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SAHELIAN SOCIAL DEVELOPMENT

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IV. THE CONDITIONS OF AGRICULTURAL INTENSIFICATION IN THE WEST AFRICAN SAVANNAH

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Introduction

The intensify of agriculture, as we define it here, ia: (a) a measure of the frequency of land use, (b) a classification of agricultural techniques that promote more continuous cropping and the restoration and maintainance of soil fertility, and (c) a means of increasing yields by raising inputs of energy (principally labor) on a fixed area of land. In the simplest terms, intensive cultivation is that system of agricultural land use in which fields are planted with crops for longer periods of years than they are allowed to remain unfarmed or fallow. The most intensive system would keep the same field in annual production or, by means of multicropping, produce several successive harvests from a single plot in one year. A piece of land farmed two years out of every three or six years out of ten could be technically referred to as intensively used. In contrast, the extensive system of shifting cultivation (also called slash-and-burn, swidden, bush fallow, etc.) makes use of impermanent fields planted with crops for shorter periods of years than they are left fallow (Conklin 1961). The clearing and burning of bush or forest cover releases nutrients accumulated in the vegetation and removes plants that would compete with the growin crops. Over a few years of farming, the amount of phosphorus and potassium from the ash, the level of humus, and the amount of nitrogen and phosphorus mineralized from it decline (Nye and Greenland 1965:123). Crop production is further reduced by heavier growth of weeds and insect predation until the field must be fallowed for natural regeneration. In many areas 15 to 20 years may be required for the accumulation of necessary nutrients, and fallows shorter than 4 to 8 years may cause forest to be replaced by grass. Efforts to keep a field in more continuous production and shorten or eliminate fallow periods while preventing sharp declines in fertility reflect intensification. The greater frequency of land use and a higher ratio of crop to fallow years distinguish the process of intensification.

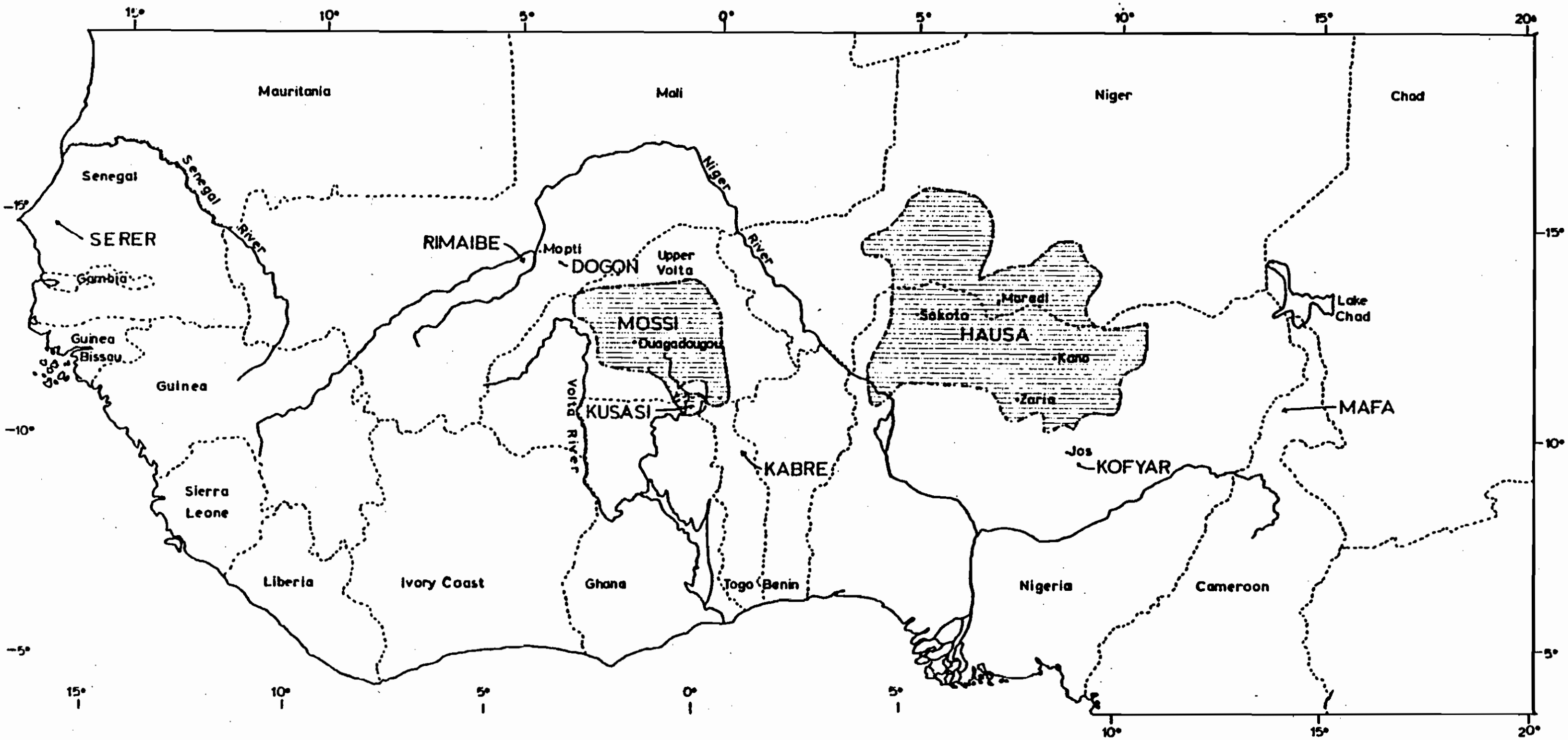
Under conditions of continuous farming, it is necessary on all but the richest alluvial or volcanic soils to artificially preserve or restore soil nutrients and physical properties and limit the competition of undesired plants, insects, and animals. Intensification thus requires specific techniques such as manuring or other fertilization, more complete initial tillage, repeated weedings, and crop rotation. Leguminous plants or trees beneficial to the soil are often encouraged. Changes in field surfaces may be made as in terracing to reduce erosion, ditching to improve drainage, or leveling to allow effective irrigation. Rainfall may be supplemented by retaining floodwaters with dykes, building dams and canals on permanent streams, or raising water from wells. Ridging and mounding may further conserve soil and control water. Fences are sometimes constructed and the guarding of ripening crops becomes necessary. Extra tasks such as seed selection, transplanting, thinning, or selective harvesting along with more precise scheduling of agricultural activities often become important in the course of intensification. As these techniques are applied to a landscape, areas of waste or forest land tend to recede and fields become more clearly bounded, more regular, and more neatly kept.

Rather than defining intensive and shifting cultivation as distinct and mutually exclusive types of cultivation, we want to emphasize the fact that they actually represent intergrading bands in a spectrum of agricultural land use.

Most farming groups know and practice both more and less intensive methods at the same time, for example, by clearing bush fields for millet while growing vegetables in permanent dooryard gardens. Agricultural change can be seen as moving in one direction or the other along a continuum. Shortening fallows signifies a trend toward intensification even if manuring has not yet been introduced. An increase in the proportion of land or labor devoted to more intensive uses reflects the same transition. Under other circumstances a group may "disintensify," adopting extensive techniques and crops that require less care.

Intensive agriculture in West Africa has been little studied until recent years because shifting cultivation appeared dominant in most forest and savannah areas and because distinctive elements of other systems such as animal traction with the plow or irrigation networks were absent. Evidence for intensive cultivation came chiefly from remote, often mountainous areas where small ethnic groups had avoided incorporation into traditional states and maintained their indigenous social and religious organization. Such so-called "hill pagans" were seen as refuge populations escaping assimilation by more powerful neighbors who occupied the plains and maintained long-distance trade routes. The Kofyar on the southern escarpment of the Jos Plateau in Nigeria exemplify this intensive pattern (Netting 1968). They grow an association of millet, sorghum, and cowpeas with interspersed vegetables and tree crops on permanent homestead farms of one to two acres. Soil fertility is maintained by annual application of composted organic material from corrals where tethered goats are fed grass and leaves. To prevent soil erosion and retain rain water, hillsides are terraced and waffle-like ridges (basin listing) are constructed on fields. Mounds and ditches are used to drain swampy areas. Even bush fallowed fields are given application of cooking-fire ashes and are double cropped with nitrogen-fixing peanuts and transplanted millet. The agricultural system adequately fills subsistence requirements and supports population densities of 60 to 200 per square km.

Many of these same practices have been described for other hill dwellers such as the Kabre of northern Togo (Froelich 1963), the Dogon of the Bandiagara plateau in Mali (Paulme 1940, Palau Marti 1967), and the Mafa of the Mandara Mountains in northern Cameroun (Boulet 1975). The Mossi of Upper Volta (Mangin 1921, Hammond 1959) and the Serer of Senegal (Lericollais 1972) use a variety of intensive methods in more open plains environments (Figs. 1-3). Many of these groups use animal dung as fertilizer,



··········	International boundaries
-·-·-·-	Approximate ethnic group boundaries
HAUSA	Ethnic groups
Kano	Place names

Figure 1. Location of ethnic groups practicing intensive agriculture.

Figure 2. Cross-cultural comparison of agricultural techniques

Tribe	Mossi	Dogon	Kabre	Serer	Mafa	Kusasi	Kofyar	Hausa	Rimaibe
Agricultural practices									
Animal traction	1			1		1		1	1
Manure-planned pasturing of animals		1		*	1	1	1	1	
Manure-stabled animals	1	*		1	*	1	1	1	
Manured "house gardens"	1	*	*			1	1	1	1
Manure-nearby fields	1	*	*		*		1	1	
Use of trash/refuse	1	1			1	1	1	1	
Tillage/turning	*	*	*	*	*	1	1	1	1
Mounds or ridges, squares	1	*	1		*		1	1	
Large mounds							1		
Use of compost soil placement (or turning in of vegetation)		1				1	1		
Slope retention		*	1			1	1		
Terracing			*		*	1	1		
Soil drainage		1	1		1		1	1	
Irrigation		1						1	
Inundated cultivation (or low-lying areas)	1	1	1	1	1			1	1
Water retention dams		1							1
"Dry season" cultivation	1	*				1		1	
Encouragement of <u>Acacia albida</u>				*		1		1	
Killing of insects		1	1						
Major crops interplanted almost always	*		*			1			
Some major crops segregated		1(?)		1	1				1
Some major crops interplanted				1	1				
Only gardens continuously cultivated						1			
Repeated non-garden cultivation	1	*	*	*	*	1	1	1	1

Figure 3. Cross-cultural comparison of agricultural crops and techniques

Tribe	Mossi	Dogon	Kabre	Serer	Mafa	Kusasi	Kofyar	Hausa	Rimaibe
Population density (per km^2)	–	100	70	85	245		60-200	20-350	10-25
Rainfall (mm per year)	500-900	–	1500	764	1000	950	1000-1500	500-1500	550
Basement rock		sed.[a]	grn	marl[b]	grn[c]	grn	grn	grn	
Crops									
Eleusine coracana (L.) Gaertn. (finger millet)					1		1		
Oryza glaberrima Steud. (African rice)									x
Sorghum bicolor (L.) Moench (sorghum)	x	x	x	x	x	x	x	x	
Digitaria exilis Stapf (fonio or hungry rice)		1					1		
Pennisetum americanum (L.) K. Schum (pearl millet)	x	x	x		x		x	x	1
P. gambiense Staph and Hubbard				x					
P. pycnostachyum				x					
Zea mays L. (corn)	1	1	1			1	1	1	1
Oryza sp. (rice-variety not specified)	1	1	1	1	1	1	1	1	1
Manihot esculenta Crantz (cassava)		1	1	1			1	1	1
Discorea sp. (yam)	1		1		1	1	1	1	
Allium cepa L. (onion)		*				1		1	?
Lycopersicon esculentum Mill. (tomatoe)	1	1				1	1	1	?
Hibiscus esculentus L. (okra or gombo)	1	1	1		1	*	1	1	?
Arachis hypogaea L. (peanut or groundnut)	1	1	1	x	x	x	1	x	1
Gossypium spp. (cotton)	1	1		1		1	1	x	1
Vouandzeia subterranea (L). Thou. (Bambara groundnut)	1		1		1	x	1	1	
Indigofera arrecta Hochst. ex A.Rich.(indigo)	1							1	
Vigna unguiculata (L.) Walp.(cow peas)							1	1	

Figure 3 continued

Tribes	Mossi	Dogon	Kabre	Serer	Mafa	Kusasi	Kofyar	Hausa	Rimaibe
Cannabis sativa L. (hemp)	1						1	1	
Nicotiana tabacum L. (tobacco)	1	1			1	1	1	1	1
Sesamum indicum L.	1				1	1	1	1	
Colocasia esculenta (L.) Schott (taro)	1		1		1		1		
Ipomoea batatas (L.) Lam (sweet potato)	1	1			1	1	1	1	
Butyrospermum paradoxum (Gaertn.f.) Hepper subsp. *parkii* (G. Don) Hepper (karité, shea butter tree)	1	1				x		1	1
Parkia biglobosa (Jacq.) Benth (néré, dawadawa)	1	1	1			x	1	1	
Elaeis guineensis (oil palm)	1						1		
Borassus aethiopum Mart. (wine palm)				1					

Key: 1 = characteristic present

* = characteristic present and very important

x = staple crop

(a) sedimentary

(b) calcareous marl

(c) granite

often pasturing cows or small stock on fallow fields, as well as collecting manure from stabled animals. Where stall-fed animals are kept in the compound, the pattern of manure application typically reflects the difficulty of its transport (Sautter 1962), and fields nearest the compound are most adequately fertilized. It is often possible to discern three concentric zones in the fields: house gardens, intensive non-garden cultivation, and non-permanent fields at a greater distance from the house. These zones frequently correspond with densities of Acacia albida, a leguminous tree which symbiotically fixes nitrogen in the soil. Gardens and garden crops receive a good deal of care. Among the Dogon, and, to some extent, among the Mossi, this includes some double-cropping, particularly in tobacco and in onions. Most groups take advantage of naturally low-lying, water retaining areas for dry season cultivation.

Though farmers with well developed and long standing traditions of intensive agriculture employ a variety of specialized techniques, the most time consuming tasks remain hoeing and weeding (Boulet 1975:55, Lericollais 1972:72). Mafa cultivators hoe their millet up to four times during the growing season, and the 44.7 per cent of total hours worked outweighs that devoted to care of live-stock, spreading of manure, and so on. For the Serer, hoeing and weeding took up about half of all time spent in agricultural work.

Our cases of somewhat isolated peoples with very intensive indigenous agricultural systems suggest that intensification has a long history in West Africa and is probably not based on recent innovation or diffusion of techniques. Though they illustrate the possibilities of intensification using local crops and relatively simple techniques, they are perhaps not the most representative examples of on-going or prospective agricultural change. Pockets of permanent cultivation often originated in restrictions on available land due to historic threats by neighboring peoples, and when tribal warfare ceased to be a danger, people often left their mountain retreats. Most of these societies also grow food primarily for subsistence, and often they are poorly situated for producing cash crops and participating in the market economy. In attempting to more accurately judge the factors that both promote and impede intensification, we have selected for more detailed discussion the rice-growing peoples of the Niger inland delta in Mali, the Kusasi of northeastern Ghana, and the Hausa of northwestern Nigeria. Our aim has been to contrast the process of intensification under a range of different environmental conditions, crop complexes, and political economic situations in an effort to detect common elements and assess their relative significance.

The definition of intensification we have offered is a simple one designed for easy identification of intensive systems and their characteristic methods. Frequency of land use can be readily ascertained, and the presence of techniques such as manuring or erosion control can be observed in the field. Intensification is not always equivalent to higher yields, more efficient production, or greater labor intensity, and a major goal of our analysis will be to determine more precisely what these relationships are. For instance, annual yields per unit of land under intensive agriculture may be either lower or higher than those of shifting cultivation, but the fact that the land is kept in permanent use means that its average production over time is sure to be higher than that of a bush field with its long fallow period. It is also probable that there is less yearly fluctuation in crop production under an intensive regime. If farmers do, as we believe, make rational economic decisions in achieving certain levels of production from their available land resources and technology they must choose the manner in which they allocate labor. We have seen that shortening fallow periods reduces the amounts of nutrients stored in the vegetation cover, and also reduces the amount of humus accumulated in the soil. In addition, the nature of the fallow cover often changes -- from secondary forest to bush or to savannah. Fields cleared from bush or from grassland require hoeing and weeding, which, as noted above, is costly in terms of time. In addition, there is the necessity to compensate for decreased levels of soil nutrient accumulation (Boserup 1965:31). Thus, intensification of land use increases labor requirements.

One way to visualize intensification of land use, is with the population function for a single variable input (Upton 1973:21ff) as is done in microeconomic models. If you assume that all factors but one (labor, in this case) are fixed (i.e., that you have a fixed plot of land), it is possible to examine the relationship between labor inputs and product, pictured in Figure 4. Product is expressed as total physical product per year, as average physical product (total product divided by units of labor), and as marginal physical product (the extra product or output added by one extra unit of labor (Samuelson 1970:518). As one keeps putting in more units of labor, the marginal product (after an initial rise) starts to decline, eventually reaching zero and becoming negative, as the law of diminishing returns says it ought to.

The average product of labor will be greatest at point

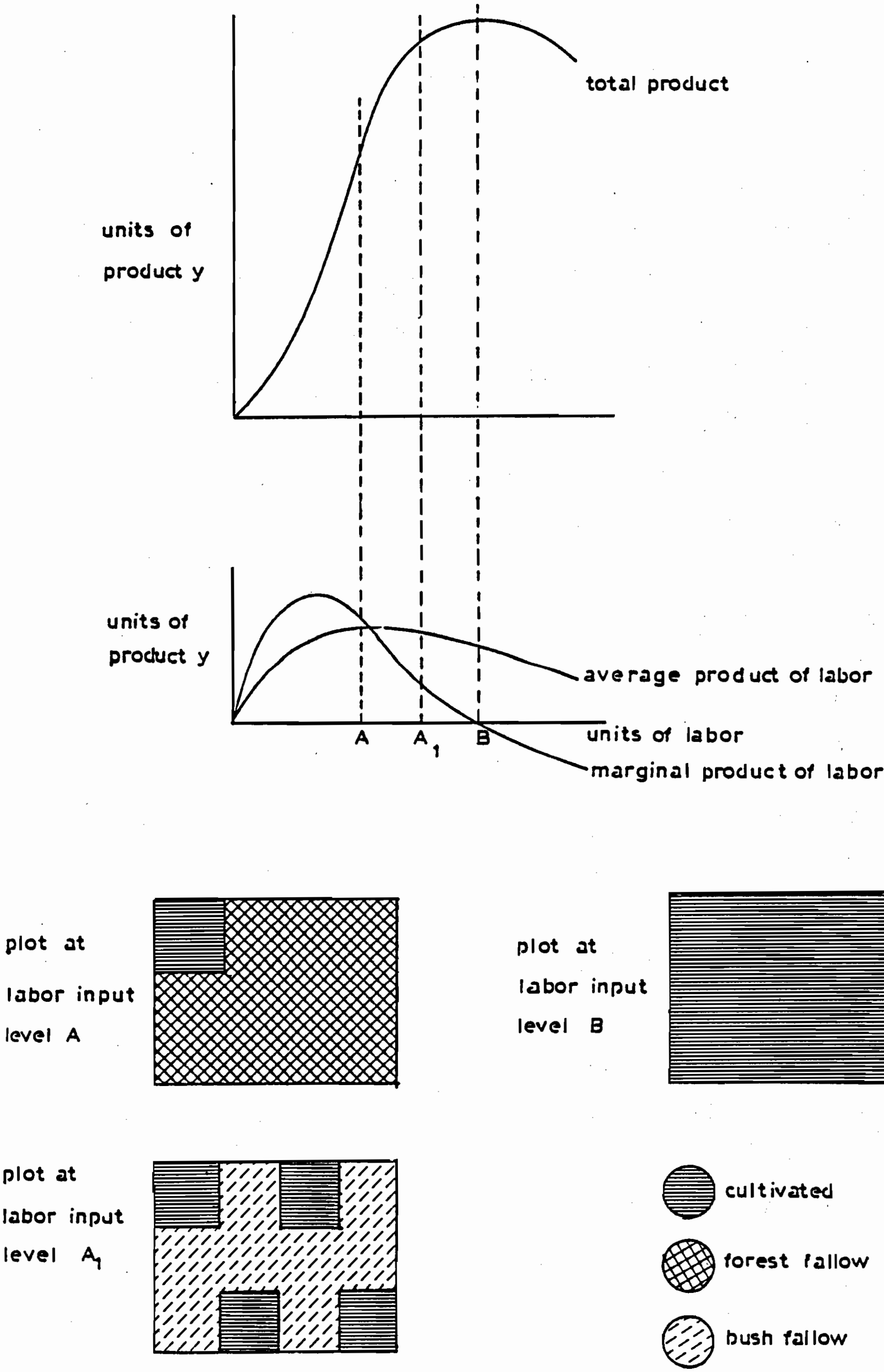


Figure 4. Schematic representation of total, average, and marginal products of labor for plots of different cultivation intensity.

