found in other clan territories.

In the Ayr mountains of northern Niger it is probable that such a system previously existed since the territories of vassal clans were marked out by stone walls, river valleys or trees (Capot Rey 1953). A similar system may have also existed in the Adrar mountains of northern Mali. In the Tegama area south of the Ayr mountains in Niger in the early 20th century, noble Twareg clans controlled access to water and pasture and allocated them to vassal clans; the nobles used their control of land and water to extract a tribute from the vassal pastoral clans and from Hawsa-speaking agriculturalists (Oxby 1978). In the 19th century, the Kel Gress Twareg of Niger had a comparable

system; precise boundaries to clan territories are still remembered, although the social groups concerned are now dispersed (Bonte 1975: 187).

Nicolas (1950: 132) records that in the land occupied by the Kel Dinnik around Tahwa in Niger, each clan had defined territories; regular watering of animals at a well was considered to give permanent pasture rights unless the original owner of the well required payment of a toll which indicated that he intended to reserve priority in watering.

In the Malian Gurma, south of the Niger river, the original Twareg system remains in recognisable form (Gallais 1975a: 51-75). Here the territories of pastoral clans are relatively clearly defined and have changed little since the beginning of the century. Each territory is based around essential points such as wells and natural salt licks. Clans of equivalent social status (nobles on the one hand, vassals on the other) have territories which do not overlap; the area is divided between the main noble clans, and the territories of vassal clans are defined within these major units. Within each of these pastoral territories, exclusive use rights can only be created by work, especially by digging a well; pasture itself cannot be appropriated. However a group which puts up its tents four years running in the same place acquires a definite and inalienable right to that site, and others must move away if asked. Elsewhere pasture is allocated on a first-come-first-served basis, and each camp has the right to the minimum pasture space needed to feed its herds as long as it stays in that place.

The Tubu of northern Chad appear once to have had a territorial organisation in the mountains, with each clan in theory possessing one or more valleys (Capot-Rey 1963: 83; Chapelle 1957: 367). Strangers were admitted on certain conditions: they were forbidden to cut Acacia branches for

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traditional social organisation, which although generally no longer effective, often still determine the broad pattern of spatial distribution of pastoral groups, their ownership of water rights and their receptiveness to new forms of territorial organisation, some pastoral societies in dry west Africa have no traditional territorial organisation, and no claim to specific pasture areas other than effective occupation on a first-come-first-served basis, although this may still be combined with ownership of wells by the person or group which dug them. This lack of territorial organisation is found where pastoral groups are moving into new land, or where several groups coexist, as in northern Upper Volta or the Chad-Sudan border.

The nomadic pastoral Fulani of northern Nigeria and Niger, and in particular the Wodaabe, are an example of the first case (Stenning 1959: 239; Dupire 1962: 70-92; Dupire 1970: 229; Dupire 1975: 323-327). These Fulani are not organised territorially. Social organisation is flexible, the main unit being a migratory group composed of several clans, under an elected leader, the ardo. Spearhead migratory groups move into a new grazing area using it at first only as wet season pasture. After a few years they dig wells and start to use the area as a dry season base. When they move further north in the wet season, other Wodaabe groups, less mobile or more recently arrived, start to occupy the area in the wet season.

The Wodaabe do not know how to construct wells, so a clan subscribes and has a Hausa specialist dig it; the well is then the collective property of the subscribers. Use of the water is strictly reserved to members of the group. Wells tend to be dug alongside Twareg wells to be sure of finding water, and so pasture is competed for freely by Twareg, Buzu and Fulani. However it appears that there is some de facto synchronisation of transhumant movements at

the end of the wet season between Twareg and Fulani. In order to avoid too much competition for water and pasture, large herds normally move first and use principally surface pools, while small herds and small stock, which have lower demands, move later.

The successive changes in transhumance areas are the stages of the migratory drift by which Fulani have moved north into much of the area previously occupied by Twareg in Niger. At first these Fulani were obliged to accept the conditions of the Twareg and Hausa who controlled the land, and pay a tax. But as the Fulani acquired water rights by constructing their own wells and pools, they began to claim customary rights to pasture without paying tribute. And in areas where Fulani expansion is long established, transhumance routes and pastures tend to become well defined by habit, unlike the apparently chaotic pattern in recently occupied areas. In places unregulated use of land by migratory Fulani runs up against the formal territorial organisation of more anciently settled Fulani. In Cameroun, migratory groups of Wandu Wodaabe were forbidden access to the pastures of Ngaoundéré by the Fulani established there in the more rigid social framework of a lamidate (Dupire 1970: 224).

In Nigeria, there is a similar lack of territorial organisation among pastoral Fulani. Hopen (1958: 160) states that in Sokoto province in the past clans were territorially compact groups with acknowledged grazing rights, but that there is no recent sign of this. In Bornu province, no form of rights to exclusive grazing or to transhumance orbits are claimed by Wodaabe Fulani, although the establishment of village headships from pastoral clans by the colonial authorities resulted in the creation of agricultural villages with demarcated lands to which pastoral lineages returned regularly each wet season (Stenning 1959: 224-239).

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The spread of agriculture has reduced the land available for pastoral herds throughout the region. Gallais (1972) reviews some of these cases of loss of land, which are particularly severe in the flood retreat pastures in the valleys of the Senegal, Niger and Logone rivers, now priority areas for agricultural development. In the Ferlo in north Senegal large pasture areas have been taken over for peasant groundnut cultivation as a result of the agricultural colonisation schemes inspired by the Mouride religious movement (Pelissier 1966, Cruise O'Brien 1971). Land has also been alienated by governments for forest and wildlife reserves and large-scale agricultural development schemes (and in a few places for ranches). In some areas, increasing competition for agricultural land, combined with new economic processes such as migrant labour, lead to a progressive dissolution of previously communal tenure of village lands and its replacement by increasingly individual control, although this as yet generally stops well short of individual ownership. This makes relationships between pastoralists and peasant farmers based on crop residue grazing more difficult, particularly where these incipient changes in tenure are accompanied by changes in crop mix and increased intercropping. In northern Nigeria court cases brought by farmers against Fulani pastoralists for crop damage are increasing as a result of these changes (Van Raay 1975: 35-38). Pastoral Fulani in this area feel that sedentary Fulani chiefs, who once protected their interests and their access to grazing resources, now increasingly identify with the sedentary Hausa cultivators among whom they live.

A further process of potential major impact on pastoral access to environmental resources is hardly documented at all in the literature. This is the increased buying into the pastoral production system by non-pastoralists, in particular livestock and other traders, civil servants and other people able to invest money in livestock. This process takes two

main forms: buying animals which are then herded by contract herdsmen paid in cash or kind, and buying or paying for the construction of water points in places where access to water assures a largely uncontested access to pasture. It is likely that both these processes were speeded up by the Sahelian drought of 1968-73, when salaried state employees were able to buy animals from destitute pastoralists at emergency sale prices. But the process started before that. Already during the 1960s, livestock merchants from the inner Niger delta in Mali, especially Diawambé and Sarrakolé, were employing salaried herdsmen and building up large cattle herds which grazed in the north Gurma, previously used only by Twareg, Fulani and other local pastoralists (Fofana 1974: 118-9). If these processes continue, as seems probable, they will cause profound changes in the social and economic organisation of pastoral production.