A, which corresponds, in the scheme above, to the labor input for slash-and-burn cultivation of the plot, permitting a long fallow between cultivations. As the fallow period shortens, labor inputs move toward point B: while total product rises, the average product of labor (or labor productivity) falls.

If you assume the cultivators of the plot behave like economic men, then, in making production decisions, they will be weighing the value of the marginal product for a unit of labor used in agriculture, against other uses for that unit -- in crafts, in wage labor, and so on. As labor inputs to the plot increase, and as marginal product of labor decreases, alternative occupations become more and more attractive. (A more detailed explanation of labor intensification in micro-economic terms can be found in Upton 1973:100-116.)

Actual figures for average and marginal products (expressed in kg wheat equivalent/man-hour), and for labor inputs (expressed in man-hours/ha/year) are shown in Figure 5. Because the data were plotted on a log-scale, they differ in appearance from the curves of Figure 4. The story, however, is the same -- as labor inputs rise, labor productivity, and the marginal product of labor decline. The data used are from community studies of Gambian peanut

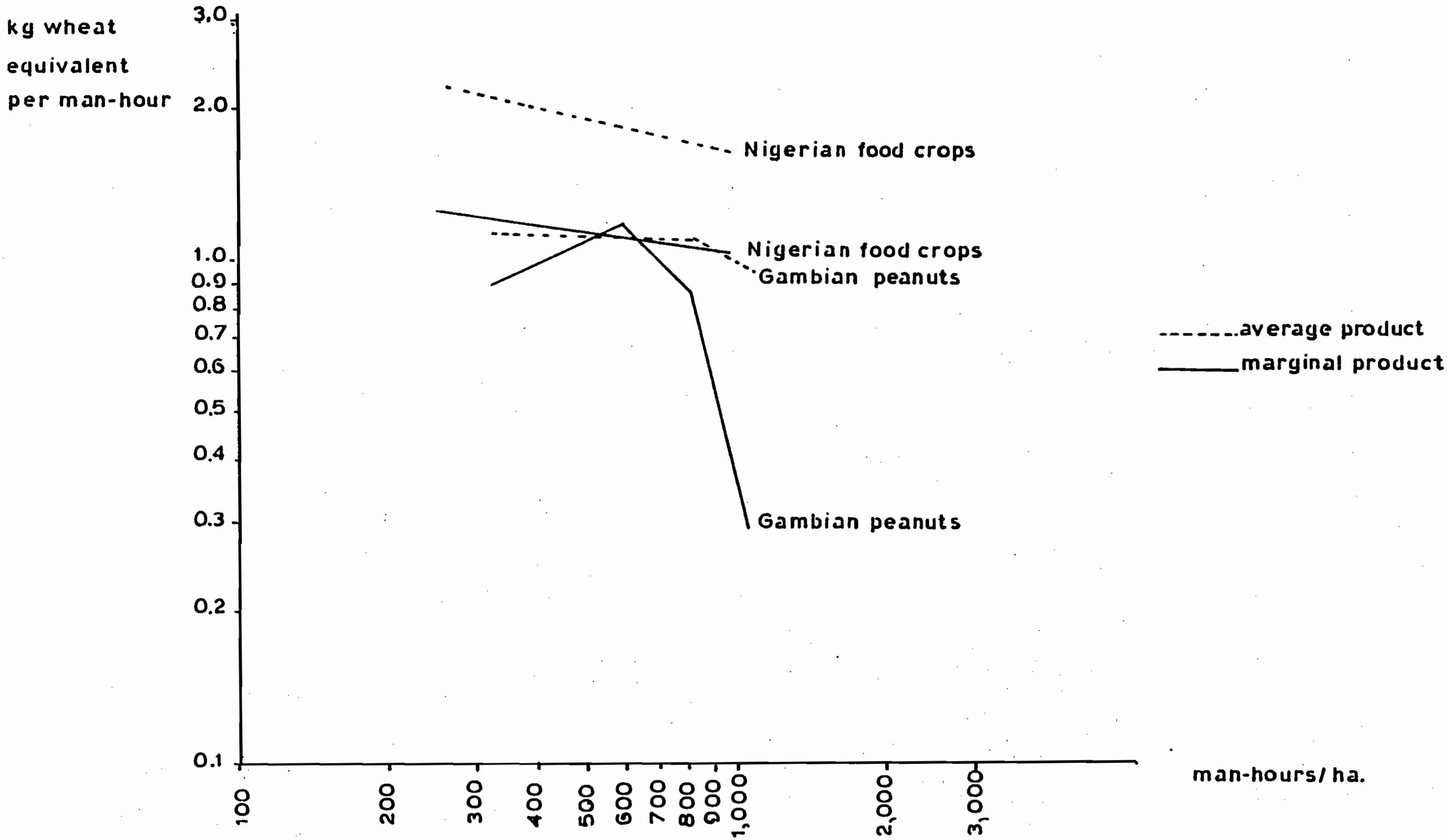


Figure 5. Actual average and marginal products of labor, for two groups of African cultivators.

cultivators, and for Nigerian farmers producing food crops (Clark and Haswell 1967:92-96). For the Gambian cultivators, the decline in marginal product was especially rapid, for labor inputs above approximately 800 man-hours/ha/year. The investigator noted:

> "The author's experience in the village showed that cultivators did in fact stop putting any further labor into cultivation at about this point. The Gambian male cultivator may not be able to read or write, but he knows the difference between marginal and average product, which is more than can be said for some highly educated accountants" (Clark and Haswell 1967:97).

Unfortunately, marginal product figures are not available for the other crops of this Gambian village, but Figure 6 shows the productivity for rice cultivation (carried out by women), and for millet cultivation, and it should be noted that productivity is lower for these subsistence crops (expressed in wheat-equivalents) than for peanut cultivation. Figure 6 also shows data from three Hausa villages for both upland fields of millet and sorghum, and for low-lying fields of sugar cane. The low-lying fields, in all three cases, show higher average productivity than do upland fields, due to being better supplied with water. When the three villages are compared, the negative relationship between labor productivity and labor inputs/ha shows clearly for both low-lying and for upland fields.

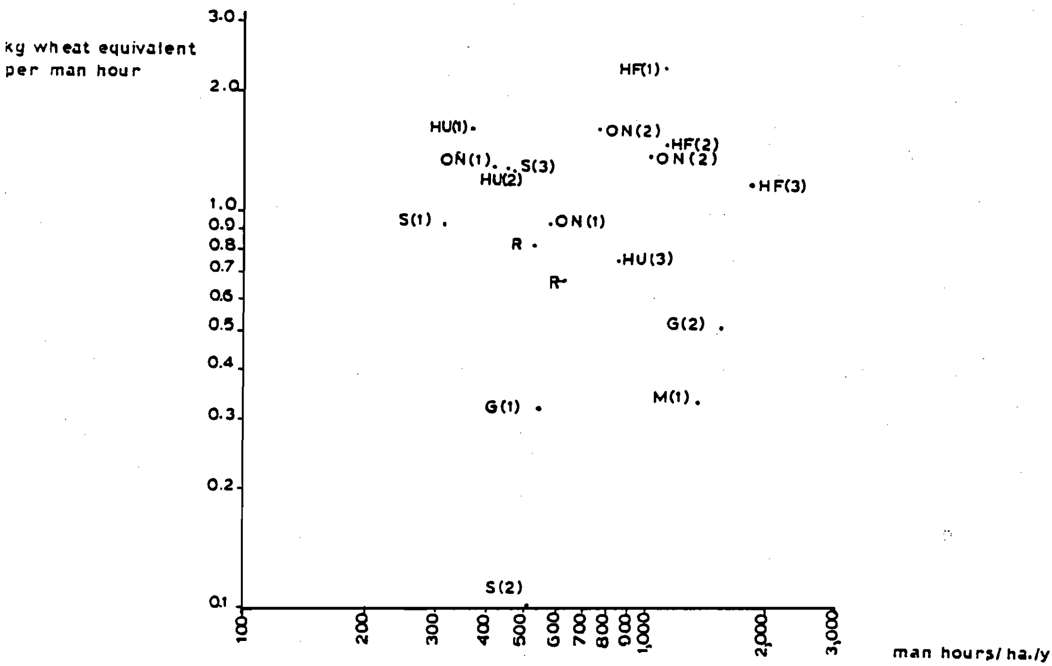


Figure 6. Average productivity of labor in selected West African localities.

Key:

Graph symbol	Tribe and crop
S (1)	Serer late millet/sorghum; Lericollais (1975)
S (2)	Serer early millet
S (3)	Serer groundnuts
R	Rimaibe - traditional rice; Gallais (1967)
ON (1)	Office du Niger - without transplanting; de Wilde (1967)
ON (2)	Office du Niger - with transplanting
G (1)	Gambia millet; Clark and Haswell 1967:99)
G (2)	Gambia rice
M (1)	Mafa millet; Boulet 1975:67)
HU (1-3)	Hausa upland (millet-sorghum) fields; Norman (1972:E12)
HF (1-3)	Hausa <u>fadama</u> (low-lying) fields - sugar cane; Norman 1972:E12)

Figure 6. Average productivity of labor in selected West African localities.

The reasons for this kind of variation within a single community will be discussed further below.

The other data points in Figure 6 show average product (labor productivity) for different crops grown by cultivators in communities within the 1100 mm rainfall zone. We see that the Serer (see Figs. 2, 3 and map in Figure 1), the Rimaibe, and the Office du Niger (map in Figure 1) have, in general, relatively lower levels of labor inputs, and relatively higher productivity, than do the Mafa (see Figs. 2,3) of the Mandara mountains, Cameroon (Figure 1). We also see that population density for the Mafa is far higher than for the Rimaibe or the Serer. The relationship between population density and labor intensification will be discussed in another section.

Another point to be made about these figures for labor productivity is that they will vary from year to year, for regions in which rainfall amount and distribution vary widely from year to year. Thus, for example, the Serer data are for an unusually bad year (Lericollais 1975), which was especially unfavorable for early millet (see S(2) on the figure).

The labor intensity of agriculture in West Africa (as measured in man-hours/ha) obviously varies widely between regions. Total hours worked/year by African cultivators

(Upton 1973:139) show an equally wide range, from 1600 hours/year in the cocoa zone of western Nigeria, to 400-900 hours (Malawi) or 855 hours (the Gambian peanut cultivators discussed above). In many cases, cultivators in northern regions with a relatively short agricultural season migrate during the dry season.

This section has given definitions of intensification accessible to persons observing a concrete situation, as well as to those with access to data on agricultural production and on productivity. Although field observation, cross cultural comparison, and examination of economic data can give an indication of "how intensive farming is" in a particular situation, the questions of where the system is moving, and what is its potential for change, can be answered only after a detailed consideration of the conditions surrounding the system. The case studies were designed to give an example of the kind of analysis needed of intensification in its ecological context.

The Semiarid Savannah

The main feature of the area we are concerned with are (1) enough rainfall to support agriculture distributed in a distinct wet/dry season pattern, and (2) savannah type vegetation with grasses predominating. As we will use the term here, the siarid savannah of West Africa (hereafter often referred to as "savannah") lies between 10 and 15^{o}N between roughly the 1100 and 300 mm isohyets and has 3 to 7 months with 50 mm or more of rainfall (see Figures 7, 9). There is a north to south gradient of most climatic factors in West Africa, which is reflected in vegetation bands, and, to some extent, soil types.

Environmentally this area is much more vulnerable to degradation than the forest area to the south, and is also the region where most indigenous forms of intensive agriculture are found. Because of its sparser vegetation and more level surface, it has often been seen as having great potential for supporting large scale irrigation and/or mechanized agriculture. Recent drought and accompanying food shortages in the area have brought it into world-wide attention. While the immediate international responses tended to be in the form of donation and distribution of food, there is also increased interest in long-term attempts at making the area agriculturally self-sufficient.

In this section we consider the physical and social environment of the semiarid West African savannah as it relates to agricultural intensification.

Rainfall is "undoubtedly the most significant climatic factor in Africa as a whole, as temperature has a relatively

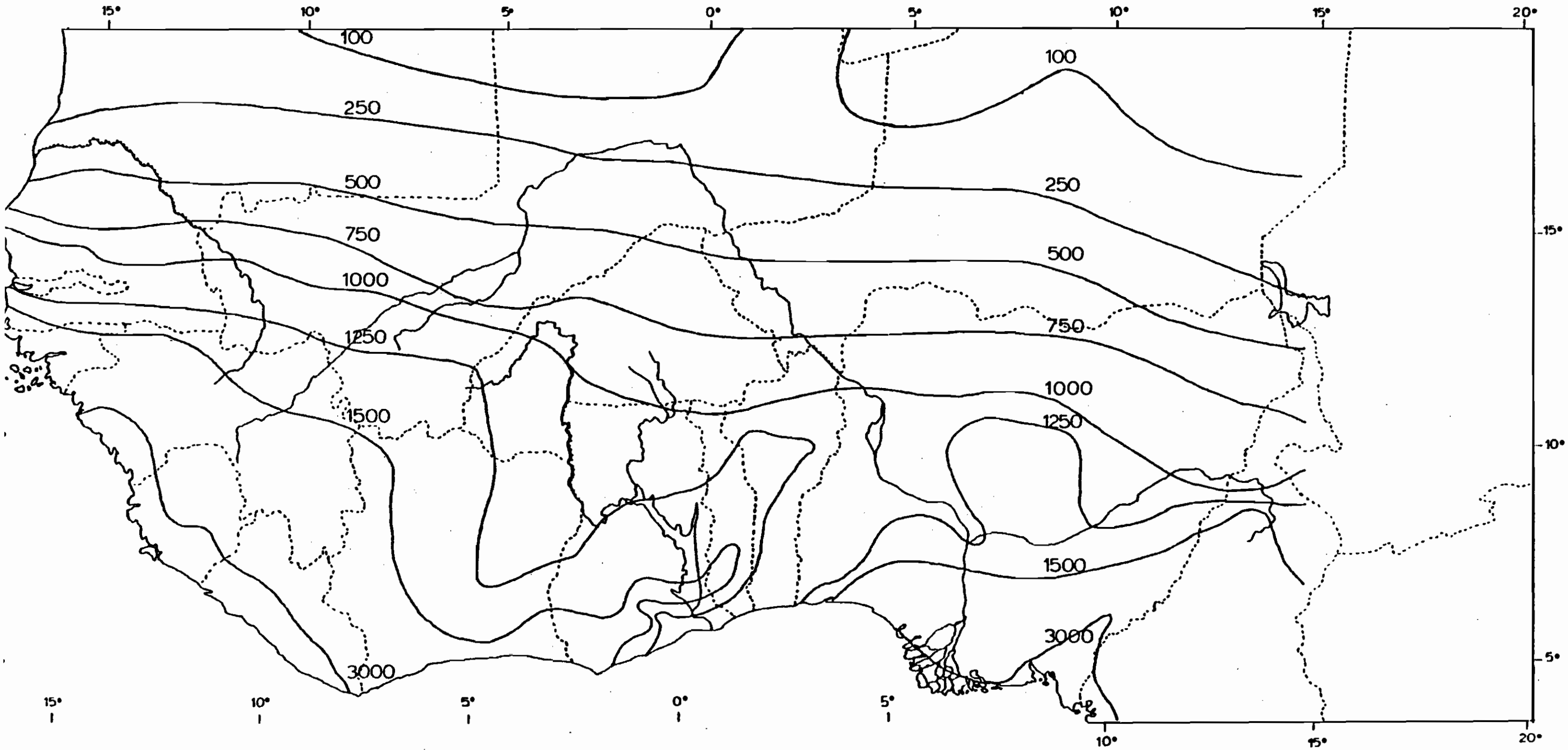


Figure 7. Average annual precipitation (in mm) in West Africa.
(Simplified from IFAN 1968.)

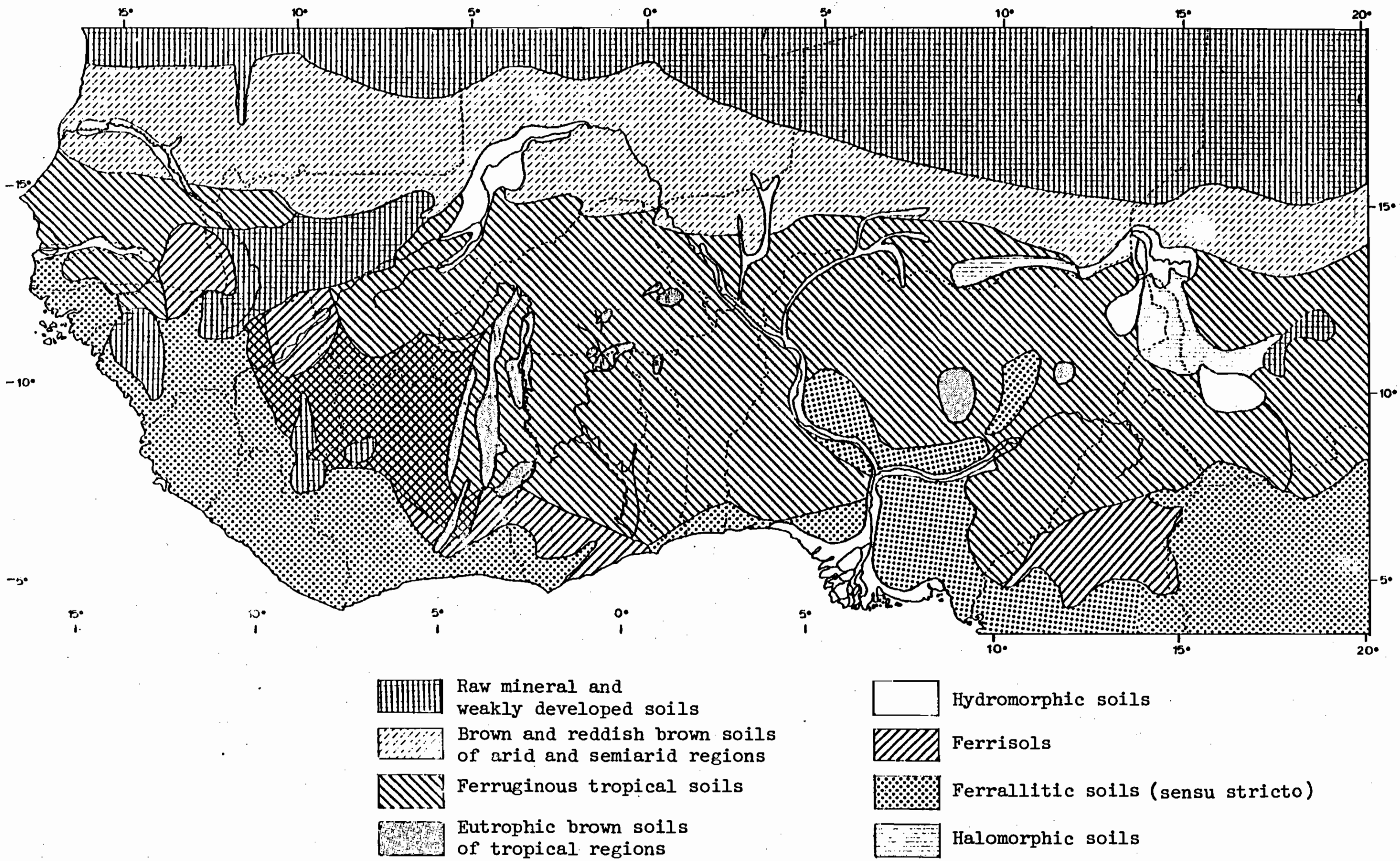
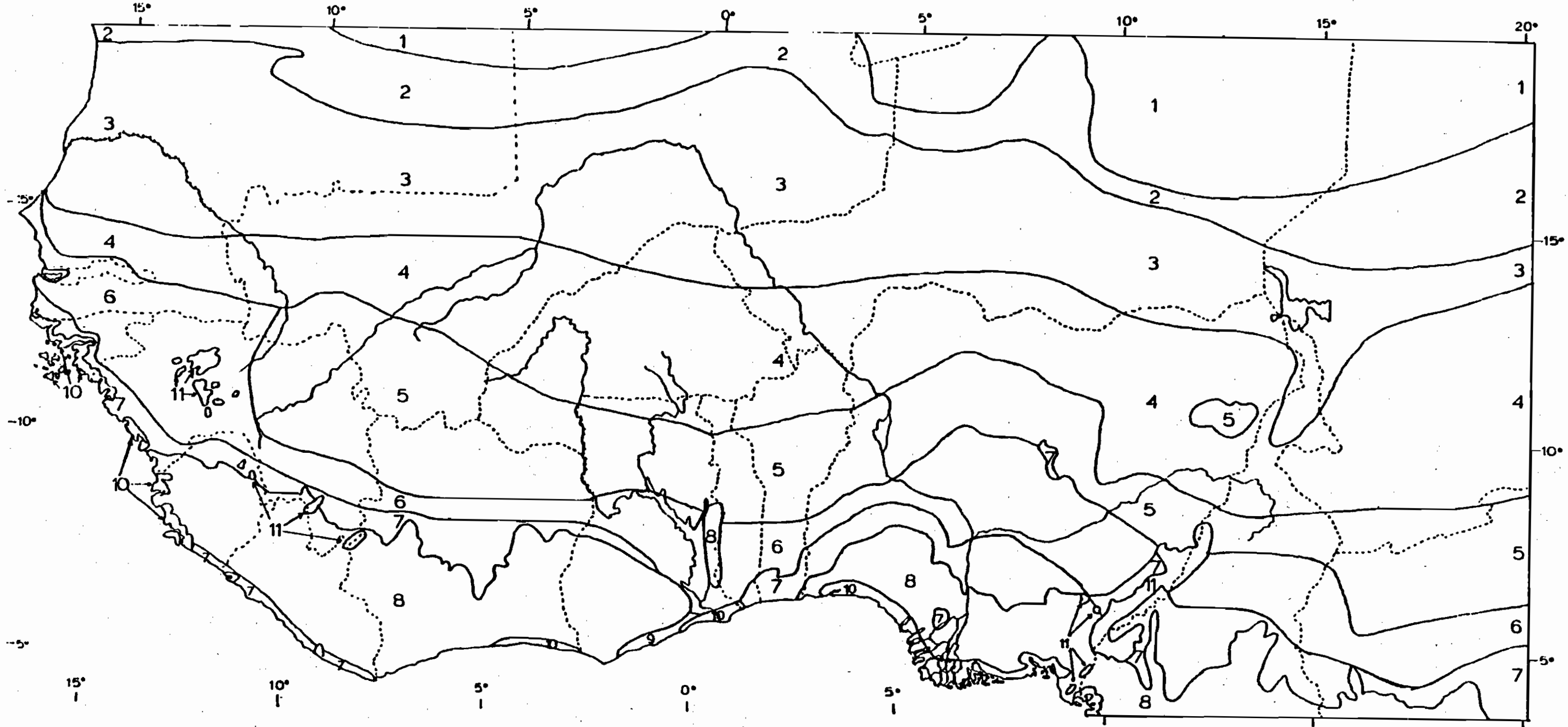


Figure 8. Soils of West Africa (simplified from D'Hoore 1964).



Key:
1. Desert
2. Subdesert steppe, tropical types
3. Wooded steppe with abundant Acacia and Commiphora

4-6. Woodlands, savannahs, and steppes
  4. Undifferentiated: relatively dry types
  5. Northern areas: with abundant Isoberlinia doka and I. dalzielii
  6. Undifferentiated: relatively moist types

7. Forest-savannah mosaic
8. Moist forest at low and medium altitudes
9. Coastal forest-savannah mosaic
10. Mangroves
11. Montane communities

Figure 9. West African vegetation (simplified from Keay et al. 1959).

small annual range, and wind is generally of low speeds" (Griffiths 1972:7). Distinctive wet/dry belts show pronounced migration across the region associated with the north-south movement of the Inter-Tropical Convergence Zone (ITCZ), and the accompanying surface discontinuity (SD). To the south of the ITCZ is the humid maritime (Atlantic) air with winds from the south and west, and to the north of the zone is the dry continental (Saharan) air with winds from the east and north often carrying much dust (Griffiths 1972:168:69).

About 300 to 1300 km south of the SD the main precipitation occurs, but it is not continuous or even daily rainfall; rather it is short-lived with little cloud cover between (Griffiths 1972:169) so that evapo-transpiration is also high. Rainfall is associated with: (1) disturbance lines, which are belts of intense thunderstorms (sometimes called line squalls) moving east to west at about 30 - 50 km/hr, bringing first a strong wind followed by intense rain for up to half an hour, and then drizzle (ibid:173-74); and (2) local thunderstorms with widespread, variable, and sporadic rainfall.

Rains accompanying the SD move north into the semi-arid savannah in May and south out of the area in October. Their movement is not regular, however, but in a series of latitudinal steps, showing a wide deviation both daily and from year to year (*ibid*:171). Thus the beginning and end of the rainy season are marked by great irregularity, which means that farmers must try not to plant until they think the rains will continue regularly. Sporadic rains at the beginning of the rainy season can mean replanting or loss of crops, especially the more drought-sensitive like early millet; at the end of the season when late grain varieties are heading, they can also affect yields. The heaviest months of rain throughout the area are July, August, and September, when the effects of the line squalls with their heavy winds are greatest, and can do much damage to standing crops. The thunderstorms are extremely variable in distribution over even small distances.

Temperatures in the semiarid savannah vary little, with a mean annual of 27 - 28°C, with highest temperatures just prior to rains in March, April, or May with extremes of 43 - 47°C. Lowest temperatures occur at the end of the rainy season with minimums of 7 - 9°C (*ibid*:196). With these high temperatures annual potential evapotranspiration is in excess of precipitation with ranges between 1600 and 2000 mm (*ibid*:199), with soil water surplus occurring in only a short period toward the end of the rainy season (Benneh 1973a).

The recent drought in the area has led to a search for possible causes with a view to prevention and prediction. There are two main ideas about causes of the drought: (1) anthropogenic degradation resulting from grazing and cultivating, and (2) change in rainfall patterns of either short or long term.

Pastoralists and agriculturalists tend to adjust to good years by expanding herds or areas cultivated, so that the most dangerous situation is a period of good years followed by a long drought when livestock destroy vegetation and tilled land is left exposed to the effects of wind and sun (Grove 1977, Swift 1977). This is what happened in the recent drought beginning in 1964. The increasing demand of growing urban populations for firewood and charcoal has also led to the deforestation of large areas (Grove 1977).

There is general agreement that human activity has played a role in the "desertification" of savannahs, and the advance of savannahs into forest regions, but there is also evidence for changes in amounts of rainfall (Shove 1977). Even though the recent drought was perhaps the worst since the 1830s, prolonged dry periods have been a common occurrence in the region for many centuries. These have not only affected rain-fed agriculture, but also those using irrigation, for river levels also fluctuate dramatically. Among possible causes that have been suggested, changing pressure patterns are prominent, and a relation to sunspot cycles has been proposed. A number of precipitation cycles of varying frequency and amplitude may exist, and the present low rainfall being experienced could be part of a long term change that will persist for some time.

Most of West Africa is an immense but non-uniform plateau with elevations predominantly between 200 - 500 m. Elevated areas in the north and south delimit a central depressed area, which north-south plateaus divide into four basins: Senegalo-Mauritanian, Western Niger, Volta and middle eastern Niger, and Chad. The savannah region occupies the northern part of the southern elevation and much of this central basin area. It includes elevated plateau areas important because they have served as refuges, attracting high population densities, and for the intensive agriculture often practiced there.

The Senegal, Niger, and Volta are the main river systems draining the savannahs and their richer valley soils and water availability make them foci of agricultural intensification.

Different systems of western scientific soils classifications were developed under colonial governments in Africa and applied to West African soils. Work up to that time was summarized and synthesized in a soil map of Africa in 1964 (D'Hoore). A simplified version of this map for West Africa appears as Figure 8. Classification is based primarily on the extent of weathering and leaching of soils and so the major groups are broadly related to climate and vegetation belts. Parent material is a secondary, though often agriculturally important, consideration.

In the semiarid savannahs of West Africa the following soils are the most important, and their relationship to agriculture will be briefly outlined (based on D'Hoore 1964, and Ahn 1970) in reference to the numbers used on the map.

1. Raw mineral soils and weakly developed soils. These soils generally have very little agricultural potential and are used mainly for grazing or extensive harvesting of tree crops such as gum arabic.

2. Brown and reddish-brown soils of arid and semiarid regions. Good structure and permeability, low organic content, usually in areas of less than 500 mm per annum. Suitable only for extensive grazing. Under irrigation can produce millet and cotton, but there is danger of destroying soil structure. Located immediately south of the weakly developed desert soils.

3. Ferruginous tropical soils. These are the most common soils of the semiarid savannah in West Africa. They tend to be developed over the richer Precambrian basement complex and often

contain appreciable reserves of weatherable minerals. They are fairly thin soils, seldom thicker than 250 cm, and very susceptible to erosion. Fertility is greater than the highly weathered soils of the wetter regions to the south, and they tend to respond well to fertilizers. These soils frequently show separation and concentration of iron oxides in mottled layers in the subsoil; when exposed by erosion they may harden irreversibly, drastically reducing productive capacity.

4. Eutrophic brown soils of tropical regions. These soils are not very widespread and the main reason for their separation as a mapping unit is their superior agricultural potential. Within the semiarid savannahs they occur primarily in northern Ghana, Upper Volta, and the Jos Plateau of Nigeria. They are rich in available plant nutrients with large reserves of weatherable minerals, developed over generally rich parent materials, and are generally well structured and permeable.

5. Hydromorphic soils. These soils, too, are not abundant in the region, but are important because of their agricultural potential, especially for irrigation. They are found along most streams and rivers, but only occasionally are extensive enough to be mapped, as in the Niger delta area of Mali and in the lower Senegal, Niger, and Volta valleys. They are much used for rice and sugar cane.

In general, the semiarid savannah soils are thin, "particularly low in organic matter and may have poor structures, poor nutrient reserves, and poor moisture-storage properties" (Ahn 1970:237). The main agricultural problems are water control and maintaining (or increasing) organic matter content. Under long periods of cultivation these soils are especially susceptible to sheet and gully erosion and development of indurated layers near or at the surface (see above, ferruginous soils). Continued cultivation also decreases soil organic and mineral content (especially nitrogen and phosphorous) and leads to increases in weed and insect pests (Ahn 1970:244-45).

The above generalizations about savannah soils are of little use on a local level, whether for a development project or an individual farmer. They only give a broad indication of the possibilities for intensification, and knowledge of local soil conditions is essential to success in efforts to increase production.

The traditional method of maintaining fertility under cultivation is to shift fields under cultivation when production has declined to a certain point, clearing a new field and leaving the previous one to rejuvenate under natural fallow, which restores organic and mineral content and protects it from erosion and sun. Humus is important in maintaining soil structure, and is the most important factor making nutrients available to plants in savannah soils, and provides mineral nutrients as it decomposes. Fallowing also reduces insect pests and drives out weeds of cultivation.

In contrast to land cleared from forest fallow, that cleared from savannah fallow suffers a serious shortage of nitrate which lasts for one year, and may continue into the second year. There are two reasons for this: the locking up of nitrogen reserves in grasses which are lost in burning during land preparation, and the inhibiting effect of some grasses, especially Andropogon, on nitrogen fixation by soil microbes (Vine 1968:105-7).

Burning is the subject of much debate, and is generally considered to be harmful, but there are some important positive aspects of the use of this important agricultural tool in the savannahs. Almost all sulfur and nitrogen are lost during burning, but phosphorous and potassium remain and are more immediately available. The alkaline nature of the ash also increases the availability of all plant nutrients. Burning may also have a partial sterilizing effect which increases supply of nutrients and inhibits growth of weeds. Exposure of the soil to the rain and sun causes increased oxidation of organic matter, destroys soil texture, and leaves the land vulnerable to sheet, gully, and wind erosion (Ahn 1970:242-43).

In the continuously cultivated fields that are important under intensive agricultural systems, the farmer seeks to duplicate the effects of the fallow by adding organic material to the soil, protecting it from erosion and sun, and controlling weeds by continuous hoeing. In maintaining fertility under more intensive systems the farmer may use animal manure, green manure, compost, or chemical fertilizers.

Animal and green manure and compost are valuable because of their slow rate of mineralization and addition of organic matter to the soil. Green manure also encourages soil bacterial activity and is important for maintaining soil structure (Vine 1968:100). Knowledge of fertilizer responses of savannah soils is limited and based on local experience. Available results from long-term experiments show strong responses to nitrogen, especially after a fallow period; little response to potassium; small to moderate but erratic responses to phosphorous, including millet and sorghum; good responses to sulfur by leguminous crops and cotton, but little response by cereals (Ahn 1970:266-269). Chemical fertilizers do not add organic content and do not prevent the decline in physical quality (and may even accelerate it). "It is doubtful if chemical fertilizers alone can maintain productivity on many West African soils if their physical properties decline" (Ahn 1970:245).

The accompanying map (Fig. 9) shows the major vegetation zones in West Africa, and is adapted from Keay (Keay et al 1959). In the semiarid area under consideration the dominant vegetation is a "Savanna," defined as "vegetation in which perennial mesophytic grasses...at least 80 cm high... play an important part; such vegetation is usually burnt annually" (Keay et al 1959:6). Fire resistant trees are scattered throughout the savannah, being more abundant toward the south with increasing moisture availability. The whole area is probably a fire pro-climax, the result of centuries of burning, grazing, and farming by humans that prevent restoration of a 'natural' climax consisting of closed woodland with little grass.

To the north the savannah grades into steppe, a vegetation type in which the perennial grasses are less abundant, and annual grasses become dominant. It is far less liable to burning than savannah. The abundant Acacia and Commiphora of this zone become less abundant and of low stature further north as the next zone, subdesert steppe-tropical type, replaces it.

The savannahs contain abundant plant resources that have been used by the inhabitants over the centuries, some of which have been domesticated, including millet (Pennisetum spp.), sorghum (Sorghum), rice (Oryza spp.), cowpea (Vigna), bambara groundnut (Voandzeia subterranea), sesame (Sesamum spp.), and Hibiscus spp. (including okra and kenaf) (Irvine 1970).

A number of savannah trees have been traditionally used, and these are selectively left during clearing for agriculture. These include locust bean (Parkia clapertoniana --

seeds used to prepare a nutritious fermented cake), shea butter (Butyrospermum paradoxum -- seeds used to prepare a solid fat used in cooking, lamps, and skin care), baobab (Adansonia digitata -- leaves are an important source of food for humans and animals at the end of the dry season and beginning of the rainy season), and wild fig (Ficus spp -- leaves are used for animal fodder).

Rose Innes (1977) has described the process of change occurring in the stable fire pro-climax under cultivation for northern Ghana, and it is relevant to the rest of the savannah zone under consideration. About three years after initial clearing of the land, leaving only desirable trees, there is a decline in fertility and an increase in weeds, especially Striga spp., a parasite on millet and sorghum. Under a system of bush fallowing, the plot is then abandoned and felled trees regenerate from living stumps, with succession back to fire pro-climax being quite rapid, probably about 20 years. After many decades of increasing exploitation and decreasing fallow periods, none but selected trees survive, resulting in a parklike landscape with low status annual grasses, undergoing continual short rotation cultivation. At this point land essential for the maintenance of shifting cultivation or mixed farming (including rotated pasture for restoring fertility) is no longer available. If pressure on the land continues, a "super-mature" parkland develops, with even the desired species of trees being lopped off or felled, and increasing soil exhaustion and denuding resulting in extensive soil erosion (Rose Innes 1977).

We have described the climate, soils, and vegetation with which the farmers of the semiarid savannahs are faced in their efforts to support themselves and their families. Farming is above all a family affair, and the longstanding bias in Western literature that sees the farmer as only the adult male head of the family is now realized to be erroneous. Women and children play very important roles in providing food, with men and women often complementarily specializing in different crops, tasks, or times of labor input. Young children are especially important in taking care of the animals, a task that requires relatively little energy expenditure or skill. The roles of women and children in the fields themselves become more important with increasing intensification of agriculture, with more labor intensive methods, and less time spent on the very heavy labor of clearing new fields from bush.

The great ecological bands that run from east to west across West Africa have influenced the development of human activity. In the arid north are pastoralists, a thin population of humans and animals on relatively poor soils. Going south, the importance of herding tends to diminish and to be replaced by agriculture in the savannahs as the growing season becomes longer and the water availability increases. Millet, sorghum, and groundnuts are the most important crops. Population densities increase, but not uniformly. Population density tends to be concentrated on the most fertile soils, and this is where intensive agricultural systems have developed. Further south into the forest region, resources for agriculture become more abundant, and high population densities are supported primarily under extensive cultivation of root and tree crops.

Tools of the savannahs are the hoe, cutas, and fire. The use of iron may have been introduced into the area from across the Sahara about 2500 BP and undoubtedly has had an important effect in allowing increased production (Goody 1971). There is no tradition of plows or wheeled vehicles, but even without complicated tools, the people of the semiarid savannahs have developed an agricultural system that is adapted to making a living from this very formidable environment.

A wide variety of naturally occurring food resources are known and exploited, and although they tend to be used less and less with the development of more intensive agriculture, they always form a reserve in times of hunger. The main crops of the area are the millets and sorghums; a large number of varieties are adapted to the growing season and water supply at the various latitudes of the semiarid savannahs.

The prevalence of infectious disease in Africa is very high, and that the people there "labor under a heavy burden of sickness in everything they do is beyond question" (Hughes and Hunter 1970:445). Some of the most important infectious diseases in the semiarid savannah of West Africa are trypanosomiasis (sleeping sickness), onchocerciasis (river blindness), schistosomiasis (bilharzia), malaria, dracuncluliasis (guinea worm), intestinal parasites, cerebrospinal meningitis, measles, and leprosy.