This rapid survey of the way access to environmental resources is regulated in dry west Africa suggests the following conclusion. Where politically stable systems (usually hierarchical, class-based) have been long installed, social units tend to have a territorial base and there are institutions to allocate exclusive grazing, hunting or collecting rights to specified social groups; indeed the control and allocation of land may in some Twareg and Moor societies be the basis of social organisation itself. This type of organisation reaches a very high degree in the inner Niger river delta. On the other hand, where pastoral society is in a state of flux, either because particular groups are extending their range (such as the Wodaabe Fulani), or because several different pastoral societies, with no political mechanism for coordinating resource allocation between themselves, are competing for the same area, there is no allocation system other than first-come-first-served, or private ownership of water. The first type of system, based on a stable, hierarchical social order is characteristic

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More is known about pastoral techniques for the organisation and management of flocks and herds.

Domestication and Social Organisation of Herds and Flocks

West African pastoralists' animals are in general highly domesticated, unlike those of some other African pastoralists. However the attention given to different animals varies according to their place in the economy, and through that in the preoccupation of the herdsman. Thus some Twareg are much more interested in camels than in cattle, and spend a great deal of time looking after their camels and giving them appropriate veterinary care, while largely ignoring their cattle (Bernus 1978); other Twareg devote much more time to cattle. Fulani cattle are almost always well cared for, and some show an exceptional degree of social behaviour under human control; some herdsmen are reputed to be able to halt their herds by a simple signal, or to stop a charging bull with their voice alone. Wodaabe Fulani herds reputedly can be used by their herdsmen for self-defence, since they can be trained to charge or to gather round him at a signal (Dupire 1962: 97) Most Fulani herds have a few highly trained animals as herd leaders, and through them the whole herd can be easily manipulated by a small boy if necessary. Such pastoral skills are an important if unquantifiable element in the success of a pastoral economy.

Control of Reproduction

Some form of reproductive selection is practiced by most west African pastoralists since all males not needed for reproduction are usually castrated. Deliberate selection for desirable qualities only takes place in general with large stock. The qualities selected for in camels are more often stated in terms of individual beauty than in more practical terms. Thus the Tubu select their camel progenitors for their beauty, as do many Twareg (Chapelle 1957: 183;

Bernus 1978; Nicolaisen 1963); beauty appears in this case to mean a combination of coat colour, size and strength. Wodaabe Fulani make conscious crosses of Twareg Azawak cattle with their own Bororoji cattle, because Azawak are thought to be better milkers and to live longer. Bulls are only allowed an active reproductive life of about 4 years, in order that potentially sterile unions with their own daughters are avoided (Dupire 1962: 110-111). Fulani cattle are also carefully selected for coat colour, in order to give a uniform colour throughout the herd; this is usually expressed in aesthetic terms, but in view of the fact that Masai have been shown to select the coat colour of their cattle adaptively according to environment (light for heat reflection in the hot lowlands, dark for heat absorption in the cool highlands - Western 1979), it is likely that pastoralists' aesthetic preoccupation with coat colour in west African cattle and camels has an adaptive meaning. This needs further investigation.[1]

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1. Camels on the scuthern edge of the Sahara and in the Sahel, where temperatures rarely fall very low and heat is the main problem, are often very pale, almost white, and this is the colour said by these pastoralists to be most beautiful; they are also tall and slim, a good shape for facilitating heat loss. In the central Saharan mountains and north Africa, where winter temperatures often fall below freezing, camels are smaller and stockier, and dark camels are much commoner, although so far as I know there is no record of what colour is considered aesthetically most desirable. The difference between the short-legged, strong, dark-coated and foot-sure camels of the Tibesti mountains of north Chad, and the large, slim, pale-coated camels of the neighbouring lowlands is particularly striking (Le Rouvreur 1962); it shows the success of selective breeding by local pastoralists. Wodaabe Fulani believe cattle coat colours to have either good or evil effects: out of 8 coat colours which bring good luck, 5 are pale and one of the exceptions is a scapegoat to be slaughtered if the herd does not increase; all 5 coat colours that bring bad luck are dark (Dupire 1962; 115).

More is known about pastoral techniques for the organisation and management of flocks and herds.

Domestication and Social Organisation of Herds and Flocks

West African pastoralists' animals are in general highly domesticated, unlike those of some other African pastoralists. However the attention given to different animals varies according to their place in the economy, and through that in the preoccupation of the herdsman. Thus some Twareg are much more interested in camels than in cattle, and spend a great deal of time looking after their camels and giving them appropriate veterinary care, while largely ignoring their cattle (Bernus 1978); other Twareg devote much more time to cattle. Fulani cattle are almost always well cared for, and some show an exceptional degree of social behaviour under human control; some herdsmen are reputed to be able to halt their herds by a simple signal, or to stop a charging bull with their voice alone. Wodaabe Fulani herds reputedly can be used by their herdsmen for self-defence, since they can be trained to charge or to gather round him at a signal (Dupire 1962: 97) Most Fulani herds have a few highly trained animals as herd leaders, and through them the whole herd can be easily manipulated by a small boy if necessary. Such pastoral skills are an important if unquantifiable element in the success of a pastoral economy.

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However this is prevented except in very good years, in order to prolong lactations and increase young animals' survival chances. Sheep reproduction is controlled by the shepherd in some pastoral economies and not in others. Thus in Darfur in western Sudan, sheep reproduction is not controlled by the shepherd; seasonal changes in ewe condition result in a peak in lambings 5 months after the start of the rainy season, and 40 percent of births take place in November, December and January, against only 14 percent in May, June and July (Sudan 1974: 29-33). These sheep are not milked, which may be the reason for a lack of concern that many lambings take place at the start of the dry season. Among nomadic Illabakan and Kel Adrar Twareg further west, where sheep are milked, rams are prevented from mating from the start of the rains until December or January, with the result that most lambs are born at the start of the rainy season, ensuring a long lactation and that there will be grass for the lambs to eat at weaning (Bernus 1978, Swift 1979). In very good pasture years, rams may be left unattached after the birth of the lambs in order that a second lamb crop is produced in December and January.

The breeding cycles of Illabakan and Kel Adrar goats are regulated differently from sheep, reflecting the different ecological requirements and economic utility of goats. In a normal year the does naturally come into oestrus early in the rainy season, and the kids are born from September to January. For ewes and lambs, which particularly need grass at the period of maximum stress during lactation and at weaning, there is an ecological advantage for births to take place during the rainy season, when grasses grow rapidly. But goats browse by preference on the shoots, seedpods and fruits of bushes and trees, which are most abundant in the cold season. Thus goats do well to produce kids in the dry season, since there is plenty of the goats' preferred food during lactation, and the kids have the right food at weaning. This timing also provides goat milk for pastoral households

during the cold and hot seasons when milk from other animals is scarcest.