Malnutrition, primarily protein-energy malnutrition (really under-nutrition, PEM) is widespread in Africa, and is especially prevalent in the semiarid savannahs of West Africa (Bengoa 1975). The statistical evidence is fragmentary, but such surveys as have been done, and information from hospitals and clinics, show very high rates, especially among young children. This malnutrition interacts synergistically with infection to increase the morbidity and mortality that would result from either one alone (Scrimshaw, Taylor, and Gordon 1968).

Kwashiorkor, or severe protein undernutrition, was first defined in southern Ghana and the idea of relative protein deficiency in African diets has had wide popularity until recently. It is now being realized that in areas like the savannahs where the staple food (grain and legumes) is high in protein, the problem is not one of protein deficiency, but of total food deficiency, i.e., if enough calories are available, then adequate protein will be supplied.

Before the 20th century, West Africa was probably the most unhealthy region of the world and had the highest death rates. Only high birth rates sustained population numbers. Death rates have been greatly reduced since the beginning of the 20th century, though still among the highest in the world. Fertility rates, however, have not fallen significantly, and they, too, remain among the highest in the world, with potential demand for contraceptives among the lowest internationally. While much of West Africa remains rural, the rate of urbanization is again among the highest in the world (Caldwell 1975a). These developments, along with a high incidence of migration, indicate that West African population has undergone major changes in this century and these have had an effect on society, agriculture, and economics.

Within West Africa there is a contrast between the coastal areas and the interior savannahs. In the latter, population densities and growth rates are lower, partly as a result of a harsher environment, higher mortality and lower fertility, and higher emigration. Yet the direct impact of modernization is less, and the desired family size tends to be larger while demand for contraceptives is lower.

The fast growing populations of the savannahs are characterized by a large proportion of children so that the ratio of consumers to fully self-supporting producers is high. Thus the population pyramids tend to be broad-based, narrowing rapidly toward the older age groups. Population pyramids are illustrated in the case studies. Migration has the effect of distorting the age structure of populations and this, too, is reflected in the pyramids. Because the savannah areas have been labor reserves for the forest and coastal areas to the south since the turn of the century, there tend to be fewer males than females in the 15 - 45 year age group.

It should be mentioned here that increasing population tends to absorb national resources in the provision of services such as education and medical care, diverting them from capital investment to increase production. This may slow economic development so that the effect of modernization on decreasing fertility may be long delayed. There is even some evidence that modernizing trends may tend to increase fertility. For example, in some West African countries urban fertility appears to be higher than rural fertility. Nomads and women in polygynous marriages have lower fertility than sedentary agriculturalists or monogamous women, and as sedentism and monogamy increase, they may operate to increase fertility (Caldwell 1975a).

The unilineal descent group forms the basis for social organization for some of the centralized states as well as the acephalous chiefless or segmentary societies of the savannah. Unilineal means that descent is reckoned in only one line. In the savannah this is the father's line, hence the term patrilineal descent groups. Clans are usually groups of lineages whose common ancestry is not demonstrable and often mythological. All members of the lineage are considered to be legally equal, and descent is basically a jural concept that forms a connecting link between internal domestic and external political and legal relations. The lineage acts as a group in defending its territory and settling internal disputes (Fortes 1953). Its unity is often symbolized by religious ritual centered around ancestor worship. There is a strong tie to the land of the ancestors, but the lineage itself is not tied to a locale, and there is abundant evidence that farmers will leave their homeland to take advantage of economic opportunities elsewhere.

In state level societies, kinship may be somewhat less important and membership in an ethnic or occupational group may be emphasized. Political relations reflect a hierarchy in which government officials or wealthy land owners have a larger role in making policy and enforcing the laws. In such societies, economic stratification and patron-client relationships are often significant. Islam as the dominant religion in most areas admits members universalistically without reference to prior kinship ties or ethnicity.

We use the terms 'family' and 'household' interchangeably in this paper to mean the domestic group that functions as a unit of production and consumption. In most of the savannah area polygyny (a man having more than one wife) is considered the cultural ideal, and is made possible by the younger ages at which women marry. A household can thus include a man and his wives and children. At a later stage it might include in addition the married sons and their wives and children. When the father dies there is a tendency for the household to break up into smaller households, first along lines dividing full from half brothers. Groups of brothers might also continue living and farming together. Thus there are several stages in the development of the family that can influence the incentive or ability to intensify.

Trade in the savannah area has a long history and has provided contact between the Arab desert peoples to the north and the forest dwellers to the south. Colonialism changed this around, orienting trade toward the coast and de-emphasizing the east-west routes that existed. Africa was seen as a source of raw materials and cheap labor, and slaving was encouraged in the interior savannahs. Later development of export agriculture, mining, and increasing government activities along the coast led to recruitment of forced labor in the savannahs, and establishing a trend of emigration, both seasonal and long term, from these areas that continues to be a major factor affecting agriculture today.

A dual society grew up in the coastal areas and in interior capitals with African elites adopting much of the life style and material wants of the Europeans. After independence these elites formed the governments and saw as their political base not the rural farmers, but the increasingly large urban populations who were learning to want the same things as the elites. Post-independence development projects have tended to extend colonial patterns with an emphasis on large scale industrial projects in the cities and export oriented cash cropping in the rural areas to support industrialization and, more immediately, the western lifestyle of the elites and urban dwellers. An important aspect of this policy has been keeping prices paid to farmers for food and cash crops low to supply urban dwellers with inexpensive food and to increase the government's profit on exports. This has worked against increasing production in the rural sector. When these programs failed, as almost all of them did in their own terms, blame is often put to the economic backwardness of the rural farm family.

Explanations for Agricultural Intensification

Agricultural intensification, or the lack of it, is often "explained" by certain factors in the physical or social environment of a human group that stimulate the practice of certain new techniques or that interfere with their adoption. Such explanations may be based on implicit assumptions about human nature, inherent traits of ethnic groups, or the way in which revolutionary social change takes place. In many cases they result from after-the-fact attempts to understand why a seemingly beneficial innovation has not caught on or why a well-funded project has failed.

Social scientists may dignify their explanations as hypotheses or models, but it is not necessary to adopt an arcane vocabulary or a specialist approach to see certain persisting patterns of explanation and to test them objectively against real cases of intensification in West Africa. We will consider in turn explanations that focus on cultural predispositions, environmental constraints and options, technological change, population pressure, economic incentives, and political or governmental activities. These different viewpoints for evaluating the process of intensification are plainly not mutually exclusive, but we will attempt to clarify their interaction in particular ecosystems and to suggest their relative importance in situations of change.

Resistance to more intensive methods of crop growing is often credited to the cultural background of the people concerned. Because ethnic groups in Africa are often quite distinctive with an identifiable language, dress, settlement pattern, and subsistence system, it is easy to characterize a "tribe" as having ingrained attitudes toward work, shared personality features, and social customs that take precedence over economic calculations. Because a cultural group has survived from the past and lacks written history, it is presumed to be slow changing, traditional, and conservative. Frequently the peoples' own explanations of their behavior support this stereotype. When asked why they do not adopt a new practice, they may cite the ritual timing of their old agricultural calendar, a religious attachment to the land and graves of their ancestors, or customary bars to men or women doing certain kinds of work. Such explanations may emphasize the persistence of ideal behavior and neglect changes that are indeed taking place. A certain practice, regardless of how it is rationalized, may actually be economically adaptive for the farmer. Practical decisions made by the small-holder over time cannot threaten his subsistence, and it has long been demonstrated that people respond to obvious economic opportunities, even when these seem to run counter to certain cultural values (Schultz 1964).

When agricultural intensification is not vigorously pursued, outside observers often cite a lack of motivation and behavior which one expects in a western market system. People are said to be incapable of seeing that a new tool would raise their efficiency, or that devoting all their labor to one high-value crop would maximize their returns. They are said to value leisure highly and to work only long enough to acquire the cash for some limited goal. Wealth that they acquire is dissipated, going into increased consumption, or bridewealth, or used to support parasitical relatives, rather than being productively invested in their enterprises. These assertions can be contradicted by the evidence of people working harder and longer when the rewards justify it and altering residence, marriage patterns, and household arrangements in order to maintain or increase their incomes (Sahlins 1957, Netting 1965, Basehart 1973, Hanks 1972). Where maximization of production or income is absent, it is often found that the farmer is protecting himself against climatic fluctuations or market gyrations and assuring the food supply of his family under conditions of considerable risk (Wharton 1971). Cultural predispositions are indeed present, and they may affect the rate and direction of agricultural change, but they do not form a rigid shell warding off all innovation. Only when the costs and benefits to the individual of more intensive farming can be realistically evaluated can the supposed maladaptive influences of traditional culture be assessed.

It often appears that the traditional social groups organized around production or consumption impede the changes necessary for agricultural intensification. It is true that large communal work parties composed of a lineage or an extended family household may be effective in tasks such as clearing or weeding the relatively large fields under shifting cultivation. On the other hand, a small group such as an independent nuclear family may provide all the labor necessary for the limited, manured plot that is kept in annual production by the continuous attention and fine-comb techniques of the gardener. Similarly a big residential unit with a number of adult workers under the leadership of a headman can practice a diversified agriculture on widely dispersed plots along with a variety of secondary occupations, pooling its crops and earnings to provide a secure subsistence for the whole group. Where land is concentrated and confined, increased effort may be elicited if each nuclear family is responsible for its own needs and can seize new economic opportunities without waiting for the approval of a corporate group and without sharing the proceeds of a successful endeavor. The size and composition of households and kin groups seem to be significantly related to the kind of agriculture being practiced, but this does not mean that the organization customary at any point in time is fixed and resistant to change. In fact, there is evidence that large extended family compounds of Ibo broke into constituent family units living separately as land shortage brought about the transition from shifting to intensive cultivation (Udo 1965). When the Kofyar of the Jos Plateau in Nigeria moved from the densely populated hills to the free land of the plains, they not only took up bush fallow agriculture but expanded the household work force by marrying more wives and keeping married sons at home. They also began to hire labor for the first time (Netting 1969). It would seem, therefore, that such cultural features as family structure and work group organization are more flexible than had been thought, and that they have the capacity to adjust to alterations in the environment and to changing labor needs. These changes take place with little feeling among the people concerned that they are breaking cultural rules or denying social values, and they result from individual decisions as to when it is advantageous to marry or where one can best set up housekeeping. Such choices are not culturally unconstrained, but over time they are responsive to economic variables.

Customary law is frequently seen to be in direct opposition to agricultural development in the area of land tenure. Many westerners carry with them the conviction that African communities held resources in common and that private property was absent. Again, the stereotype may fit shifting cultivation where individuals had rights only to the crops they grew and not to the land which was a communal possession allocated temporarily to families according to need. On the contrary, when land is too rare to be fallowed regularly, when it has been improved by fertilization, irrigation, or terracing, and when it has the potential to support tree crops or other kinds of permanent production, it becomes too valuable to revert to the group. People who must compete for land and farm it intensively develop continuing rights to it, first the right to pass it on to their heirs and then progressively more inclusive rights to loan, rent, and finally sell it. People in the same village may have some of their territory in individual tenure and the rest as a communal holding, but these contrasting bundles of rights reflect different kinds of _land use_. As the agricultural systems change and land acquires value, tenurial practices adjust, often in a spontaneous and almost insensible manner. They may be recognized in litigation and legal precedent long before either customary or statutory law includes them. This gradual process may be preferable to the attempt to institute individual rights in land as a way of hastening intensification which is like putting the cart before the horse. There may indeed be conflict between villages or ethnic groups with different types of land use. Communal rights may be asserted over presently unused bush in an effort to prevent its appropriation by outsiders who wish to bring it under permanent cultivation. In effect this requires a decision by external authorities, not just over the legal status of the disputed property, but over the most desirable use to which the land can be put.

Though no one should expect a painless or automatic transition in the socio-cultural factors of household and village organization of land tenure rules, it seems apparent that these institutions show some degree of correlation with agricultural systems and that individuals, _when given a choice_, may act so as to bring about change that adjusts their social behavior to an altered set of ecological constraints and options.

An area like the Sahel, much of which has marginal rainfall and a high potential for disastrous drought, would seem to lay primary stress on physical factors in determining the limits and possibilities for different agricultural techniques. Where precipitation is erratic and crops have no alternate sources of moisture, the use of fertilizing, extra weeding, or terracing on uplands might be wasted effort. Uncontrolled flooding of lowlands might be equally dangerous, and the presence of ironstone caps or red clay soils that are difficult to work when either wet or dry would seem to decisively hinder cultivation in certain areas. Geographers and agronomists have often used soil classifications to indicate the limits of permanently cultivable land and the fallow periods necessary where only shifting cultivation could take place (Allan 1965). This view is not environmental determinism but it has been called "possibilism" and it does purport to establish the environmental limits on the agricultural potential of an area (Netting 1974). Both the presence of indigenous intensive agriculture in many places (Fig. 1, Jos Plateau, Mandara Mountains, northern Ghana savannah, inland delta of the Niger, Bandiagara escarpment) and the recent extension of permanent cultivation over wide areas (fertilized infields in Hausaland) indicate that environmental factors may be less narrowly restrictive than had been thought. Carrying capacity may be limited under certain technologies, but the more favored parts of the Sahel may still afford opportunities for productive intensification. Though little further production can be expected from lands already supporting 700 to 900 people per square mile, human efforts at increasing fertility through organic and artificial manures, crop rotation, irrigation, and more frequent working of the land can substantially increase the yields of large areas still in bush or under long-fallow cultivation. Forest clearance can eliminate tsetse fly and lessen the danger of cattle and human disease.

Environmental limitations are, therefore, not absolute but relative. For each set of climatic, edaphic, and topographic features, there appear to be several intergrading systems of land use possible. Where low precipitation means frequent crop failure, only nomadic herding may be possible, but at higher rainfall levels, a range of shifting and intensive agricultural systems may exist (Porter 1965). Empirical analysis may give the gross outlines of what is agriculturally feasible, but the more relevant question is whether production may be significantly increased by local efforts using methods for intensification _already present_ in the society. If people can maintain permanent gardens, even for small quantities of secondary crops like kitchen vegetables or tobacco, then the environmental potential may be present for an expansion of intensive cultivation. The types of land chosen for such activities in terms of soil qualities, vegetation, slope, and distance from settlement, may indicate the most promising conditions for the process to take place. On the other hand, evidence of soil exhaustion, erosion, and localized depopulation may indicate the passing of an environmental threshold beyond which intensification cannot take place, given the technology and knowledge to which resident farmers have access. Environmental factors, considered in isolation, may set broad limits for exploitation, but in better watered parts of the Sahel savannah, they neither create nor prevent intensification. Workable soils of adequate or improvable fertility and access to sufficient water at the proper intervals for crop growth are necessary but not sufficient conditions for intensive cultivation.

The intensification of agriculture is often thought to be synonymous with the conversion of farming from manual labor and simple tools to non-human energy sources and complex mechanical devices. Both westerners and educated Africans frequently accept the technological revolution that reduced labor and simultaneously increased production as a model of what the Third World must do. We must ask if such a change is the same thing as intensification and to what extent it is economically feasible in Africa. Intensification as we have defined it involves the permanent use of land in such a way that yields are sustained without environmental degradation. If this result can be achieved with a digging stick on a flood plain or by tractors and combine harvesters, it is still intensive agriculture. Indeed, certain types of intensification such as the oriental method of hand transplanting wet rice may achieve higher production than motorized methods and be applied in spaces too cramped for effective use of power tools. Many African societies use the same simple home-made tools such as the hoe and sickle in both shifting and intensive cultivation and bring to each the same physical skills and repertoire of crops. Where shifting cultivation is dominant, it is not because people lack knowledge or aptitude for permanent cultivation but because, for a variety of reasons, intensive cultivation is less efficient in meeting their needs.

New tools, and in this we include such other inputs as improved seeds, manufactured fertilizer, pesticides, and herbicides, undoubtedly save labor, but are they therefore more efficient? Making and using them consumes large amounts of fossil fuels. When this energy source is cheaper than human or animal labor, it is preferred. When fuels are scarce and expensive, costs of production rise to the point where renewable people and draft animals may be cheaper (Pimental 1973). In a largely subsistence economy, the capital for even minimal technical innovations may not be present. Since plows and ox teams conserve labor, they may be used to bring new land on the settlement frontier into cultivation rather than to substitute for hand methods on smaller plots where labor is plentiful. Thus even intermediate technology may operate to <u>de-intensify</u> agriculture, decreasing yields per unit land while increasing total production. The invention and diffusion of agricultural technology is thus not equivalent to intensification nor is its desirability always high and constant. Availability of land, costs of labor and capital, susceptibility of specific crops to increased productivity, and market outlets for agricultural surpluses may all influence rural technological change. It may well be that the cost/benefit ratio may be highest for relatively small developments such as improved crop varieties and fertilizers that can be acquired cheaply and integrated easily in existing systems of cultivation. High-energy mechanical technology on the Western model may be an illusory goal that delays or diverts the course of local intensification.

Perhaps the most influential explanation of agricultural intensification to appear in recent years is the hypothesis of Ester Boserup. She sees increasing population density in rural areas as a major causal factor reducing the time that land can remain fallow and promoting systems of permanent land use. Instead of the conventional Maltusian sequence beginning with the invention or diffusion of new agricultural techniques making possible increased production and permitting population growth, Boserup (1965) suggests that the process is actually reversed. If local population density goes up for any reason, people must find ways to raise the production of each unit of land. The other crucial component of the Boserup model is her recognition that intensification has a cost -- in terms of output per unit of labor, it may be less rather than more efficient. Shifting cultivators make little investment in tools, use fire to clear trees, fertilize the soil with ashes, and kill weeds and insect pests. They often do not turn the soil at all, and their annual work expenditure is relatively small. In contrast, more intensive farming requires greater land preparation, soil conservation techniques such as ridging, terracing, and ditching, fertilization that may depend on tending domestic animals that produce manure, increased weeding and field guarding, and water control such as irrigation or drainage. There is now little doubt that intensive agriculture requires the average farmer to put in more hours of labor over the course of a year than does shifting cultivation (Hanks 1972). For the scarce resource of land, the farmer substitutes labor. The costs of this trade-off make understandable the reluctance of many long-fallow cultivators to adopt intensive methods. Though farmers may not calculate hours of work and exact yields, they make economically rational choices, and the best general rule for predicting their behavior is that they "work to get the maximum return for the minimum effort" (Nye and Greenland 1960). Therefore, "practices of extensive agriculture are normally adhered to until population pressure becomes such that the system ceases to be viable through lack of sufficient land for rotation" (Dumond 1961).

Simply stated, the Boserup explanation claims that increasing population density will force more frequent cropping of land, higher production per unit land, and an increase in labor input. The process of intensification is visible in decreasing amounts of fallow land, smaller farms, higher and more sustained yields, and the application of ever greater amounts of energy to each unit of land. Regional studies in West Africa have demonstrated again and again that population density correlates with agricultural systems in a regular manner with low density groups practicing shifting cultivation, higher densities engaged in rotational bush fallowing, and semi-permanent or permanent agriculture maintained under high densities (Gleave and White 1969, Udo 1965, Benneh 1973b, Netting 1969). The threshold for transformation to an intensive system in the Sudan zone may be a density of 200 to 250 per square mile, though this is subject to local environmental conditions (Prothero 1962).

What factors modify this postulated connection between population pressure and land use? Boserup does not specify why population should grow but merely suggests what happens when it does. The same effect would be produced by any change in man/land ratio, e.g. by demographic growth through increased fertility or declining mortality in a circumscribed area, by in-migration, or by a shrinking land base due to losing part of an area to competitors or alternative uses. The process of intensification itself may further stimulate population growth as higher and more stable levels of food production are achieved. According to the model, however, if the density of population is relaxed, people may revert to less labor-intensive shifting techniques (Boserup 1965:65). An apparent technical regression took place when Europeans colonized a sparsely settled southern Brazil or when Kofyar terrace farmers moved into a nearly vacant savannah area and took up slash and burn techniques (Netting 1968). In both cases, people with the knowledge and experience of intensive methods abandoned them because they no longer needed to economize on land and because they opted for larger returns on labor. It is true that once a complex irrigation system or an area of fenced and leveled farms has been established, people may maintain it even in the face of falling population (Brookfield and Hart 1971), but the overall co-occurrence of population density and agricultural intensity appears to be supported. Moreover, demographic growth seems to initiate the logic of intensification because it limits the ability of rural food producers to subsist by less demanding means.

We have been discussing intensification as if it took place in an artificial universe where local groups provided for their basic subsistence as influenced by existing environment, technology, and population. In fact we know that almost all rural people today are involved in both regional and global economic networks, and that their choices of how to farm and whether to farm or follow alternative occupations are influenced by conditions in the market place. It is also clear that farmers are shrewd judges of profitability, putting land and labor into those crops that fetch a good price and rapidly switching away from products on which returns have declined. Given this practically universal eagerness to participate in market exchange, can economic factors alone trigger intensification? This may depend on a set of other ecological variables. If there is market demand for a crop that can be grown by shifting techniques and if land is plentiful in relation to labor, increased production will take place by extension of the farmed area. If the crop demands a resource in short supply, such as the water required for irrigated rice, or if special practices are needed, as in the transplanting and fertilizing of tobacco, the introduction of the crop demands intensive means, regardless of the man/land ratio. Under such circumstances, there may be selective intensification of cash crops while subsistence foods are cultivated by traditional shifting techniques. Intensification may spread to the rest of the farming system only if the other factors of population pressure and resulting land shortage are present. Even where a cash crop is currently profitable, however, farmers may be reluctant to rely entirely on it, preferring to maintain the subsistence insurance of home-produced food as a hedge against the uncertainty of market prices.

Economic factors emerge most clearly in relationships between distance and intensity of agriculture. Farmers characteristically practice the most intensive methods, e.g. the kitchen gardening of vegetables, in plots nearest to their residences where travel time for the frequent visits to tend, manure, protect, and harvest, is minimized. Zones at greater distance from the homestead are characteristically cultivated with declining intensity. Similar land-use rings may be seen surrounding settlements. Markets also set up spheres of attraction within which certain products may be produced mainly for trade. The farther one is from a city, the greater the cost of transport and the more the risk that perishable products like fresh vegetables or fruit will not arrive intact. An urban market is both a dependable outlet for food, condiments, fibers, and other raw materials and a source of the necessities that more specialized farmers do not produce for themselves. It is pointless to argue whether large centers attract population or dense populations crystallize into market-based towns and cities. The fact is that peri-urban areas are characteristically more densely populated than the hinterland, that high demand and low transport costs encourage intensive use of scarce resources such as land, and that market exchange rewards both specialization and year-round production. The fine-comb methods and multi-cropping of the truck gardener are typically found in close proximity to market centers.

With the extension of market inducements along rivers, roads, and railroads, allowing cheaper transport and ease of communicating economic information, the conjunction of higher population density and agricultural intensification may radiate into the countryside. Migrants take up land near roads, and land develops a scarcity value. Building sites compete with agricultural uses, and the familiar cycle of high land prices and the need for increased, constant agricultural returns begins. Over large areas of West Africa, economic development is based on cash cropping. More land is taken into cultivation, and there is also a premium on increasing output per acre. Increasing the land requirements of the community lowers the critical population density and at the same time hastens the same agricultural changes that are also contingent upon increasing population density (Gleave and White 1969). The spread of cash cropping and population growth are practically inseparable as causative factors, but it is safe to say that intensification will proceed most rapidly when both are present, and that cash cropping without dense rural populations is less likely to employ intensive means.

Because economic development implies the diversification of opportunities to make a living outside of agriculture, there is no simple one-to-one relationship between increasing population density and intensification. With shrinking land resources, small holders may decide to work as part-time craftsmen or traders or they may seek seasonal wage labor in their own communities or abroad. Wives may find cottage industry more lucrative than farming, and unmarried sons may get jobs in the city and send remittances home. The choice is not whether or not to participate in the market economy, but whether more intensive agriculture is the most profitable way to do this.

Regional comparisons in which factors of physical environment and population pressure are held constant show that core areas near large market centers follow the course predicted by Boserup, producing food and raw materials by means of permanent cultivation. Peripheral areas, on the other hand, make up the short-fall from traditional shifting cultivation by sending migrant wage laborers to distant plantations or mines. With cities less accessible and transport costs high, farmers from the hinterlands cannot compete effectively. Rather than make expensive, long-term investments in terraces or soil improvement, they can achieve more immediate economic benefits by selling their labor (Smith 1975). Where intensification is not a response solely to subsistence needs but also to market demand, it may reflect local differences in purchasing power in addition to demographic factors. The economic model requires consideration of a variety of economic strategies, of which agricultural intensification is one, and an effort to assess the relative rewards of each.

All of the factors we have been discussing may be affected both indirectly and directly by the actions of national governments and international organizations. Development in the agricultural sector and particularly the intensive production of cash crops for the world market was approached during the colonial period by expansion of the transport and marketing infrastructure, by eliminating warfare and unsettled political conditions that interfered with commerce, and by imposing taxes that forced people to sell products or services. Colonial conditions probably stimulated both population growth and economic activity, thus contributing both push and pull factors to the intensification of agriculture. Since World War II, in the closing years of colonialism and in the new independent states of West Africa, large planned projects or schemes have also attempted to change cultivation directly, introducing modern, high energy technology to irrigate, plow, and harvest cash crops by means developed in the West. Stepped-up scientific efforts were devoted to coping with local environmental conditions through the breeding of new crop strains and experiments with different fertilizer applications, crop rotations, and soil characteristics. In many cases it was assumed that the dissemination of scientifically proven new crop varieties and methods along with a labor-saving technology would produce such immediate and obvious benefits that they would be rapidly adopted. Dreams of a Green Revolution often went unfulfilled, however, and intensification often proceeded by traditional methods outside the projects rather than within them. By establishing projects in sparsely populated areas, seeking to limit economic alternatives for workers, and favoring expensive mechanical solutions over intermediate technology, governments often neglected the incentives to intensification present in both man/land ratios and private profitability. Where elaborate plans have not borne the expected fruits, there is always the tendency to blame single factors -- the intransigence or ignorance of local ethnic groups, a poor rainfall regime, ineffective agricultural extension, or the lack of capital and trained personnel to keep equipment running. Propaganda for the new techniques and exhortation of the farmers was sometimes replaced by subtle forms of coercion in requiring the repayment of agricultural credit or forcibly claiming a part of farmers' harvest. While believing that indigenous agricultural intensification took place in the past and continues spontaneously today and that governments have enormous powers to assist or hinder this process, we wish to suggest that the process involves a variety of factors in complex systemic interaction, and that not all of these are subject to direct manipulation from the outside. Since we are not discussing the type of intensification achieved by highly capitalized and tightly administered agribusinesses or state farms, we will be most concerned with the variables affecting the cumulative decisions of small farmers in the light of their own material best interests. There is no automatic assurance that such decisions to make agriculture more permanent and more productive will always coincide with the goals and the priorities of the state.

Case Studies

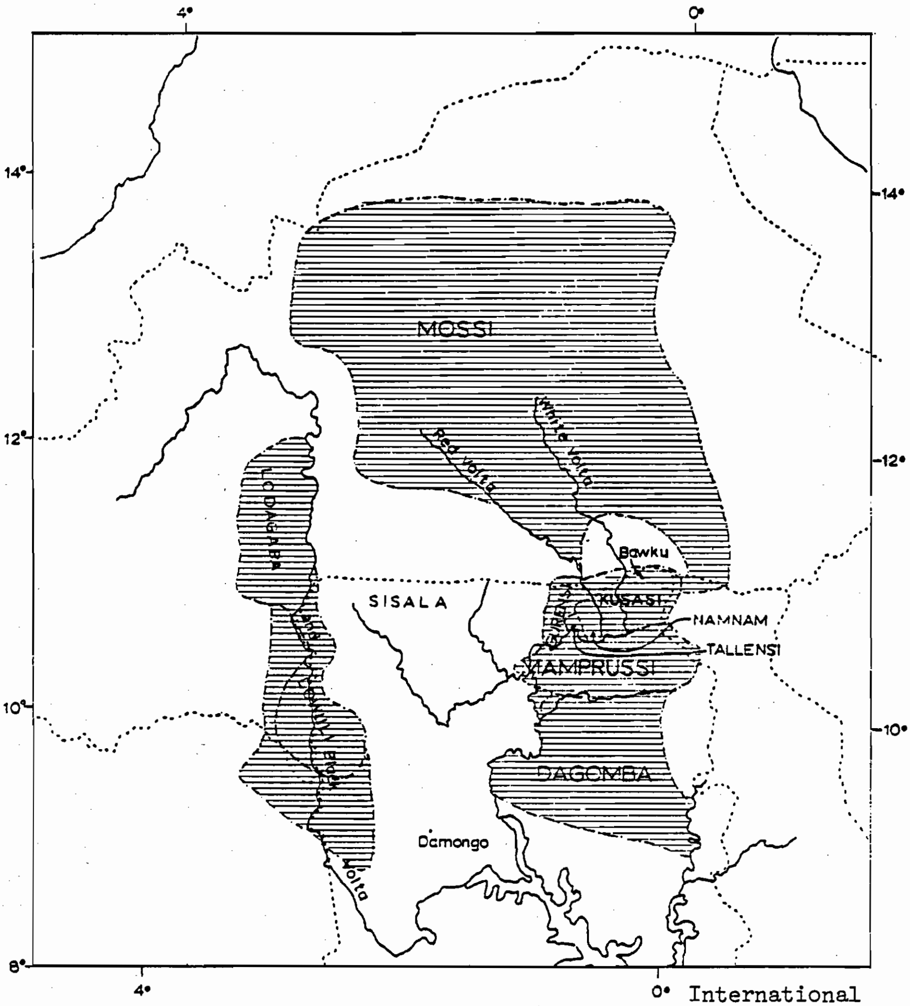
The purpose of the case studies is to present the range of factors influencing intensification in a given situation, and to show how these factors might change through time. Each case study is in turn representative of types of intensification related to possible casual factors. We are not trying to set up a typology, but merely to suggest associations, possible causal relationships, and to evaluate application of the models presented in the previous section.

The first case is that of the Kusasi of northeast Ghana, which is representative of rural rain-fed agriculture in densely settled areas. Next we will deal with the Hausa of northern Nigeria as representative of various degrees of intensification, including permanent cultivation near large traditional cities. The last case, representative of irrigation agriculture, is the interior delta of the Niger River in Mali, where rice is the major crop.

The Kusasi of Ghana. The Kusasi are a group of about 250,000 people living mostly in the northeast of Ghana, with smaller numbers across the borders in Upper Volta and Togo. This homeland is called Kusack. Significant numbers of migrant live further south in Ghana, especially in the cities and cocoa growing regions, and there is more and more of a tendency for them to become permanent residen there.

Their language, Kusaal, is one of the Mole-Dagbane languages. Along with other tribes in this group they form a culturally homogeneous area in Northern Ghana and Upper Volta (see Fig. 10). Within this area, where millet, sorghum, and peanuts are the main crops, it is northeast and northwest Ghana that the most intensive rain-fed agriculture is practised.

The Kusasi system will be presented as an example of intensive agriculture. Much of the discussion is based on preliminary analysis of information gathered during field work in one village of about 2,100, here referred to by the pseudonym of Tenga. (This field work was done by Cleveland from October 1976 to March 1978, and was supported by a grant from USAID to the University of Arizona). All the people were Kusasis with the exception of seven families of Fulani who specialize in cattle herding for other villagers. Some information on the other



Mole-Dagbane language group

Frafra = Gurensi, Tallensi, and Namnam

International boundaries

Approximate ethnic boundaries

Figure 10. Location of the Mole-Dagbane area in Upper Volta and Northern Ghana (from Fortes 1945, Goody 1967, Hunter 1968).

intensive farmers in northern Ghana (Tallensi, Frafra, Namnam, LoWiili, LoDagaba and Mossi) will also be presented. In addition, comparisons will be made between intensive farmers as a whole and the more extensive farmers (Mossi, Mamprussi, Sissala) in the area.

Prehistoric population movements in West Africa are little known, but the Kusasi and related groups have legends about origins to the east, in what is now northern Nigeria and southwestern Chad. This agrees with what is known from historical studies (Fage 1969). It is not possible to say why the Kusasi first came to the area where they live today, but it was probably part of the general migratory movement that seems to have characterized much of west West African history, resulting from trading, slave raiding, movements of nomadic herders, and military movements by various states and kingdoms. It is difficult, too, to know the origins of the Kusasi intensive agricultural system, based on the manuring of a permanently cultivated compound field adjacent to each house. Extensive farmers in the Mole-Dagbane area also have manured compound fields but they are abandoned when fertility wanes. High population density and intensive farming appear to be correlated in northeast and northwest Ghana.

It may be that present population distribution is to some extent influenced by slave raiding. Hill areas in northern Ghana are often more heavily populated, partly because they tend to have more fertile soil, but it could also be a result of the refuge they provide from slave raiders, as well as local hostilities.

Societies in the Mole-Dagbane area can be divided into those with chiefs organized into kingdoms, and those acephalous groups without a tradition of chiefs or kings. Both groups are, however, patrilineal societies. It is probable that small groups of warriors from the north brought the ideas of kingship and chiefship to the Mole-Dagbane area, founding the kingdoms of Dagomba, Mamprussi, and Mossi among local acephalous peoples towards the end of the 15th century (Fage 1964). These invaders brought Islam and associated traditions such as the use of the horse and wearing of a red fez, still symbols of chieftancy today. The Kusasi and other smaller groups occupy a sort of buffer zone between the states.

The kingdoms were involved in the north-south trade, and it appears that it was originally to protect trade routes that attempts were made to set up chiefs and establish some control over the acephalous societies outside of the main kingdoms. This process was still going on in northeast Ghana at the time the British first established effective presence in the area in 1900, cutting short a retaliatory raid by the Manprussi against a makeshift alliance of a few Kusasi villages. It was not until the British established control and demanded to deal with the local population through a chieftancy system that it became firmly established in the acephalous groups.

Amongst acephalous groups like the Kusasi the largest political units were villages, with much fighting going on between, or sometimes even within them. The oldest man in each village, or part of a village, is designated the "tengindana" (lit. "land owner," but often translated as "earth priest"), who is in charge of allocating land and making sacrifices at harvest and other ceremonies. In addition to spirits of the earth and other natural objects, the Kusasi believe in ancestor spirits, and events of the agricultural cycle are marked by sacrifices and ceremonies honoring these forces in Kusasi life. Tengindanas are still important today; people say that they are in charge of the earth, while chiefs are in charge of the people, a role the tengindana never had. Even in the Mole-Dagbane kingdoms there is still a recognized division between the local and invading group, one with their tengindana and the other with their chief, with mutual interdependence emphasized on ceremonial occasions.

The most restrictive environmental consideration for Kusasi farmers is water, and food production is almost entirely dependent on rain. Some farmers are able to cultivate dry-season gardens by watering from shallow wells dug in stream beds. During the rainy season a small quantity of rice is grown beside little streams.

Daily distribution of precipitation during the May to October rainy season is highly variable. Farmers begin planting after the first two or three good rains in late April or May, and if there is subsequently a temporary dry spell, then extensive replanting is required. This has been the case during the last several years in Kusaok. Replanting, however, can only be done for a certain period because of limitations imposed by growing periods and labor available for weeding later in the season. Poor rains in June and July of 1976 led to poor yields of early millet, while exceptionally heavy rains in October, during setting and development of seed on late millet and sorghum, led to poor yields of these varieties, with a high incidence of smut.

The extreme temporal and spatial variability of rainfall is met with the Kusasi belief that it is controlled by certain "rain owners," or gods, and appropriate sacrifices and tributes have to be made to ensure a good rainfall. On the other hand, Kusasi farmers employ methods to make the most of the water they receive such as using more drought resistant varieties in shallow upland soils and planting less drought resistant varieties like early millet in valley areas or on manured fields. Terracing of hills and planting of grasses across shallow valleys helps to slow down run off. Yet the intensity of cultivation has led to an increasing amount of erosion, creating large expanses of soil with much reduced fertility.

Most of the streams in the area are intermittent and there is little surface water in the dry season. Water for drinking and domestic use is obtained from shallow wells, or more recently from deeper lined wells, dam ponds or tube wells. These first three water sources are subject to heavy contamination and are foci for the spread of disease

The wet season brings its own water related health problems, with mosquitoes breeding in shallow ponds and puddles and bits of pot shards. The black fly (Simulium damnosum) which is the vector for river blindness, breeds in fast flowing streams. Hence this disease is more prevalent in the granitic and metamorphic areas such as Kusaok, as opposed to the sandstone areas, since the former's steeper stream profiles lead to the higher velocities necessary for black fly breeding. River blindness is hyperendemic north of 10°30' along the major river valleys and associated streams (Hunter 1966a:265). Among the Namnam just east of the Kusasi (see Fig. 10), there is evidence that there has been at least one cycle of advance toward the Red Volta in the late 19th century (Hunter 1966a). It was caused by a period of poor rains and insufficient production, followed by a longer period, since about 1918, of retreat from the river primarily because of onchocerciasis. It is easy to see from maps showing population distribution that much land along the large rivers is virtually uninhabited due not only to onchocerciasis but also to trypanosomiasis.

Within the northern savannahs of Ghana are three main groups of soils whose properties are determined primarily by the parent material over which they developed (Ghana Geological Survey 1955; Adu 1969).

1. Soils developed over Birrimian rocks of metamorphosized lavas and other intrusives are inherently fertile with high phosphorus content; rate of erosion is high because they are found in hilly areas; they correspond to the eutrophic brown soils of Figure 8.

2. Soils developed over intrusive granites are not as fertile, but respond well to manure and fertilizer applications; they are shallow, and under intense cultivation and grazing may develop large, severely eroded areas in which most of the organic content is gone, as around Bawku town and in the larger Pusiga area to the east of Bawku.

3. Soils developed over Voltaian rocks -- sandstones, shales, and mudstones -- give generally poor quality soils with low nutrient content, but good drainage, and yams are a common crop in these areas.

These last two soils are in the area classified as ferruginous soils in Figure 8.

There is a general association between the distribution of these soil types and population density, with highest densities on the granitic areas of northeast and northwest Ghana. This is demonstrated on a more local scale by data from a 1955-57 survey of 68 square-mile sections in the Frafra area northeast of Bolgatanga (see Fig. 10). The more fertile soils carry higher densities of both humans and livestock (Topham 1957). In Upper Volta, however, there does not appear to be a good correlation, as the heavily populated Mossi area in the center of the country has poorer soils than the sparsely populated areas to the east and west.

All soil types are affected by slope, with the upper inter-valley soils being the most fertile and easily worked and less subject to erosion. Lower slope and valley soils tend to be heavy with high clay content, subject to water-logging and difficult to work with hoes or ox drawn plows. Kusasis have a soil classification system which they use together with their knowledge of the requirements of various crops in deciding what to plant in each field.

Fire and cultivation are the two major effects of man on soils, leading to decreased organic content and exposing the soil surface to wind and water erosion and insolation.

The granite areas which make up most of Kusaok are characterized by a gently rolling terrain of 150 - 250 m elevation. The Birrimian greenstone hills northwest of Bawku town rise fairly steeply to an elevation of 420 m. At the southern edge of Kusaok, where the Voltaian sandstone begins, the Gambaga escarpment rises abruptly from the valley of the Morago River to 500 m. In the rainy season there are many small streams flowing, and gully and sheet erosion are common throughout the area. In the dry season only the major rivers have water, and they are reduced to not much more than a trickle.