After the birth of the kids, the buck is prevented from mating until the start of the following rainy season in order that there is no reduction in the flow of does' milk such as would result from a new pregnancy. In a year when the rains have been very good, or where a household has adequate milk from other sources, the bucks are left unattached and a second kid crop is born the same year.

Other Twareg societies have a more elaborate system of timing goat breeding. In the Ayr mountains of Niger and the Ahaggar mountains of the central and southern Sahara, goat flocks are divided into two parts, each of which produces kids and milk in different seasons, usually during the rains and at the end of the cold season. This is done to ensure a good supply of milk for household consumption, and among the northern Twareg to keep up the quality of goat hair (Nicolaisen 1963: 38-39).

Herd splitting

Pastoral households often divide their herds and flocks into smaller functional management units at certain moments of the year, and may arrange for these to be herded jointly with similar management units belonging to other households. A common division in camel or cattle herds takes place in the dry season when animals still in milk stay close to the camp, while others remain at pasture some way away, and go directly to water every few days without ever coming to the camp. Alternately all the animals of one species may be sent away to better pasture elsewhere in the care of a herdsman.

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marriage as the nucleus of their future independent family herds, the head of the household may not be entirely free to dispose of them. Similarly, his milking cows are divided between his wives, who have full ownership rights over the milk and butter they produce. Women own cattle acquired by inheritance or as a gift, and these animals are also managed by the husband. Cattle presented at marriage by the husband to his first wife are also managed within the household herd, and they appear to belong simultaneously to both husband and wife.

The importance of these various transactions in the present context is the constraint they may place on the sale or consumption of animals from the household herd.

Distribution of animals between households

There are differences in the number of animals owned or managed by different households in all pastoral economies, but the degree of this unequal distribution of the main means of production is difficult to assess because of the lack of accurate data on household livestock holdings. Few data have been published, and none distinguish between animals owned and animals managed in the household herd, as discussed in the previous section. This is important since animal loans will conceal inequality: rich men will be likely to lend more animals than poor men.

What needs to be established is whether there are differences in characteristic patterns of distribution of total animal holdings between households according to broad ethnic, social or economic categories: for example Oxby (1978) suggests that there is greater inequality of animal ownership in Twareg than in Fulani society, and that this is a direct consequence of the class structure of Twareg society, based on control of access to land by noble clans. Differences are also likely to exist between rich and poor households within one broad ethnic category, or, where the society is socially stratified, as among the Twareg, within

classes. The available data only allow superficial, partial and somewhat confusing answers to these important questions.

In traditional Moor pastoral society the concentration of control of livestock into a few hands was remarkable. It was estimated in the 1940s that the range between poor and very rich families within one clan was from 40 sheep per poor family to 500-600 sheep, 100 cattle and 100 camels per very rich family. Reduced to Standard Stock Units,[1] the range in family wealth is from 4 to 205 SSUs, which means that the very rich family is over 50 times richer than the poor family. The chief of the clan was much richer than this, holding 500 cattle, 2000 sheep and 500 camels, or a total of 950 SSU; he was estimated to own one third of the livestock wealth of the clan (Dubie 1953: 141, 151-2).

Three sources of data are available on wealth distribution in Twareg society. The first, based on a French administrative census and thus of doubtful accuracy, gives figures for the average livestock wealth of different clans among the Iwllemeden Kel Dinnik Twareg in the 1930s (Nicolas 1950: 252-257). In table 22 I have recalculated Nicolas' data to show average livestock ownership by social class in this Twareg confederation. On average vassal clans are much richer than others in sheep and goats, while religious clans are richest in cattle. There are however no great disparities in average household livestock holdings between the classes (vassals are on average three times richer than slaves), although the data do not allow calculation of wealth differences between individual households within any one class, or in the confederation as a whole.

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1. 1 SSU = 1 camel, or 2 cattle, or 10 sheep or goats.

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Table 23 Family size and livestock holdings, Illabakan Twareg, Niger

Number of SSU	Number of families	Average "free" people/ family	Average total family size	Average SSU/ family	Average SSU/ "free" person	Average SSU/ person (total)
150 +	1	23	45	200	8.7	4.4
100-149	3	25.7	25.7	126.7	4.9	4.9
75-99	5	10.6	20.2	85.4	8.1	4.2
50-74	9	10.4	13.7	58.9	5.6	4.3
40-49	10	7.6	8.2	44.6	5.7	5.4
30-39	10	8.2	10.7	33	4.0	3
20-29	15	9.3	9.7	24.3	2.6	2.5
10-19	24	7.5	7.6	14.2	1.9	1.8
0 - 9	26	6.0	6.1	4.7	0.8	0.7
Total	103	8.6	9.9	30.5	3.6	3.1

Source: Bernus 1974: 68

Table 23 shows that inequality in livestock holdings, very marked at a family level, is much less marked in terms of the number of animals per head of "free" population in each SSU size class, and less marked still in terms of distribution per total head of family population. The richest family has 43 times as many animals as the families in the poorest SSU class, while the number of animals per "free" person in the richest SSU class is only 11 times that in the poorest, and the number of animals per person in the richest SSU class is only 6 times that in the poorest. Put another way, although 49 percent of animals are owned by 18

percent of families, those families account for 34 percent of the Illabakan population.

(c) Bernus also finds that camels and cattle are owned by the same rich families, and that poor families have neither, herding only smallstock. The poorest families own only goats, and the distribution of goats in Illabakan society as a whole is much more equal than that of other species.

(d) Bernus concludes from this that ownership of large animals and overall wealth in animals is directly associated with the presence of ex-slaves. According to him, in rich families ex-slaves profit from their masters' wealth and do not seek to leave them. By their labour they enable the family to maintain a large and diversified herd.

The family size data in table 23 show that richer households do join together to herd their animals in common, and the fact that camel and cattle herding is confined predominantly to such large families suggests that a large labour force is necessary for a diversified herd of this sort, although not all the large families, rich in livestock, have large numbers of ex-slaves with them.

Bernus' data suggest that livestock are unequally distributed in Illabakan society, although not to any considerable extent. Since ex-slaves own very few of the animals which make up the wealth of the large families, the best measure of wealth distribution in table 23 is that of SSU/"free" person; this is quite uneven in the wealthier SSU size classes, although it declines regularly in the poorer SSU size classes. When ex-slaves are added to the "free" family populations, the number of SSU/person becomes remarkably stable at between around 4 and 5.5 in the wealthier SSU size classes.

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animals per person is much less variable. The Kel Gress data imply that substantial concentration of at least some species may exist within a Twareg confederation comprising several social classes. The two Fulani samples suggest no significant inequalities in animal wealth. It would be hazardous to conclude more than this.

Herd structures

The age and sex structure of a herd or flock is a result of both the biological process of birth and death, and the way the herd is managed. For all species, a crucial factor in determining the age and sex structure is the age at which male animals surplus to reproductive needs are sold or eaten.

Camels

There are few field observations of camel herd structures. The proportion of males in a camel herd is likely to vary widely according to the use made of them: if they are used for transport, a household will sell few of its male camels and there will be a high proportion in the herd; if on the other hand young males are sold or slaughtered, the proportion of males will decrease rapidly in older age classes. Simulations using observed or estimated fertility and mortality, and assumed high rates of male sales, give likely herd structures with between 34 and 48 percent adult females (Dahl and Hjort 1976: 195; Swift 1979).

Cattle

There are several surveys of cattle herds kept by west African pastoralists. These surveys show considerable differences in age and sex structure, which reflect principally the age at which male calves are sold or slaughtered. Some simplified age and sex structures for west African pastoral cattle herds are shown in tables 25 to 27.

Table 25 Pastoral cattle herd structures, Niger 1970-71 (percent)

Age class	Fulani		Twareg	
	male	female	male	female
0 - 2 years	12.4	18	13.9	18.2
2 - 4 years	5.3	14.4	5.6	13.9
4 + years	6.0	43.9	5.5	42.9
Total	23.7	76.3	25.0	75.0

Source: Coulomb 1970-71

Table 26 Pastoral cattle herd structures, (mainly Fulani) northern Nigeria (1965-70) and northern Ivory Coast (1975)

Age class	Nigeria		Ivory Coast	
	male	female	male	female
0 - 1 year	(18.2)		9.6	9.8
1 - 4 years	13.0	15.3	13.0	21.1
4 + years	9.3	44.4	8.5	38.0
Total	31.4	68.8	31.1	68.9

Source: Nigeria calculated from Van Raay 1975: 44.
Ivory Coast, in Ivory Coast 1975: 21.

Table 27 Pastoral cattle herd structures (Fulani and Twareg), north Upper Volta (1975-6)

Age class	male	female
0 - 2 years	13	13.5
2 - 4 years	9.5	12.5
4 + years	9	41
Total	31.5	67

Source: Upper Volta 1976: 60

Given the difficulty in collecting accurate figures from a large sample of cattle under nomadic conditions, these figures should be treated with caution. However there appear to be substantial differences between the Niger Fulani and Twareg figures and the more southerly ones. In particular, females form a greater proportion of the total herd in the two Niger cases, indicating greater selling of males in these two economies than in the other cases. And the low proportion of males in the 2 to 4 year age class in the Niger cases (just over one third as many males as females in the same age class, as compared to around two thirds to three quarters in the other cases) indicates that in these two Niger cases, males are being sold much earlier than in the other economies. In fact the disproportion starts in the 0 to 2 year age class, indicating sales of very young calves.

There are two possible explanations of this. One is that, contrary to popular belief, the most nomadic of the pastoralists surveyed here are also those who sell most and earliest. But it is also possible that these figures

reflect the years in which they were made. The Niger surveys were made in 1970-71, after several years of growing drought, and may indicate a reaction to this by Twareg and Fulani pastoralists, forced to sell increasingly young animals. The other surveys were either in areas less affected by the drought, or were after it, when cattle pastoralists were building up their herds again.

The structures given in tables 25 to 27 are typical of largely nomadic pastoral herds in west Africa: females amount to 65-75 percent of the herd, which indicates a priority in management to milk production, with early sale or slaughter of males excess to reproductive needs. The figures also indicate that these west African nomadic pastoralists are not, as is still sometimes argued, irrational hoarders, unwilling for sentimental or prestige reasons, to sell useless cattle; these herd structures, especially the Niger Twareg and Fulani ones, indicate heavy selling of very young male cattle, well before they have reached maximum weight.[1] Surveys of nomadic Twareg cattle herds in Mali made after the 1973 drought gave an even higher proportion of females, reaching nearly 80 percent in some cases, which may indicate a great effort by pastoralists to conserve cows and heifers as the nucleus of their post-drought herd (ILCA 1978a: 51-53).

Cattle herds belonging to sedentary cultivators in general contain a larger proportion of males, usually between 35 and 50 (sometimes as high as 60) percent of the total herd, indicating both the use made by agriculturalists of adult oxen for ploughing, and also the fact that for

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1. However these are aggregate figures from a large number of herds, and it is not known how rich or poor the individual households owning the cattle are. The fact that very poor households, with few other possible sources of income, sell their male cattle surplus to reproductive requirements, does not mean that rich households will do so, which would be the true test of hoarding.

many cultivators cattle are the main medium in which agricultural earnings can be stored.

The structures of transhumant Fulani cattle herds in the central Niger delta in Mali, where pastoralism and agriculture are combined, appear to be intermediate between the nomadic pastoral type and the structure of herds belonging to sedentary agriculturists, with 38-40 percent of males in the herds. Here it does seem from preliminary surveys that there are appreciable numbers of unworked adult males surplus to reproductive requirements (ILCA 1978b: 57-58)

Sheep and goats

There appear to be few reliable published figures for the structure of west African pastoral sheep or goat flocks, although figures are available for the neighbouring Sudan (Sudan 1974, Wilson 1976a, 1976b). Preliminary investigations of sheep and goat flocks belonging to transhumant Fulani based in the central Niger delta area in Mali gave the following structures however (ILCA 1978b):

Table 28 Transhumant goat flock structure (Fulani), central Niger delta, Mali (1978)

Age class	male	female
0 - 15 months	20.8	21.7
16 - 21 months	5.2	10.1
22 - 27 months	1.4	8.1
28 - 33 months	0.9	7.8
33 + months	0.3	23.7
Total	28.6	71.4

Table 29 Transhumant sheep flock structure (Fulani), central Niger delta, Mali (1978)

Age class	male	female
0 - 6 months	6.2	9.9
6 - 15 months	9.1	19.3
16 - 21 months	3.0	8.2
22 - 27 months	2.1	7.4
28 - 33 months	1.8	6.6
33 + months	3.2	23.0
Total	25.5	74.5

Despite their importance to pastoral households as transport animals, there appears to be almost no published quantitative data on donkey populations in the dry part of west Africa.

Herd and flock production characteristics

Camels. There are few accurate figures. Saharan and north Sahelian camel cows generally reach sexual maturity at about 4 years, and first calve at 5 years, producing approximately a calf every two years until 20 years; bull camels are sexually mature at 5 or 6 years and are kept until 15 or 20 years if not sold or slaughtered earlier. Gross annual fertility (total number of calves born alive per annum as a percentage of total number of females of reproductive age) may be estimated at 40 percent.[1] Mortality of calves may be estimated at 30 - 40 percent in the first year, subsequently much less. A camel herd with these characteristics would allow a sustainable offtake of 6.5 percent per annum, and

1. In Darfur, Sudan, however, gross annual fertility was estimated at 70 percent (Wilson 1978).

would grow at 1.4 percent per annum (Swift 1979).