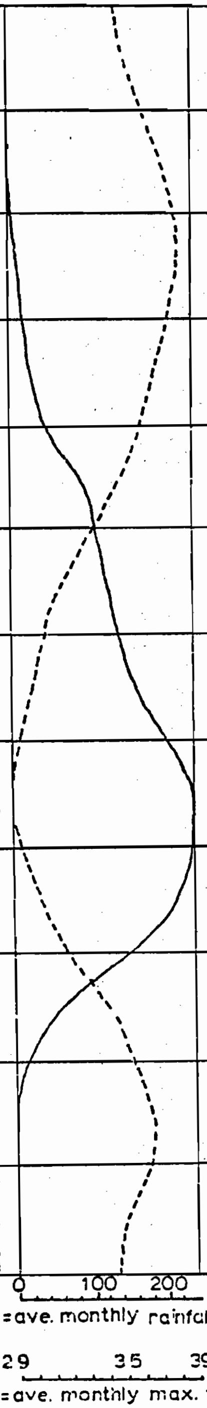
The dominant vegetation in the sparsely settled areas of Kusaok is a relatively stable fire pro-climax community of broad-leaved deciduous trees densely distributed in a continuous ground cover of perennial bunch grasses and associated forbs. The trees have spreading crowns at 12 to 15 m, but seldom form a closed canopy (Rose Innes 1977). These relatively open conditions are the result of centuries of fires, probably often started by humans either accidently, for purposes of hunting, or to promote pasture development.

Once clearing for agriculture begins, only trees, selected because of their economic value, are left standing. In several locations in Kusaok, extended periods of cultivation and grazing have resulted in soil exhaustion, denuding, and extensive erosion.

The annual agricultural cycle is summarized in Figure 11. Field preparation begins several months before the first rains and is generally limited to the compound field and fallowed fields that are to be replanted. If the farmer has enough time to spare, weeding often begins in the latter during the preceding rainy season, while the ground is soft. On previously cultivated fields preparation takes very little time, and a few hours a day may be spent rearranging the abundant rocks into heaps, or making them into ridges to check water erosion. Remains of old stalks and leaves are raked together using a few stalks held together in one hand to form a simple broom. They are heaped in small piles and burned just before the rainy season is due to start.

The application of animal manure to the compound farm before planting is an extremely important part of the Kusasi intensive farming system. Goats, sheep, chickens, and guinea fowls are kept at night in their own rooms of the house, close to the outside door. Before the rains the manure is scraped from the floor and carried in baskets to the field where it is dumped in small heaps to be distributed by the rains. Farmers who keep their own cows and bullocks, instead of giving them to the Fulanis to herd, keep them enclosed at night so that their manure can

SUBSISTENCE ACTIVITIES and FOOD SUPPLY



January	Dry season gardens prepared Hunting, fishing Building, repairing house walls begins
February	Food begins to be rationed Marketing of dry season garden produce Gathering grass for thatching roofs, weaving mats, making brooms
March	Arranging stones, burning trash on compound fields Gathering of leaves and other bush foods
April	Shea butter, locust bean seeds and baobab leaves collected Carrying manure and rubbish to compound fields Cultivating some areas of compound fields Planting begins, first on compound field with early millet,
May	then late millet, sorghum, cowpeas, neri interplanted Planting of more distant fields begins First weeding of early millet
June	Animals must be confined or herded now Planting of peanuts and rice, continues through July First weeding of late millet and sorghum fields Second weeding of early millet
July	Food supplies at lowest, in bad years many families with no grain Early millet harvest Transplanting of sorghum and late millet
August	Second weeding of sorghum and late millet continues through September Early millet harvest ceremony
Septem.	Harvesting peanuts, bambara beans, continues through December
October	
November	Harvesting of sorghum, late millet begins; harvesting peanuts continues Food most abundant
December	Harvest celebrations Burning of fallow fields to be planted next season

Figure 11. Agricultural Cycle in Kusaok.

also be used. The value of manure is well appreciated by the Kusasis, and they even go to Fulani houses to ask permission to gather manure from tethering areas to carry back to their own fields. The heavy manuring around Fulani houses produces noticeably better crops than the average. When the harvest is poor, farmers may sell animals to get money for food. Several years of bad harvests such as those recently experienced, may reduce a farmer's supply of manure and thus increase the difficulty of improving yields.

Sowing is done by all members of the household who are old enough, beginning with the compound field. A narrow-bladed (5 cm) short-handled (50 cm) hoe is used in one hand to make a hole, while several seeds are dropped in from a calabash with the other hand. The compound field is usually sown to early and late millet and sorghum, with cowpeas (Vigna unguiculata), neri (Colocynthis citrullus, a seed producing gourd) and okra (Hibiscus esculentis) often scattered about among the grain.

As sowing is completed on the compound farm, activity will be moved to more distant fields. Late millet and sorghum are the most common crops here, but peanuts and bambara groundnuts (Voandzeia subterranea) may be interplanted and form an important part of the crop rotation cycle.

Farmers with a field in a moist valley area may plant red rice.

The boundaries and sides of paths through fields are often planted with sesame (Sesamum indicum), beregas (Hibiscus cannabis -- leaves are eaten in soups and fiber for rope is made from stalks), and bit (Hibiscus sabdariffa -- same uses as H. cannabis). Women also plant their kitchen gardens at this time, which contain mainly okra and several varities of edible leaves.

Weeding is done with a short-handled hoe with a medium width (15 cm) blade. Weeding of the early millet in the compound field must begin before planting in the most distant fields is completed, as it is very intolerant of weed competition. It is weeded a second time before harvesting in July, when it provides a welcome respite from hunger for the farm families in the middle of the heavy work season. Crop production may suffer as a result of insufficient food to keep farmers strong and active at this time. Late millet and sorghum on the compound field will be weeded once again if there is time. More distant fields are weeded twice, except groundnuts and bambara beans which are only weeded once.

The household head must decide each day what fields will be weeded. Labor is the critical resource at this time of the year, and must be distributed according to amount of weeds present, weed tolerance of different crops at various stages of growth, and time and difficulty of weeding various fields. Some farmers use ox drawn plows for field preparation and weeding.

In the early part of the rainy season, weeds are simply chopped out with the hoe and left on the surface to die. Later, at the heaviest part of the rainy season, when weed growth is luxuriant, weeds are heaped in piles in the fields and covered with dirt to prevent them from re-rooting. This also provides green manure for the next season.

Harvesting of late millet and sorghum occurs in November, and rice in December. Peanuts and bambara beans are harvested from September through December, as there are early and late plantings. Little crop residue is left in the field to maintain fertility, as the demand for energy is so great that almost all parts of the plant are used. Millet and sorghum stalks provide the main fuel for cooking, beer brewing, and pottery making; they are also used in mat making and to some extent in construction, and provide a source of income to women who may carry them to the market to sell. The threshed heads are used for scouring or animal feed. Peanut leaves and vines are a major source of animal fodder in the dry season.

Water erosion is combatted by constructing crude stone terraces and retaining walls and planting certain species of grasses in run-off areas. Again, due to pressure on the land, steep hillsides and gullys may be cultivated.

As the harvesting ends, the dry season is beginning, with the harmattan wind starting to blow in out of the northeast after the first of the year. The landscape is soon changed from green to brown, and burning of grass on pasture and waste lands begins.

Various surveys in Kusaok show an average total cultivated land per person of about 0.5 ha, about one-half of which is in compound fields. The compound field is the center of the intensive farming system and is adjacent to the family homestead. This is usually the only place where early millet is grown since it needs manure and constant weeding. In addition to early millet, one or more other varieties of late maturing millets and/or sorghums are interplanted, and cowpeas and neri are grown at wide intervals. Different areas of the compound farm may have different mixtures planted on them, or even occasionally pure stands, depending on the soil and drainage characteristics. Farmers vary the mixtures from year to year according to their experiences of the previous year.

Part of the compound field closest to the homestead may be planted to a small stand of kenaf, or a mixture of kitchen vegetables. This area may be cleared late in the rainy season sometimes, and replanted to leaf tobacco.

At various distances from the compound field are usually one to three fields planted mainly to late varieties of millet and sorghum. These fields seldom, if ever, receive any manure, and were traditionally fallowed to renew fertility. Increasing pressure on land has led to a shortening of the fallow period on these fields, fertility being maintained as much as possible by rotation of crops.

Conceptually distinct from these farms where the staple grains are grown, are fields where groundnuts, bambara beans, rice, or cotton are grown. Fields may rotate between being a grain field and legume field, or may even be divided in two. Very little cotton is grown, especially in recent years. The market value of food crops compared with the government price paid for cotton, even when input subsidies are considered, makes it uneconomical. Cotton is not a traditional crop of the local people, being grown by Fulanis.

The compound field and the outlying grain fields, and perhaps some groundnut, rice, and cotton fields, are considered to be those of the household head, and all household members old enough to work on them are expected to do so, for they will be fed during the year by the produce from these fields. Most older household members have their own fields as well, which may be given to them to cultivate by the household head, or by someone else. The produce from these fields is theirs to consume or sell as they see fit. All wives have a kitchen garden behind their room where they grow ingredients for the soups which always accompany the millet or sorghum porridges. Revenue from selling some vegetables, or groundnuts from their own fields are used to provide such items as salt and dried fish, as well as personal items like cloth, pots, and sacrificial animals.

The staple crops grown in the Kusasi area are millet and sorghum; other grains such as corn and rice may be grown in small quantities but are not important in the diet. These two cereals are well adapted to the soil and rain fall; varieties with shorter and shorter growing seasons become dominant as one moves from south to north. Other crops grown in Kusasi include peanuts, bambara beans, cowpeas, neri, and several vegetables such as tomatoes, okra, and onions. Many varieties of naturally occurring plants are also used as food sources, including the three trees already mentioned, and play an important role in the diet. Many herbaceous weeds are gathered from the fields during the beginning of the rainy season to be used in soups. Meat plays a small, but perhaps significant, role in the diet. Animals, with the exception of pigs, are seldom, if ever killed solely for eating. Sacrifices of animals, however, are always consumed, and some such sacrifices tend to occur in stressful situations when extra high quality protein is valuable. Most common animals are chickens and guinea fowls, with sheep and goats next. Little game is caught during dry season hunting expeditions as it has mostly been removed from the high density areas by the increasing human activity.

Nutritionally the diet is of good quality, the major problem being one of quantity. The main dish is a thick porridge of millet and/or sorghum flour dipped with the hands into a soup,which is eaten in much smaller quantities. The most common soup ingredients are fermented locust bean paste; legume, sesame, and other ground up seeds, dried yeast from beer brewing; leaves, okra, and other vegetables; hot pepper; and salt. Soups are generally high in minerals, vitamins, and proteins, with the porridge containing 70 per cent of the dietary protein and 85 per cent of the calories (Gordon 1973). If adults eat enough of this diet they will be well nourished. It is often difficult, however, for children (6 months to 3 years) to eat enough, especially when they are sick. Studies in Tenga show a typical pattern of increasing malnutrition and decreasing rate of weight gain after 5 - 6 months when breast milk is no longer adequate. The marked seasonality of the agricultural cycle, with food scarcity coming at the time of greatest demand for agricultural labor, also leads to significant weight loss in adults, as shown by studies among the Namnam (Hunter 1967b) and in Tenga.

In Kusaok grain is stored unthreshed in mud granaries built on a stone foundation and topped with thatch. An insect repelling substance is prepared from a local plant and used in the plastering of the inside of the granary. Losses in these granaries, due mainly to insects and fungal diseases, vary widely, but are surely significant. Only the male head of the household is allowed to look into and take from the granary. He distributes amounts to the wives in his house according to their estimated needs and at intervals of about a week. Women thresh the grain with wooden flails on beaten earth thr shing floors or on large boulders and grind it into flour on specially shaped stones. More recently they may have the option of taking the grain to a small diesel mill.

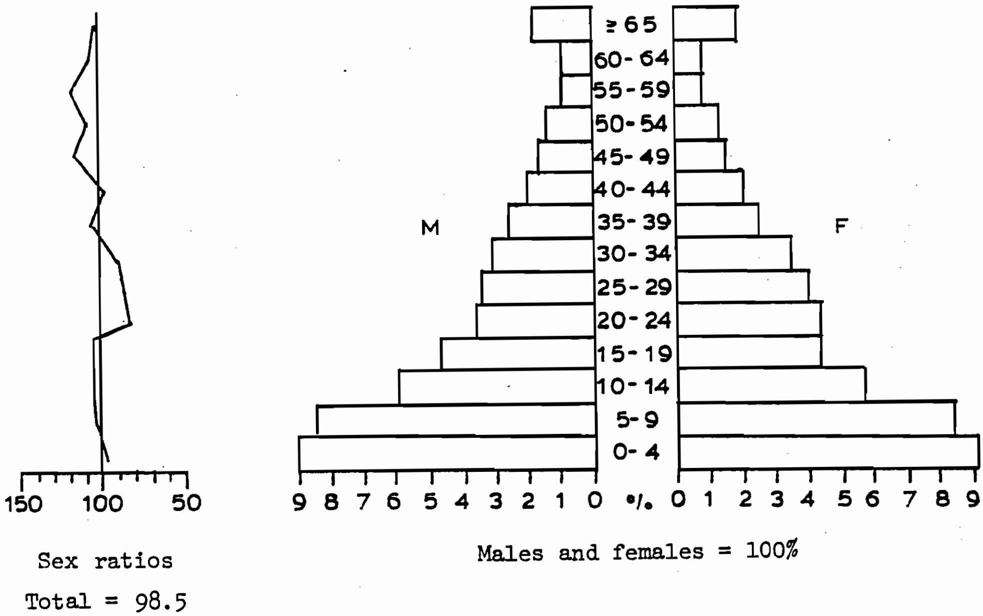
There is some sexual division of labor from the time that children first begin to help their elders, but this becomes more rigid as they get older. Men do the majority of the agricultural work, with women helping mainly during sowing and during harvesting by cutting the grain heads from the stalks which the men have uprooted or cut near the ground. The heavy jobs of field preparation and weeding are reserved for men. This is not to say that the women's work of hauling water and fuel, threshing and grinding grain, and caring for children is any easier. On their own fields women may do more of the work, and they care for their kitchen gardens by themselves.

Children begin working regularly with their parents by the time they are eight to ten years old. After about age 55 the work load becomes considerably reduced, although old people continue working in the fields as long as they are capable.

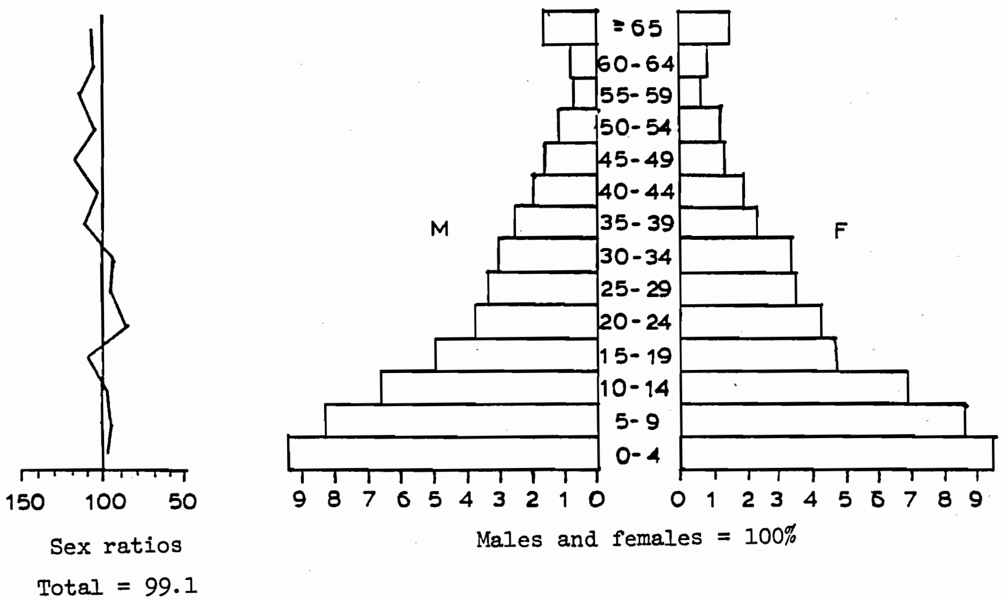
Most of the work on a household's fields is done by the members, but there are several types of non-household labor that are used, the most common being invited labor, in which a household head invites several relations and/or friends to help him in weeding in return for providing food and/or beer for them. This is not a strictly reciprocal arrangement, and older people can request this kind of help without being expected to repay. A less common form is reciprocal work groups, often of younger men. More common in the past than presently was the obligation of a son-in-law to work for his wife's father a reasonable amount of time after first marriage. Wage labor is rare but becoming more common.

Population structure in Kusaok and the rest of northern Ghana differs markedly from that in the rest of the country. Figures 12a-c, 13 compare the whole of Ghana, the Upper Region, and the Ashanti Region, a forest area in the south where extensive agriculture is practiced and where many migrants from the Upper Region go to work on the cocoa farms. Figure 12d-e shows the population pyramid for the Bawku District (which contains almost all of Kusaok) and for Tumu District, located in the central-western part of the Upper Region. Tumu is sparsely inhabited by Sissala and other tribes who practice an extensive bush fallow agriculture (see Figs. 10, 14).

The pyramids for the Upper Region are different from Figure 12a-c mainly in the rapid reduction after the 0 - 9 age groups, and the excess of females in the 15 - 44 age groups. The first characteristic is at least partially explained by the fact that the mortality rate in the Upper Region is the highest in Ghana (Gaisie 1976). The distorted sex ratios in the most economically active portion of the population are primarily due to emigration to the south



a. GHANA, ALL REGIONS (Total = 8,559,313)



b. ASHANTI REGION (Total = 1,481,698)

Figure 12. Population pyramids and sex ratios, Ghana, 1970 (from Ghana Census Office 1975).