Cattle. West African cattle under extensive pastoral management in the dry zone are generally sexually mature at around 3 years or between 3 and 4 years, and it is unusual for them to live past 10 or 11 years. Gross annual fertility is generally estimated at between 60 and 70 percent, with first year mortality at 25-35 percent; mortality in subsequent age classes is estimated at 2-10 percent. Herd growth and sustainable offtake rates are especially sensitive to early mortality. With low calf mortality rates, a cattle herd will grow at 3-4 percent per annum (Dahl and Hjort 1976: 64), with higher calf mortality at 1.6 percent or less (Swift 1979). Offtake rates also depend on the age at which male calves are sold or slaughtered: if the main offtake is concentrated in the 4-5 year age class, when animals are fully grown, an annual offtake rate of around 8 percent of the total herd can be expected (Dahl and Hjort 1976: 167). Offtake rates of Fulani cattle in northern Nigeria appear to conform to this model, since up to this age sex ratios in each age class are approximately equal (Van Raay 1975: 44). Further north, in Niger and Mali, calves appear to be sold or slaughtered earlier. Since this avoids the high mortality of early age classes, the offtake rate expressed as a proportion of the total herd is higher, and has been estimated at between 11.8 and 13.4 percent per annum. Where mortality is high, it is probably advantageous to pastoral households to sell or slaughter animals very early, since the low weight of animals sold is more than compensated by the later mortality loss that is avoided (Swift 1979).

Sheep. There are few empirical data on sheep production characteristics under extensive or nomadic pastoral management in west Africa; data from western Sudan is probably the closest to reality (Sudan 1974, Wilson 1976a). Ewes reach sexual maturity at around 10-12 months and reproduce until about 6 years. Gross annual fertility is probably highly

variable, depending on environment and management, with sheep in the dry north at the extreme limit of their range having lambing rates of 80 percent or less, and those in better conditions further south lambing rates of between 120-140 percent. Mortality is high, probably around 30 percent in the first 6 months in the Sahel for single born lambs, and higher for twins. Sheep flocks with these characteristics will give an annual offtake of around 16-30 percent depending on the lambing rate, and will grow at rates of up to 25 percent per annum.

Goats. Does are sexually mature at 10-12 months and reproduce until about 6 years. Kidding rates are generally higher than sheep, in part because of higher incidence of multiple births. Thus in western Sudan kidding rates of 170 percent were recorded, and it was estimated that in some flocks they might be as high as 240 percent (Sudan 1974). Mortality to 6 months is probably around 30 percent. A goat flock with these characteristics will allow a sustainable annual offtake of 25-30 percent; in many pastoral societies a substantial proportion of male kids is killed at or shortly after birth in order to release as much milk as possible for human consumption. Goat flocks with these characteristics will grow at 25-30 percent per annum.

Comparison of nomadic and sedentary herds. Empirical data from the Sudan (Sudan 1974: I. 5-10) suggests that there may be differences in fertility and mortality rates between nomadic and sedentary cattle herds, with the nomadic herds performing better on each score, presumably as a result of their better nutrition and ability to escape disease. The relevant rates are shown in table 30.

However a comparison of nomadic Twareg and Fulani with sedentary cattle herds in Niger failed to find significant differences in fertility and first year mortality (Coulomb 1970-71). So the question remains open as far as west Africa is concerned.

Table 30 Comparison of production characteristics of nomadic and sedentary cattle herds in Darfur, Sudan.

	calving rate (percent)	percent of heifers calving before 4 years	calf mortality 0-6 months (percent)
nomadic herds	64.8	65	11
sedentary herds	39.5	28	40

2.4 LABOUR

As is the case with other aspects of the pastoral economy, little hard information is available on pastoral labour use.

Origin and size of labour force

West African pastoral labour is largely household labour, supplemented in many of the pastoral societies concerned until recently (and in some cases still) by a labour force of slave origin. Client labour has been important in some societies, and hired labour, until recently unknown, now appears to be increasing.

Traditional division of labour by age, sex and class is now often modified. Thus although traditional noble Moor or Twareg women rarely worked at pastoral tasks, they now may do so. Children of both sexes in all social classes now form an important part of the work force, replacing in some cases departed slaves. There nevertheless remains a fairly clear age/sex division of labour in most pastoral societies. Supervision and watering of camels, cattle and sheep is almost everywhere done by men or teenage boys, although goat flocks are often looked after near camp by children or women. Among Twareg, men milk all large stock; among Fulani women milk cattle. Domestic work is done by women, helped by small children for such daily tasks as fetching

water and firewood, and for looking after infants. But this allocation of tasks is no longer absolute, if it ever was: women will herd cattle if labour is lacking, and men will fetch camp water.

The relationship between the size of a household and the size of its herd is important. There is a fairly narrow range of sizes within which households have adequate labour to manage a herd, and herds can provide adequate milk and saleable animals to provide for a household. Outside this range either households will have inadequate labour to manage their herds, or the herds will not provide adequate income to ensure the survival and reproduction of the household (theoretically both can be true at once, but this is rare). This problem is resolved in a variety of ways in west African pastoral societies.

In the first place it is necessary to distinguish both long-term demographic and social mechanisms which determine overall patterns of labour availability, and shorter-term adjustments to imbalances between the size of a household and its herd.

In the long-term, the size of the labour force available to manage household herds is a function of the social organisation of the households themselves (polygynous like a majority of pastoral Wodaabe, or monogamous like almost all Twareg), and the institutions, such as slavery or labour hiring, by which non-family labour is mobilised (Bonte 1977). It also depends on the demographic characteristics of the household itself. There is some evidence that, regardless of their social organisation, all west African pastoralist societies share some demographic characteristics which distinguish them from agricultural populations in the same regions. A demographic survey of Fulani and Twareg nomadic pastoral populations in Niger, surveys of pastoral and agricultural populations in the

Senegal river valley, in the inner Niger river delta and in Cameroun, indicate that pastoral populations have lower rates of natural increases than neighbouring sedentary farmers or than national averages, and that these low rates of natural increase are the result of low birth and death rates (Swift 1977). These trends are confirmed by a detailed demographic study in the early 1960s among Baggara and Kawahla pastoralists in the Sudan, where it was found that nomadic pastoralists had considerably lower fertility than sedentary agricultural populations within the same ethnic group, and that as pastoralists settled and changed their occupation to agriculture their fertility rose (Henin 1968, 1969).

It has been suggested (Swift 1977) that the low fertility of west African pastoral populations may be an adaptation (achieved through social regulation of fertility, acting through late age at first marriage and similar, as yet unknown, mechanisms) to the relatively low labour requirements per unit of output in a pastoral economy, to the large annual and longer term fluctuations in food supply resulting mainly from variable rainfall, and to the relative insensitivity of pastoral output to increased labour inputs. In such a situation it would be advantageous to pastoral households to remain small and grow slowly in relation to their herds, while devising institutional ways of mobilising non-family labour when needed. Slaves, hired herdsmen and clients can be taken on in a series of good years, and released in periods of crisis when food supply and labour requirements are low. An example of this labour force flexibility and occupational mobility in the 19th century Niger Twareg economy is given by Baier (1976).

Slavery was once a common institution in west African pastoral societies. In Moor, Twareg and Tubu societies, household labour was supplemented by slave labour both for domestic tasks and for herding. Where agriculture was

practiced, it was also usually done by slaves. A slave caste was present in agricultural Fulani societies, but was responsible for agriculture not pastoralism. There were no slaves among the fully pastoral Wodaabe Fulani.

In Twareg society the number of slaves as a proportion of the total Tamashek-speaking population was low (10-20 percent) in the north where pastoralism alone was practiced, and very high (70-90 percent) in the south where most slaves were employed in agriculture (Bernus 1975a: 29). But it is difficult to draw conclusions from this concerning the role of slave labour in the pastoral economy, since many other factors were involved, including the fact that the slaves came originally from the south and, many were enslaved in situ at the time of the Twareg southward population movements. Possession of slaves in some Twareg societies is concentrated in a few households.

Within the context of these long-term features of social and demographic organisation relevant to labour availability and mobilisation, imbalances between household size and herd size arise from two main causes: (a) because of the normal process of growth and decline in family size, and the reproduction of families from one generation to another; (b) because of natural events and accidents; natural growth of herds in a good series of years may take them to a number above the household's requirements or its ability to provide labour; more often, a disease epidemic, sudden drought or attack by predators will reduce the herd to below the number sufficient to provide food. This problem was first outlined in detail by Stenning (1971), who described the main social mechanisms by which pastoral Wodaabe Fulani regulate the relationship between the size of domestic units and their herds. Variations of these mechanisms are common to most west African pastoral societies.

Imbalances between the sizes of households and their herds arise in a regular cyclical manner as a result of the processes of household reproduction, herd reproduction and the transmission of animals. Households start from the marriage of two partners or from the birth of their first child, grow in size as children are born or, in polygynous societies, the husband takes additional wives, then decline in size as children in turn marry and become increasingly independent. Herds reproduce, grow and are transferred between families. These are not discrete, isolated processes, since households of one generation are dependent first on their parents' and later on their children's households, both in the transmission of rights to the animals from which household herds are composed, and also for cooperative use of labour. In Wodaabe Fulani society, nominal ownership of animals passes gradually from father to son, starting at the naming of the son at the age of a few days when he is given a calf or two as the nucleus of his future herd. He is allocated further calves at later stages; these animals grow, mature and themselves have calves while the son is growing up. At his marriage these animals are the basis of his herd. But although after the birth of his first child the son sets up an independent household, his herd usually continues to be herded together with that of his father until the son's household has sufficient labour, essentially a herdboy, to become really independent. The same process happens with the younger sons in turn. The father's herd is thus gradually depleted at the same time as he loses the labour of his sons; the last married son herds his father's remaining cattle, but on this son's marriage, the father is left without cattle and becomes dependent on his eldest son. The pattern of growth and then decline of the household parallels that of its herd.

In a more restricted, short-term sense, imbalances between household size and herd size resulting from seasonal

variations in the labour demands and the milk production of the pastoral economy, and from irregular natural hazards such as loss of stock from disease, are resolved either by the transfer of animals, through a variety of formal transactions, from animal-surplus to animal-deficit households, or through mechanisms or arrangements by which people move temporarily from labour-surplus to labour-deficit households. In Wodaabe Fulani society, Stenning identifies cooperation within polygynous households, mainly help from co-wives or their daughters for milking, as a main way of overcoming labour insufficiencies. In single households, the wife's unmarried sister or sister's daughter may be borrowed; alternately households may merge to herd cattle. In some Twareg societies, long-term quasi-adoption of children of close kin appears to be a relatively common way of achieving the same objectives. For day to day herding, individual households within a Twareg camp cooperate extensively in herd supervision, the most time-consuming task (Swift 1979). For major transhumant movements of cattle (for example out of the inner Niger delta) individual household cattle herds often join up so that their herdsmen can share the work. In north Cameroun, cattle herds commonly join together, with the owners taking it in turns to look after the animals (Fréchou 1966: 22-23).

Labour-deficit households can take on additional non-family labour. All the pastoral societies of dry west Africa have recognised contracts by which households lacking in labour can hire herdsmen for a season, a year or more; the herdsman is fed and clothed, and rewarded in animals at a standard rate. However in the last two decades straightforward labour hiring, with professional herdsmen paid a cash wage, has started to happen. It is still rare for a pastoral household to hire labourers in this way; the practice has spread as new categories of non-pastoral herd owners, especially minor government officials, livestock traders and other urban dwellers with income or capital to invest, buy animals and need people to look after them.

Labour requirements of herding

There are three main tasks requiring regular and sustained labour in a pastoral economy, and many minor ones, the labour requirements of which are small or intermittent. These latter tasks, such as veterinary care or visits to market, are not considered here. Even data on the three main tasks - herd and flock supervision, watering and milking - are scarce.

Supervision. Herd and flock supervision is a major task, but there is a wide latitude in the labour required, since it varies according to species, the type of terrain (it is higher for example in thick bush or where there are predators), or the inclination of the herder. In open terrain, supervision is often a largely passive task requiring merely the presence of a herdsman. Goats in particular are often looked after by children.

Supervision is the most time-consuming task if animals are continually supervised since it requires the full-time presence of a herdsman. Where there are growing crops, predators, the possibility of theft, or many other animals, camels and cattle need permanent supervision. Otherwise they may not be supervised at pasture. Many cases are recorded where camels and cattle are not supervised at pasture, including for example north Cameroun (Fréchou 1966: 22-23). Pastoral tradition may play a part in this. Thus in western Niger, Twareg do not supervise their cattle or camels at all, leaving them to return on their own to camp each evening; Fulani in the same area always supervise their cattle at pasture, and if no men are available the women do the job (Sidikou 1974: 172-3). But Fulani in the Ferlo of north Senegal often leave their cattle without herdsmen (Gallais 1969). Tubu leave camels unguarded, and in the mountains it may take a Tubu man up to eight days to find his riding camel. In the dry season the herdsman waits

at the well and the camels return there when thirsty. Even in well-populated areas, herdsmen only gather the herd together and release it in the grazing area each day; they do not supervise while the herd grazes. Cattle are also unsupervised most of the time (Chapelle 1957: 183-6)

The labour requirements of herding rise when households have animals of several species herded separately, or when animals are kept close to fields with growing crops. In the latter case, cattle herds may require permanent supervision, and the work may be more active than usual. To a certain extent these two situations are complementary. Thus in Niger, Twareg north of the northern limit of agriculture tend to have a diversified pastoralism with several species, which spreads risk but increases pastoral labour requirements. South of about the 350 mm rainfall line, agriculture becomes common, competing for space with pastoralism; permanent supervision of animals becomes necessary both to take the cattle to northern pastures away from crops during the rains, and to control them when they return to the cultivated area in the dry season (Bernus 1975b).