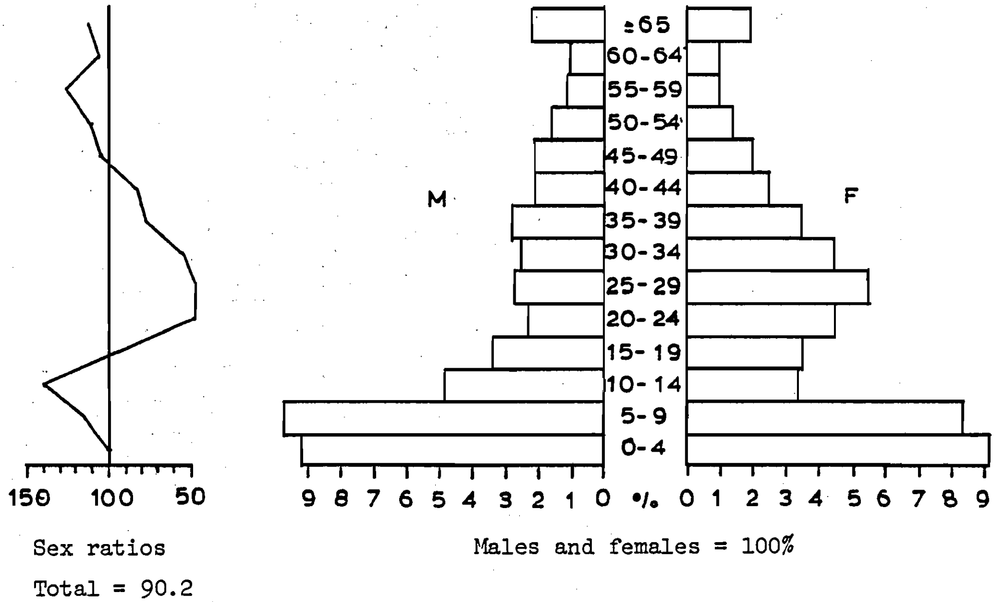


Figure 12c. UPPER REGION (Total = 862,723)

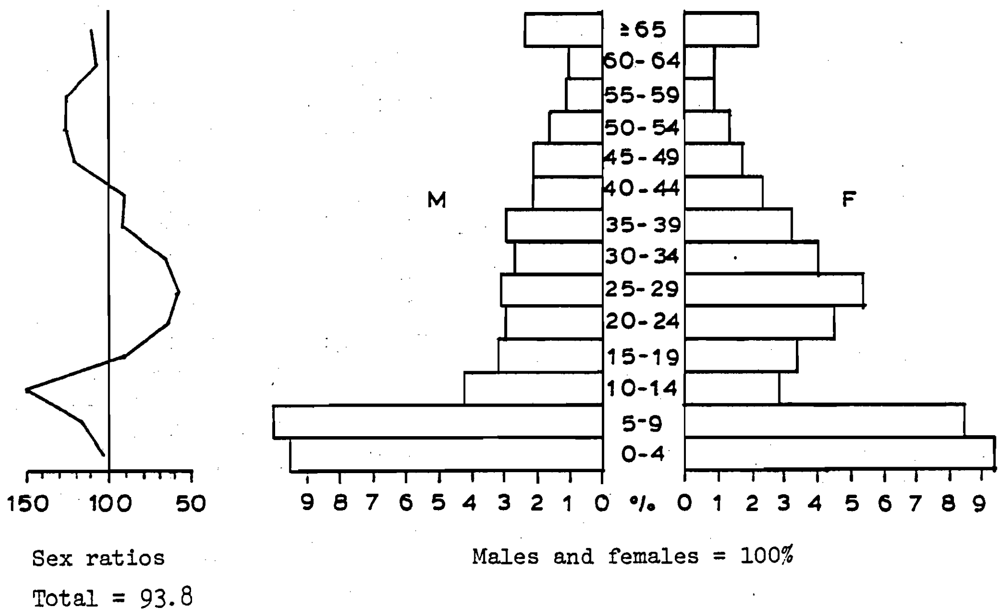


Figure 12d. BAWKU DISTRICT (Total = 221,868)

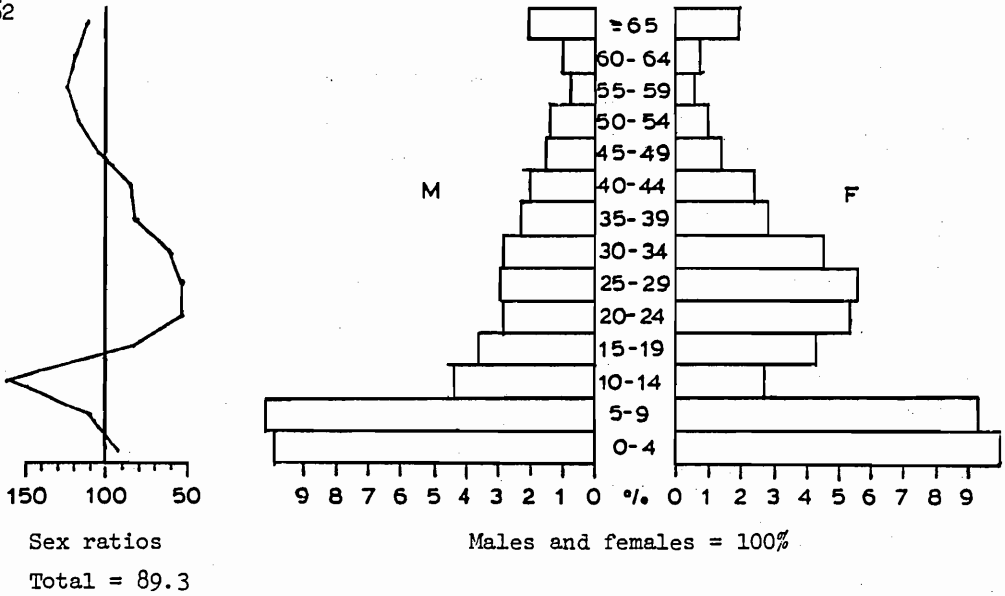


Figure 12e. TUMU DISTRICT, 1970 (Total = 42,442)

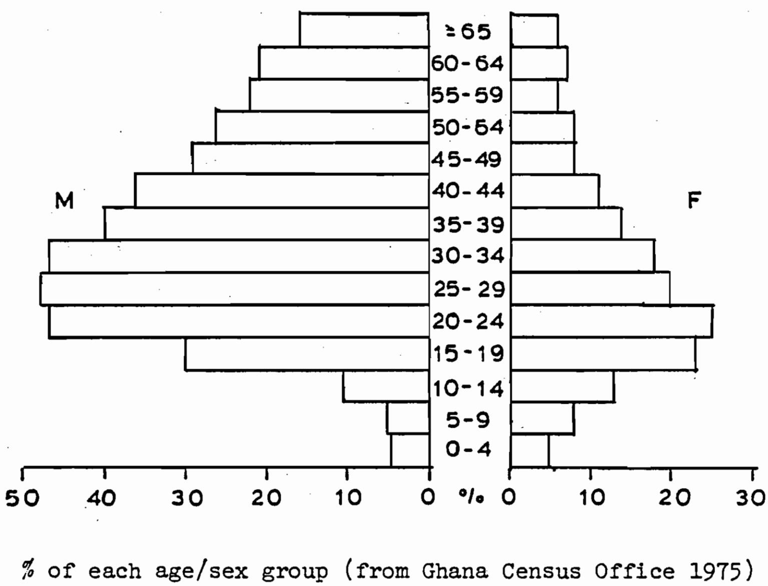
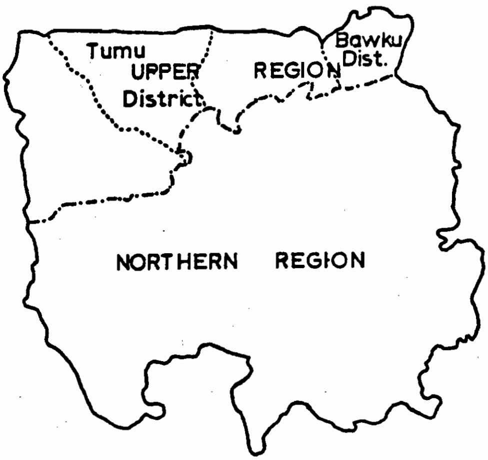


Figure 13. Percentage of people born in the Upper Region not residing in the Upper Region, 1970.



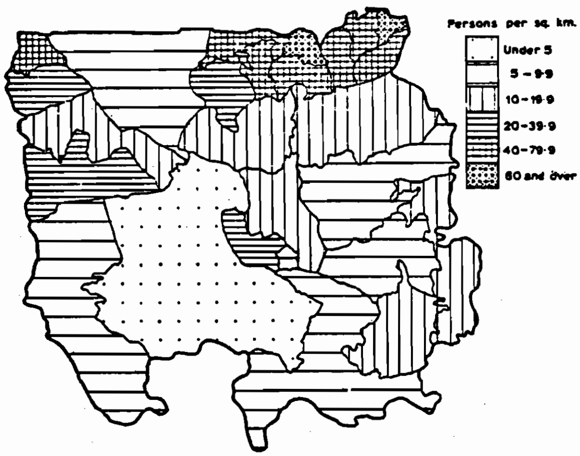


Figure 14. Population densities in Northern Ghana, 1970 (from Engmann 1975).

(cocoa farms, military/police, and service industry jobs), and reflect the relative lack of agricultural and economic opportunity in the savannah areas of the north. The age and sex structure of a population are determined by migration, mortality, and fertility.

Hunter's (1966b) calculations based on the 1960 census show that in the northern savannah areas of bush cultivation such as Tumu District, there is a definite correlation between population density and sex ratio in the 15 - 44 year age group in the various enumeration districts. Hunter sees this as indicating a response to deteriorating prospects for making a living with increasing numbers of people. In these non-granitic extensively farmed areas of the northern Ghanaian savannahs there may be little scope for intensification due to the poor quality of the soils compared with those in the northeast and northwest, so that population pressure leads to emigration rather than to intensification. In the intensive farming areas of the northwest and northeast, sex ratios are similar over a range of higher population densities. Population growth here has led to densities in excess of the system's ability to support them, and emigration is equally heavy over a range of high population densities.

Genealogical information for one major lineage in Tenga indicates the increasing incidence of migration over the last nine generations. There were a total of 136 men who had reached marriageable age, and 52 per cent of them had been migrants, most of those now dead or past middle age having eventually returned to Tenga. Periods spent outside of the village ranged from one to 30 years, and the most common reasons for emigration were to search for money for bride payment, to search for land, and to see the south. There seems to be a trend through time from pull to push factors as the major motivating force of emigration from the village. Reasons most often given for returning were simply a desire to return home, and illness or death of father or other close lineage relative, necessitating the assumption of lineage responsibilities by the migrant.

Sixty-three of the men in the lineage who have reached reproductive age were alive at the time of the survey, and 57 per cent of them were living outside of the village. Three generations (about 60 years) in the past, only 37 per cent of the men were migrants as opposed to 89 per cent now. Census data for the Upper Region for March 1970 shows a very large proportion of males outside of the Upper Region, almost 50 per cent of those 20 - 34 years old (see Fig. 13). As in the neighboring Frafra area, there is a growing tendency for migrants to stay away longer or even permanently (Nabilla 1975; Hart 1974).

The impact of this high rate of male outmigration on agricultural production is difficult to quantify, although it seems to be harmful. In Tenga it is not uncommon for old parents to be farming alone or with only young children while their adult sons are in the south working and sending little, if any, of their income home.

Infectious diseases are important factors affecting the potential for agricultural intensification. Their effect on population distribution is well documented, but the effect on working efficiency and motivation is less well known.

One of the most dramatic and important infectious diseases in the Kusasi area and in much of the West African savannah is onchocerciasis. The filarial worms in the body often migrate to the eyes causing blindness, which typically means the removal of the affected person from the work force and his conversion to dependent status. While blindness is the most dramatic symptom, other effects of infestation are also debilitating. One survey in northeast Ghana in 1966 of 16 villages found 3.7 per cent of the population blind, with the rate of infection with the parasite in persons 15 years and older well over 50 per cent (Senker et al 1973).

Together with the other infectious diseases mentioned, onchocerciasis contributes to the relatively high mortality rates in the Upper Region, which are the highest in the Ghanaian rural population at all age levels. Of every ten children born, only about seven survive to the age of five, and only five survive to the age of 35. Life expectancies reflect mortality rates and are also lowest in the country (Gaisie 1976, Chapter 4).

Another effect on agricultural production which must be mentioned is the expenditure of time and resources on illness. In Tenga the prevalence of children's diseases (during the two weeks before interview, as reported by mothers) rises from about 15 per cent in April, to about 40 per cent in July. The higher rates occur in the rainy season when demands of agricultural work are the highest. The most common childhood illness was diarrhea (42%), a typical finding in tropical subsistence communities characterized by a high rate of malnutrition.

Treatment of disease follows from the dominant belief that it is primarily due to social factors. Spirits of ancestors, witches, or living people are presumed to be the primary cause for an illness. Much time and resources are spent in sacrificing and consulting with experts in attempting to determine the agent responsible and then in placating or defeating it. Symptomatic treatment, however, is sought both from traditional sources and western medicine, the latter being favored for young children.

Although people in Tenga say that they remember a past when people lived longer and were sick less often, it seems that mortality has actually been declining. Estimates based on data gathered in 1948, 1960, and 1968 indicate a slow mortality decline during WW II and the early 1950s, and a rapid decline thereafter, with life expectancy in the rural population of the Upper Region estimated at 38 in 1968, still the lowest in Ghana (Gaisie 1976:137-39). Data on infant and child (0 - 4 years old) mortality from Tenga support this, showing a drop from about 300/1000 in the 1940s to about 150/1000 in the 1970s, a trend that is probably partially masked due to the greater forgetfulness of such children by the older women interviewed.

In the face of declining agricultural productivity and increasing population, a trend to declining mortality may seem puzzling, when one might expect, from a Malthusian perspective, just the opposite. Public health measures and provision of medical care are generally thought (Gaisie 1976) to have had an important influence: providing wells, vaccination campaigns, distribution of antimalarials, setting up of mission and government health posts and hospitals, and campaigns against such vectors as tsetse and black fly have all been important in the Kusasi area and northern Ghana. Another important consideration is that western influence has led to a greatly expanded trade and migratory network, so that local populations are no longer so narrowly dependent on their own resource base, and population reduction is limited. This process is based on the building of roads that allow for transport of food from food surplus to food deficit areas, the movement of people out of food deficit areas, and the movement of cash into the area through migrant and local labor. The result is an increased rate of population growth due to declining mortality rates and possibly increasing fertility rates.

While fertility rates in the Upper Region are the lowest in Ghana (Gaisie 1976), desired family size is the largest (Caldwell 1967; Gaisie and David 1974). This has important implications for the control of population growth in the overpopulated subsistence agricultural areas of the savannah that will be more fully considered in the next section.

Preliminary analysis of fertility data from Tenga indicate a trend to increasing fertility since 1918, especially in younger age groups. The most important reason for this may be the decreasing birth intervals reported by informants, decreasing from about four to three years in the last two to three generations. Birth intervals are consciously controlled by a post-partum taboo on sexual intercourse for the mother. The decision to terminate the taboo is taken on the basis of the youngest child's health, and the most frequently given explanation for exceptionally long birth intervals is that the older sib was sickly, and that the parents had to wait until he was healthy. The effects of too short birth intervals are appreciated by the Kusasis, who say that they can recognize the unfortunate older sib by his lean, sick condition. The increasing availability of Western curative medicine has tended to increase parental confidence that a child's illness can be successfully treated, while public health measures have probably led to a decrease in infant and (to a greater degree) child morbidity rates.

Increased personal security resulting from the establishment of the Pax Britannica around 1900 may also have contributed to reduced birth intervals. In the past mothers had to worry more about small children when gathering wood or food in the bush, visiting in another village, or going to market. If they were molested they would only be able to carry one child. Another contributing cause of higher fertility may be the decreasing age at marriage, the result of increased sexual awareness and greater social and economic independence on the part of young people of both sexes. In Kusaok a man must give four cows for a wife, and with increasing economic hardship these may become more difficult and expensive to obtain. It is uncertain whether this affects age at marriage, since young couples often run away to the south, and arrangements can be made to delay payments of the cows.

There is a developmental cycle in Kusaok in which households may move through several stages beginning with just a man, his wives, and children. From this simple nuclear family develop extended families of a man and his married sons, and then, when the father dies, to a senior brother and his own brothers, some of whom may have married sons of their own. A final stage of nuclear families may be reached when an old man or woman, or man and wives, live alone with no resident children. By far the largest proportion of households in Tenga are of the nuclear type.

To the casual observer in Kusaok the average household may appear to be very large because people from nearby households gather when a stranger is visiting. In fact, in Tenga, the average size of household was 7 (median = 5.6) with a range of 1 - 33. These values are similar to those obtained in other studies in northeast and northwest Ghana and in northern Nigeria. Average household size for the Upper Region in the 1970 census was 6.6, about the same as the northern region, but larger than that for the rest of the regions of Ghana.

The extended families in Tenga have more people in them, and a proportionately larger number of young, non-producing children (less than 9 years), but there appears to be a limit to the proportion of these young children at about 0.4, the median value for all household types being 0.3.

The most important productive resource by far is the compound field adjacent to the house which receives most of the manure. While sons of a deceased father may farm together for a while, disputes often develop rather quickly over relative amounts of labor contributed and amounts of produce consumed by the individual nuclear families. This leads to a division of the farm lands, the compound field being divided in wedges that all abut the house. Related family heads may continue to live together in the same house, although separate entrances may be used for the different households, and separate granaries will certainly be established. With increasing scarcity of land, and smaller and smaller parcels of the compound field, there is a tendency for increasing emigration.

While there is less agreement on the degree to which household size and type of agriculture practiced correlate than on the relationship between the latter and population density, there does seem to be a tendency within the Mole-Dagbane area for smaller household size to be related to increasing agricultural intensity. Among the Yatenga Mossi, even though settlement tends to be nucleated, "the elementary family as a unit in the productive system functions nearly autonomously" (Hammond 1966:96), and increasing land scarcity has resulted in a decrease in the number of people per dwelling from about 25 - 40 at the beginning of this century to about 9 - 10 today (Marchal 1977).

Other factors may be important, however. In the northwest of Ghana, Goody (1958) found that household size was smaller for the LoDagaba (7.0, with 1.5 men) than for the LoWiili (11.0, with 2.5 men) even though LoDagaba practice more extensive agriculture and have a lower population density (1.5 acres per person vs. 0.9). He sees the reason for this being the importance of matrilineal inheritance with the LoDagaba which leads to early fission of domestic groups, since a man's sons know that when their father dies a member of his matriclan and not themselves will inherit food they helped their father to produce, and the livestock that might otherwise help to get them brides. With greater land availability in the LoDagaba area, there is a greater tendency for sons to migrate in order to build up an economic independence.

An important factor in Tenga that may keep households from breaking up and growing small with increasing land scarcity and intensification of agriculture is wage laboring by one of the adult male members, while one or more other adult males remains a full-time farmer. Resources are shared, the cash allowing for the purchase of oxen, plows, and fertilizers that can increase production per unit area and even for the acquisition of more non-compound fields by borrowing. At times of crop failure, the cash may be used to purchase food in the market. Surveys in Tenga showed that 15 per cent of all households consist of non-growing nuclear families, in most cases with a male head and no adult children, but in some cases with a female head. The average number of members was 2.0. These households are usually the result of migration or death of sons or brothers and are among the poorest in the village.

Since migrants seldom return any resources to their homes, much less enough to make up for the loss of their productive labor, emigration would seem to represent a negative influence on the possibility for increased production. In fact the knowledge that older sons may often slip away to the south may act as a spur to increase fertility to replace labor lost to emigration. Observations in Tenga indicate that children begin to be net producers around the age of 10 years. This is supported by survey data (Caldwell 1967:226-27), showing that 49 per cent of respondents in rural areas of the upper and northern Regions thought that children earned their keep by age 5 - 9, and 74 per cent thought that this happened by the age of 10 - 14; and to the question "What are the good things about having lots of children," 55 per cent said that "they work on farms and in households." These are much larger proportions than for the rest of Ghana.

Thus decreased infant and child mortality may not lead to decreased fertility in these impoverished savannah subsistence farming areas, but to just the opposite. The fact that more children survive makes the total resource cost of each child (productive unit by age 10) less in terms of additional maternal resources necessary for pregnancy and lactation, and lost maternal and other household member productive energy spent in child care, especially during illnesses.

Population growth in Bawku District has resulted not only from natural increase, but from southward migration from what is now Upper Volta. This migration was especially heavy in the first part of this century, before the 1931 census, and was greatly influenced by French administrative policy. After this period natural increase was the most important factor, and has led to an increasing rate of growth. Between 1949 and 1960 the average annual rate of increase was 0.48 per cent, but between 1960 and 1970 it was 2.35 per cent, to give a 1970 population of 220,000.

Population densities have also increased dramatically from 49/km^2 (127 mi.^{2}) in 1931 to 71.4/km^2 (184 mi.^{2}) in 1970. Population is, of course, not evenly distributed, and large areas of Bawku District are uninhabitable due to onchocerciasis and trypanosomiasis, so that 1970 densities in cultivated areas was 94/km^2 (372 mi.^{2}) and 272/km^2 (704 mi.^{2}) considering cropped land only.