Watering. Although it takes less time than supervision, watering can be a demanding, energy-consuming task, especially with camels and cattle. A common pattern in dry west Africa is for camels not to drink at all for 5 or 6 months during and after the rainy season, and to be watered every 5 or 6 days for the remaining months of the year, drinking 50-100 litres each time. Cattle also get water from surface pools or fresh vegetation for about four months of the year, and are watered every two or three days for the remaining months, drinking 40-80 litres each time. Sheep need to be watered for about 6 months of the year, every third day or so, drinking 3-8 litres each time. Goats drink slightly more often than sheep, approximately every second day, but take only three or four litres each time, and can sometimes be watered from waterskins rather than directly from the well.

The type of water source determines to a large extent the work involved in watering animals. Shallow sand wells in wadi beds are easily dug and the water easily lifted, but the work becomes longer and more strenuous as the well becomes deeper. Wells up to about 25 m deep are usually drawn by hand; deeper than that a camel, ox or donkey draws the water.

There is little quantitative information on the time necessary for watering. Conditions certainly vary. Thus in the Djourab and Toro lowland areas of north Chad, wells are nowhere more than 2 m deep and Annakaza camels area easily watered (Le Rouvreur 1962: 276). On the other hand in parts of Niger, where wells are 80 m deep it is estimated that each adult cow takes at least 11 minutes (and probably more) to water (Dupire 1972: 23-24). Watering labour for all species is concentrated in the dry season.

Milking. Milking does not need a large amount of labour, and lasts only as long as animals are in lactation. Animals are normally milked twice a day, taking between about two and six minutes each, although this may be reduced to once a day near the end of a lactation. As a result of the seasonal distribution of lactation, milking labour (except for goats) tends to peak in the rainy season in the north of the dry zone, and to be more evenly distributed throughout the year further south.

Supervision labour is relatively constant throughout the year, but watering and milking labour vary greatly according to the seasons. Among north Malian Twareg for example (Swift 1979) there is a period of relatively high labour requirements for milking and watering (although it is low in relation to labour available) for camels and cattle during much of the cold and hot seasons, with a sharp fall at the onset of the rains when watering is no longer necessary. Cattle in particular have relatively high labour requirements at the end of the hot season and at the start of the cold

season, due in both cases to watering. Sheep and goats have a somewhat contrasting pattern, with sheep labour requirements for watering and milking being relatively evenly distributed throughout the year except for a fall at the start of the cold season, and goats showing a high peak in the cold season (due largely to milking) and falling to minimal amounts in the rains.

The importance of this seasonal distribution of labour demand in a north Sahelian production system (Swift 1979) is that peak labour requirements, especially for watering which is an arduous and energy-consuming task, occur in the dry season, when milk production is at its lowest. For all species except goats, milk production is lowest in the period from January to May or June, which corresponds to the hot dry season in which maximum watering labour is needed; milk production is highest in the period from June or July to September or October, when no watering is necessary and labour is needed mainly for the easy task of milking itself. Goats are an exception in that the seasonal pattern of their milk production does to a certain extent mirror that of labour requirements. The conclusion is that in this particular case, with the partial exception of goats, the hardest work occurs at the time of least milk availability. This affects principally the men, who water the camels and cattle, but since millet becomes the main food in this season, cooking and pounding labour requirements for women are also high in this season. Children may also be fully employed fetching drinking water several miles from camp. This hot dry season, when demanding labour requirements coincide with food shortages, contrasts with the following wet season when herding and domestic labour requirements fall markedly, and food is abundant.

2.5 OUTPUT

In this final section I attempt to discover an order of magnitude for the outputs from the pastoral production systems

described in the previous sections, and, more ambitiously, to express these in terms of the productivity of land and labour. These are tentative calculations based on inadequate information, but they are intended to focus attention on important questions nowhere discussed in the literature. The calculations use animal production data from Twareg and Fulani nomadic herds in Niger and Mali, and labour data in a Twareg pastoral economy in north Mali.

Pastoral output

The main measurable outputs of a herd or flock in the Sahel are meat (as such, or in the form of live animals), milk, skins, manure, animal traction, and in the case of camels, caravan transport. For want of data I have been obliged to ignore all except meat and milk. This probably does not greatly affect the analysis, except where camel transport is concerned; earnings in this can be considerable (as was pointed out earlier), but they are available to a small and probably declining portion of the overall pastoral population. Hides and skins of animals slaughtered for consumption (mainly sheep and goats, since most cattle are sold live), are rarely sold, and are a small item in household subsistence budgets. Manure is not concentrated on fields in the largely nomadic pastoral production systems of concern in this section, and animal traction exists only at a few deep wells.

It might be argued that an allowance should be made in output calculations for the annual growth of herds and flocks, since these represent an addition to capital. Cattle herds are commonly estimated to grow at 3 to 4 percent per year in the Sahel, sheep and goats more, camels less. However while this can certainly be true in the short run, in the long-term livestock populations both grow and decline. As a result it seems reasonable to make no allowance for herd growth. (It would be relatively small in cattle herds, compared to a potential 12 percent annual offtake rate).

Output is calculated as annual meat production plus milk available to households (whether drunk, sold or turned into butter, but not including the milk drunk by calves).

Estimates of total meat and net milk production in herds of 100 animals of normal age and sex structure in Niger and Mali are shown in table 31. The Mali estimates are in almost all cases below the Niger estimates, which is reasonable since they are for a drier area. Since the Niger conditions are more representative of the Sahel in general they are used in the calculations which follow.

Table 31 Production from nomadic Twareg and Fulani herds

	Niger (kg/year/100 animals)	Mali
camels		
- meat	1,332	928
- milk	18,400	12,846
cattle		
- meat	1,300	909
- milk	8,900	4,995
sheep		
- meat	364	264
- milk	1,776	1,544
goats		
- meat	385	220
- milk	2,700	2,969

Source: Niger from FAO 1977: 337-8, 341-3.
Mali from Swift 1979.

A problem arises in valuing this output. To value it at current market prices makes comparison with other areas difficult. To express it in food energy terms (kcal or MJ) would seriously underestimate the value of production, since meat and milk are high value foods with a high value per calorie. Instead of these, production will be valued in millet equivalents, that is the amount of millet for which the meat and milk could theoretically be exchanged at current market prices. Millet is in fact the commodity on which most household income from the sale of meat or milk is spent, and is a major consumption item. Valued thus, comparison with agricultural economies in the area becomes easier. Meat and milk prices for Niger in 1974 are available only for cattle, (FAO 1977: 242, 362), so the following calculations concern cattle only.

In 1974 in the Tahua area of Niger, the mean price of millet over the year was 35 F CFA/kg. A high quality steer of 160 kg dressed weight cost 25,000 F CFA live, giving a meat price of 156.25 F CFA/kg. Milk prices varied between 20 and 120 F CFA/kg. A conservative estimate of milk price would be that 1 kg millet would be exchanged for 1 kg milk, a not uncommon barter rate in practice, implying a milk price of 35 F CFA/kg. At these prices the total meat and milk production of a herd of 100 cattle is approximately equivalent to 15,000 kg of millet as table 32 shows.

Table 32 Production from a herd of 100 cattle, valued in millet

Production	millet equivalent (kg)
1,300 kg meat	5,804
8,900 kg milk	8,900
Total	14,704

Productivity of land and labour

Cattle herd output valued in this way can be expressed in terms of the productivity of either labour or land, in order to compare pastoral land-use with agriculture.

Some estimates of pastoral labour requirements make an estimate of labour productivity possible (Swift 1979). A herd of 100 cattle is supervised by two full-time adult herdsmen; if they each work 12 hours a day, supervision labour is 24 man hours/day or 8760 man hours/year. Watering and milking requires less labour, estimated at 3629 man hours/year, and can be done by the herders during supervision time, so is not added to supervision time. In fact supervision is often more like leisure than work; the herders watch over the animals, sometimes sitting under a tree. On the other hand, watering and milking, especially the former, are arduous. This gives maximum (8760 man hours for supervision) and minimum (3629 man hours for watering and milking only) estimates of the labour requirements of a herd of 100 cattle, with which to deflate the total herd production of 15,000 kg millet equivalents. On these figures, each man hour of labour produces between 1.7 kg and 4.1 kg of millet equivalent.

Calculating the productivity of land under pastoral use involves some even more hazardous estimates, but is worth attempting in order to have an idea of the orders of magnitude involved.

A herd of 100 Sahelian cattle with a normal age and sex structure would have a total liveweight of approximately 16,000 kg. The vegetation biomass needed to support each 100 kg liveweight of Sahelian cattle is estimated at 2750 kg dry matter/year, on the conservative assumption that only one third of this biomass is grazed (FAO 1977: 203). Biomass production on different Sahelian soils varies between

about 800 and 2200 kg dm/ha, and for the sake of calculation may be taken as 1200 kg dm/ha (FAO 1977: 207). In these conditions each 100 kg liveweight of cattle needs 2.3 ha of grazing land, and the reference herd as a whole needs 368 ha. Thus a herd of 100 Sahelian cattle produces 15,000 kg of millet equivalent from 368 ha of land, giving a land productivity under pastoral use of 41 kg millet equivalent per ha.[1] It should be stressed that these are conservative estimates of land requirements, and almost certainly exceed what Sahelian cattle now get; with this amount of land total production from the reference herd would almost certainly be higher than is assumed here. However this estimate of the quantity of land needed to feed cattle in a sustainable manner is a better measure to use for the purpose of estimating land productivity than the actual amount of land per head of cattle, since it is widely believed that present grazing pressure is degrading the environment, and is thus not sustainable.

These figures for the productivity of land and labour in pastoral use can be compared with figures for agriculture in comparable conditions. This comparison will disadvantage pastoralism since the pastoral productivity figures are from a drier, ecologically less productive area than the agricultural productivity figures.

Table 33 shows figures for the productivity of land in African millet cultivation, with the Niger pastoral productivity figures for comparison.

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1. Using the same figures for the land required by 100 cattle, and production figures from table 30, each hectare is producing 3.5 kg meat and 24.2 kg milk a year. This compares with an estimate of 4.13 kg meat/ha/year in Darfur in the Sudan (Sudan

Table 33 Productivity of land in agriculture and pastoralism

Area	millet yield (kg/ha)
Agriculture:	
west Africa general[1]	400-600
Upper Volta[2]	350
Niger[3]	297-436
north Cameroun (hill terraces)[4]	660-720
Pastoralism:	
Niger	41

Sources: 1. Johnston 1958: 93;
2. BDPA 1965:
3. Niger 1970: 23;
4. Boulet 1975: 67

It is clear from table 33 that, calculated thus, the productivity of land under pastoral use is smaller by an order of magnitude than that of land under agricultural use. This is not a very realistic comparison throughout much of west Africa; on land which receives less than about 350 mm rainfall rainfed agriculture becomes too risky and low yielding to be a serious proposition, and pastoralism is the only possible use of the land. But in areas south of 350 mm where agriculture in association with pastoralism becomes widespread, it is clear that pastoralism has a very low yield per unit of land.[1] The implication is that as rising

1. In this area manure from pastoral herds becomes an increasingly important input to agricultural production, thus increasing the value of output from the herds. The value of milk relative to millet probably also rises further south, so total herd output would rise further south, although almost certainly by much less than ten times.

populations in these regions increase the demand for land, extensive pastoralism will be edged out, as is already happening. The task in these areas will be to increase the productivity of pastoralism per unit of land, by use of fodder crops and other feed supplements which reduce the area of natural grazing used.

Table 34 shows figures for the productivity of labour in African millet cultivation, compared to the Niger pastoralism figure.

Table 34 Productivity of labour in agriculture and pastoralism

Area	millet yield (kg/man hour)
Agriculture:	
Gambia[1]	0.47 - 0.49
north Cameroun[2] (hill terraces)	0.43
Upper Volta[3]	0.73
Upper Volta[4]	0.9
Malawi[4]	0.43
Uganda[4]	0.5
Pastoralism:	
Niger	
- supervisory labour	1.7
- watering and milking labour	4.1

Sources: 1. Haswell in Johnston 1958: 139;
2. Boulet 1975: 67;
3. BDPA 1965;
4. Clark and Haswell 1970: 99.

Here the situation is reversed. Each man hour of labour in the Niger pastoral economy produces a great deal more than

a man hour in the millet farming examples shown. How much more depends on whether the pastoral labour figure used is that for total supervision time (which, as was pointed out earlier, has a high leisure component) or only that for time devoted to watering and milking, the two main tasks requiring labour as opposed to time. In the latter case, pastoral labour productivity is greater than Gambian and north Cameroun labour productivity by an order of magnitude.

It would be wrong to draw too firm a conclusion from these figures. But they do help to explain the place of pastoral production systems in west African rural land use, particularly when taken in conjunction with the characteristics of pastoral economies and societies discussed earlier. Pastoral production in west Africa is almost everywhere the product of a long tradition, involving social and political organisation of the use of grazing land, indigenous technologies and social mechanisms to mobilise labour. Although pastoral output per unit of land is low, the opportunity cost of the land concerned is low or nil, since it is often land which agriculture cannot use. Pastoralism appears in many respects to be a risky enterprise, requiring a considerable capital. Incomes from pastoralism are often high relative to agriculture, and output per unit of labour is much higher. This makes it likely that people with a pastoral tradition, who have animals or who can obtain them, will return to pastoralism whenever they can, even after major disasters such as the 1973 drought. West African pastoralists have the expertise, social organisation and motivation to produce livestock, and this seems on the available evidence to be an economically rational and rewarding thing for them to do. Development programmes starting from these premises have a greater chance of success than those which seek to impose on pastoral economies notions from elsewhere about the proper nature of economic activity.

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