It is generally agreed that population density is directly related to agricultural intensity in northern Ghana. In the northeast and the northwest where the highest population densities are found, are the intensive systems based on manuring of permanently cultivated compound fields (see Fig. 14). When population density for people who are normally intensive cultivators is decreased, then extensive methods are taken up. Goody noted this for the northwest (1958:64), and settlers to government resettlement schemes from densely populated Frafra district to sparsely settled areas of the Northern Region did the same thing.

While other factors may influence the degree of agricultural intensification, their most important effects may be through their influence on population densities.

There doesn't appear to be so direct a relationship between settlement pattern and agricultural intensity, and there exists little hard evidence for northern Ghana. In the Upper Region, settlement is dispersed throughout, in areas of both intensive and extensive agriculture. In the northwest there appears to be an equal degree of dispersal in less densely populated LoDagaba area where bush fallowing is practiced and for the LoWiili, where compound fields are the mainstay in an intensive system (Goody 1958).

Among the Namnam, Hunter (1967a) suggests that dispersal was encouraged by the segmentary lineage system, with no central political authority, and was made possible after peaceful conditions were established through political control of a small invading clan possibly in the late

18th century. Dickson (1971), on the other hand, believes that settlement in the northern savannahs was dispersed because of the segmentary lineage system prior to such an invasion, which had the opposite effect of tending to nucleate settlement, at least in the kingdoms like Mamprussi.

Markets have always been an important part of the local economy in the Kusasi area, and one of the major historic trade routes crosses the area, connecting the desert with the coastal forests, moving such items as slaves, gold, salt, kola, horses, and cloth. Since the advent of the Europeans, however, local economics have become rapidly tied in with the rest of the world.

Markets in northeast Ghana operate on a three-day cycle. The development of all weather roads has been slow and a paved road does not yet extend all the way to Bawku from the regional capital at Bolgatanga. There are no paved roads in the northwest. A railroad, first promised by colonial officials in the early part of the century, has never materialized and all transport is by truck over roads whose poor quality significantly increases the cost of transport.

Since Kusaok is on the border with both Upper Volta and Toto there is a flourishing blackmarket which works to the extreme disadvantage of the local subsistence farmer. Many manufactured items from the south meant for local consumption pass across the border, pulled by a ten-to-one or greater black market rate. To some extent this is also true of agricultural goods, including food shipped in for famine relief, although this is much more prevalent in other sections of the Upper Region.

With the main harvest around November, prices in the market drop to the lowest yearly level, a 45 kg (180 lb) bag of millet or sorghum selling for about $50 in 1977. Soon after this the prices begin to soar, as petty traders and big time speculators greedily buy up the grain. Prices continue to rise throughout the dry season, and if the early millet harvest is bad, as it was in 1977, prices just before the main harvest reach levels 400 - 500 per cent of the lowest level. Other commodities also reflect this seasonal fluctuation, generally to a lesser degree.

Thus, just at the time of the year when food is in shortest supply, and demand for agricultural labor is the greatest, prices for staple foods in the markets are the highest. The situation is exacerbated by the fact that prices for livestock are the lowest at this time of the year. Farmers traditionally use their stock as a kind of bank, a hedge against food shortage, selling them when necessary to convert into grain.

During the dry season there is little agricultural activity for those not lucky enough to have a dry season garden, and time devoted to crafts and other non-agricultural activities increases, in part to supply the demand created by funeral celebrations. Most lucrative of occupations is beer brewing, always done by women, who usually use the residue to raise pigs. This job requires not only skill at organizing and directing the brewing of the beer, but financial and social skills in maintaining a popular beer house. This is a relatively new occupation, since beer brewing was traditionally done only for special occasions and was never sold. Other occupations include making and selling pots, mats, and baskets; trading; gathering or collecting items for sale; playing music; giving medical advice; and circumcising.

Within Tenga the incidence of wage labor is much higher in that area closest to the market and administrative center of Bawku, and as mentioned above, may constitute an important strategy on the part of extended families for maximizing food supply.

In Kusaok the husband provides the staple foods for the family, while the wife provides soup ingredients from her kitchen garden and purchases in the market, financed from selling produce from her own fields, from trading, or from craft work. Thus, the budgets of each wife and each husband are separate, and there may be borrowing between husbands and wives, between brothers, or between father and son. If a household has more than one adult male, they will pool some resources to purchase such items as tin roofs, fertilizer, livestock, or a plow.

The most frequently purchased non-food items are soap, cloth, kola nuts, and local beer. Funeral ceremonies, cows for bride price, and animals for sacrifices, are the other major expenses, and funerals may be postponed for many years until the family has enough resources to buy the food and beer necessary for a proper ceremony. Out of a yearly average household income of $100 - 200 there is little left for purchasing capital inputs like fertilizer or plows.

Many of the expenses are often considered by development programs to be wasteful. For the most part, this is not true. Funerals frequently occur in the early part of the dry season and the relatively large amounts of food eaten help to restore weight lost during the hungry season. Livestock used for sacrifices is eaten and portions always shared with a wide range of relations. One of the four bride cows is also sacrificed, and the others are often re-circulated and used for plowing (bullocks). The unstrained local beer is nutritious, and the by products are used: the dried yeast as a soup ingredient and the mash for feeding livestock.

The British colonialists soon came to think of the northern savannahs as a cheap source of hard working labor as well as a potential supplier of food to fuel development in t he south.

Recruitment for the private mines of the south began very early (1906), and was often actually forced labor under very poor conditions with high mortality rates (Thomas 1973). The government, too, recruited for construction projects, and later for the military and police, and the northerners quickly gained a reputation for hard work. Thus became established a kind of seasonal or short term migration, often of parts of the family, especially the adult males, not to establish new farms but to take part in the cash economy while retaining their interest in the home farming area. This was stimulated by head taxes, introduced in the northeast in the 1930s. To the north, in Upper Volta, government pressure on farmers to migrate to Office du Niger projects, and to cultivate cash crops and work on local government projects like road building, was apparently much more severe, and stimulated large waves of migration, at first predominantly into Ghana (Courel and Pool 1975).

While northern labor contributed significantly to the wealth of the south, the colonial government did little to improve conditions there. They hindered missionary efforts at establishing schools and missions, hoping to retain a more docile labor force and avoid conflict with Moslems. Indigenous land tenure traditions were ignored and all land was declared vested in the state (a different situation than in the south), and farmers were simply chased off land the government needed for various projects (Der 1975, Bening 1975).

There were many early attempts to introduce commercial cattle raising, cotton, groundnut, and fiber production in the north, all of which failed. Efforts continued to extract agricultural produce from the northern savannahs, and there is still a feeling on the part of some that it could become the bread basket of Ghana.

There was a growing awareness, however, especially by some of the local colonial officials, that the potential of the north to produce food surpluses was not perhaps as great as it had at first seemed. In fact, total production, especially in the intensive areas of the northeast and northwest, often fell short of need, resulting in food shortages and even famines. These food shortages were seen to be the result of three major and interrelated factors that the colonial officials attempted to change in various ways: dense populations, land degradation, and inadequate agricultural practices. An agricultural survey of the northeast was begun in 1932 which led to an excellent report documenting the problem at that time, and also summarizing the results of agricultural experiments in the area which had begun with the opening of several agricultural stations in the 1930s (Lynn 1937). Most subsequent work on improving production of the local system was carried out in the northeast, especially in Bawku District.

Experimental work in the early 1930s confirmed the efficacy of indigenous practices, namely mixed cropping, crop rotation, and use of animal and other organic manure. Manure application of two to four tons per acre at least every four years was found to be desirable and have high residual effects. Manured fields had yields of up to 80 per cent higher than un-manured, and on the average increased total yield of grains from mixed stands by about 50 per cent (Lynn 1937, 1940). It has also been concluded that several innovations would be introduced, the most important being mixed farming. This entailed primarily the introduction of bullock plowing and the making of kraal manure. The other major innovations which were to be demonstrated were dry season gardening with shallow wells, and the use of single superphosphate on peanuts. Peanuts were promoted as a highly nutritious food crop and a source of cash income to finance purchase of plows and bullocks. All of these innovations built on existing resources and practices: confining of small livestock at night and manuring of compound fields; the use of local trypanosomiasis-resistant West African shorthorn cattle; gardening; and growing of peanuts (an introduced crop, but one with requirements very similar to the indigenous bambara groundnut).

The main effort was put into the dissemination of mixed farming, and the results are impressive. The number of mixed farmers in Bawku District went from one in 1938, 60 in 1946, 300 in 1950, to 2,645 in 1960, distributed throughout the District. The great increase in adoption rate after WW II is associated with the establishment of the Kusasi Agricultural Development Cooperative Society (KADCS) in 1951. The 1960 figure represents about 15 per cent of farm families in the District, and 63 per cent of all mixed farms in the entire Northern and Upper Regions (Collins 1960, Uchendu and Anthony 1969).

Because the introduction of the plow in a system of mixed farming was so successful and has not since been duplicated, the methods will be considered briefly (based on Collins 1960, and conversations with Issaka Diddliman, Chief Magistrate in Bawku and a former Agricultural Instructor in the program). Chiefs and others were brought to agricultural stations where the use of the plow and the manufacture of kraal manure was demonstrated. At Manga, a station near Bawku, land abandoned by farmers because of low productivity and erosion was brought back into production using mixed farming techniques. Trained agricultural instructors assisted by "illiterate itinerant plowmen, natives of the area...who know farmers personally" carried out extension work (Collins 1960:65-66).

To become a plow farmer a man first had to go through a period of probation as a prospective farmer for at least one rainy season. He was instructed to build a simple kraal and make manure with his stock using bedding. During this time he was visited weekly by an itinerant plowman and monthly by an agricultural instructor and his progress noted under four headings: (1) size of stock of bedding material, (2) condition of kraal, (3) amount of bedding in kraal, and (4) whether animals were kept in the kraal the previous night. At the beginning of the dry season the best prospective farmers were approved to become plow farmers (and in later years to join the KADCS). He was then eligible for a loan to purchase bullocks and plow. Bullocks were trained initially on chiefs' farms, and later on the farmers' own farms with the help of itinerant plowmen. Graded contours were laid out in the farmers' fields, and manure manufactured during the probation period was applied. At the end of the first season as a plow farmer, a man had to make the first repayment, often in the form of peanuts and to a lesser extent, rice. The success of the program is indicated by the good rate of repayment and the increase in peanuts (1,437 to 4,422 180 lb. bags) and rice (40 to 1,354 180 lb. bags) sold by KADCS between 1955 and 1959 (Uchendu and Anthony 1969:26).

Plow farmers continue to be inspected, and only if they maintain satisfactory manure production and make payments on their loan are they provided with spare parts, namely plow shares, several of which are worn out each season. Indeed, farmers tend to think that the plow is more important than manure making. The technical staff thought just the opposite: "It really would not matter a scrap if we never extended the use of a single plough if only the manufacture of farmyard manure could become universal...which is the real solution to the food problem" (Lynn 1940:27). The goal was to prevent land degradation and increase soil organic matter, to intensify land use and labor, and technological input. It was not intended to encourage extensive plow cultivation of farms so large that they could not be manured adequately, causing even more land degradation.

In some areas, at least, it was recent immigrants rather than Kusasis who first took up the plow (Benneh 1972) or dry season gardening (Collins 1960), but Kusasis were quick to follow, at any rate.

After independence, government support was withdrawn from the KADCS (see following section) and while current government policy in the northeast still emphasizes mixed farming, there is little actual support for it. The credit and repayment in produce program no longer functions, there is no further recruitment or inspection of plow farmers, and spare parts are expensive and difficult to obtain. In Tenga several plows had not been used in many years because of lack of spare parts and inadequate resources for buying oxen.

The North Mamprussi Forestry Conference in 1947 marked the beginning of organized land planning and conservation in the northern savannahs and in the following years, more forest reserves were established and many miles of contour bunds and numerous other water conservation measures were constructed in designated land planning areas of the north-east. It is debatable whether the net effect of these conservation measures has been to increase per capita food production. Forest reserves removed good farmland from production, and they have not been utilized by local farmers for fuel and building material as had been originally intended. Many of the dams, while they may have led to an increase in ground water supplies and a decrease in erosion, have probably also led to an increase in such water-borne diseases as malaria, filariasis, and schistosomiasis. Many of the dams are now in disrepair and most of those that are not, are not being used to grow food. The reasons appear to involve problems with land tenure and technical problems of irrigation during the dry season.

From a social standpoint, perhaps the most ambitious approach was the attempt to reduce pressure on the land by moving large numbers of people from the most densely populated areas, primarily Frafra, to less densely populated areas of the northern savannahs. The first such effort began in 1938, when the repopulating of a valley in the northwest recently cleared of trypanosomiasis was encouraged and assisted by the government.

Between 1947 and 1957 the Gonja Development Company (GDC), a subsidiary of the government Agricultural Development Corporation, had a license to develop 30,000 acres near Damongo (see Fig. 10). It was to experiment with mechanized farming (of groundnuts, mainly), increase food production, and resettle Frafras from the most densely populated and famine-prone area of the northeast (Dadson 1973). Initially the project was to resettle 400 to 500 families of 5 to 9 persons on areas of 30 acres each. The GDC was to provide housing, piped water, schools and hospital, and to carry out all agricultural work except weeding, which the settlers were to do. Harvest was to be shared between the GDC and farm families on a 2:1 ratio (Dadson 1973).

Farm families were almost completely dependent on the Company, with little involvement in decision making. Many settlers returned to the Frafra area and arrangements were subsequently revised to allow for greater farmer initiative in decisions about his own farm. But increasing "social," as well as economic, managerial, and technical problems led to the end of the GDC project in 1957, with insignificant numbers of Frafras remaining in Damongo (Dadson 1973:194).

A new attempt was made at resettlement of Frafras into the Damongo area by the Department of Agriculture beginning in 1956. Some lessons were learned from the previous failures and a "very careful psychological approach was adopted" (Ghana Farmer 1958), and much initial propaganda work was done. Size of allotment for each family was reduced to 12 acres (4.8 ha, closer to the usual size in the northeast); proper customary ceremonies were carried out giving rights to land; regimentation was reduced; farm families built their own houses and fields as they wished, following soil conservation rules; and whole households were moved, so that their land in the Frafra homeland would be available (Ghana Farmer 1958; Hilton 1959).

Yet even though the Gonja people living in the area encouraged the settlement of Frafras, there was plenty of "reasonably fertile" land, and the government provided free transport, seed, clearing and plowing, it failed to attract significant numbers of migrants. The situation of over-population and inadequate food production in Frafra and the rest of northeast Ghana was not affected, and is worse today.

Attempts at improving the situation in the overpopulated intensive areas work against encouraging emigration to resettlement schemes. But social factors and attachment to the ancestral land are usually cited as the main reasons for lack of significant migration. While these social factors are no doubt significant, there seems to have been little actual analysis of the resettlement projects in terms of actual risks and benefits to the farmers. However, because the resettlement was tied in with mechanized farming, cash cropping (peanuts and tobacco), and provision of many services to settlers, an important cause of failure was lack of adequate administrative and technical resources. The same factor contributed to the failure of national programs.

To some extent the new independent government renewed the idea of the potential of the northern savannahs to supply food to the south and for export, while making attempts to compensate for the neglect of social development, primarily by a vigorous school building program (Bening 1975). Increased education along with improvement of roads encouraged emigration of young men, helping to defeat the government's plans for the north to provide cheap food for the industrializing south. These plans have involved primarily large scale mechanized agriculture as opposed to small scale, family agriculture.

In 1962 the Nkrumah regime transferred government support from the successful KADC mixed farming program in the northeast to large scale mechanized farming ventures in the center of the Upper Region. This was the approach tried throughout the country and one which has been judged to have been a failure. The most important reasons for failure were conflicting government objectives; poor planning and lack of background research; lack of skilled administrators and technicians; and an undeveloped and inappropriate government administration. Available evidence indicates that productivity was "much lower than in the unassisted traditional sector, and that overall efficiency was low" (Dadson 1973:197). The large scale mechanized public farms were phased out after the government changed in 1966.

By the second half of the 1960s, the pressure of the government to invest in import substitution agriculture became very great. Government efforts to increase food production having been largely counterproductive, a substantial investment was made in commercial mechanized rice production in the Northern Region. Similar projects established later at Gbidembilise valley and the Tono irrigation scheme in the Upper Region have had similar results: a dualistic capitalist agrarian structure in which the bulk of the agricultural investment is in a small number of capitalist farmers, often with government connections and depending heavily on government subsidies and special favors to reap large harvests (Shepherd 1978:3, 6, 9). The extensive techniques used by the large scale rice farmers have been destructive. Little investment such as water control or contour plowing is made in the land, and "poorly tended and increasingly weedy and infertile fields of up to several hundred acres" are abandoned after four or five years and the process is begun again in new valleys (Shepherd 1978:10a). Recent poor rainfall has exacerbated the situation.

In 1974-75 Ghana declared self-sufficiency in rice, but output fell one-third to one-half in 1975-76 (Shepherd 1978:7) and has not improved substantially since. Even the temporary success of these schemes was only made possible by substantial state subsidies, mostly to influential northern town dwellers and more recently to southerners (Shepherd 1978:7, 12). In addition it has depended on cheap local labor and acquisition of local lands from chiefs. This has begun to create a situation that could encourage a landless peasant class, dependent on wage labor on large farms for subsistence.

The Upper Region Agricultural Development Project (URADEP), initiated in 1977 by the World Bank, the British Government, and the Government of Ghana, ostensibly aims at increasing the well being of the subsistence farmer. The aim of the project is also, however, to make the project pay for itself in the fairly short term (25 years) by including large investments in cash crops, namely cotton, and livestock ranching. It thus ignores the fact that in the populous northeast there has long been a lack of food and increasing reduction in production potential due to land degradation, and that harvests have been particularly bad in recent years. That initially farmers in such areas require subsidization has been recognized by field workers since Lynn, who wrote: "an adequate and reliable food supply is a prerequisite of all development" (Lynn 1937:34). There is almost no consideration of social, cultural, biological, or ecological obstacles or repercussions. For example, artificial fertilizers are a major part of the program to increase both subsistence and commercial production. Yet no consideration is given to the uncertain price and availability of future supplies, or to the necessity of assuring adequate supplies of organic manure to insure that soil structure does not deteriorate. Neither is there adequate consideration of how the tremendous infrastructure needed to implement the 55 million-dollar project can be assembled and put into operation. Failure to provide adequate infrastructure, including administration, caused the failure of previous large scale programs in Ghana.

The Onchocerciasis Control Program (OCP) in the Volta River Basin area is another large scale multimillion-dollar project which includes northeast Ghana. Like URADEP, its approach is simplistic and generally ignorant of local social and ecological conditions. For example, it assumes that onchocerciasis was the primary impediment to re-populating largely abandoned major river valleys, failing to consider other diseases, poor health of previous in-habitants, and necessity of reserving large areas for conservation purposes (OCP 1977:50-51).

Neither project takes into consideration the initial impact that the hoped for improvement in standard of living is likely to have in increasing already high population growth rates.

We have considered some of the major efforts in Kusaok and the northern Ghanaian savannahs to intensify agri-cultural production. It is our impression that it is the small scale programs, based on local practices and aiming first at ensuring adequate food supply that have the most chance of succeeding. Large scale projects tend to overlook the severe limitations of organizational capabilities, infrastructure, and financing, and the potential of using indigenous agricultural practices.

Given the absolute lack of adequate food supplies, and the environmental degradation in Kusaok and much of the rest of the Upper Region, it may be necessary to subsi-dize development programs heavily, at least at first, until adequate food supply is established and environmental degradation is checked.

Within the Mole-Dagbane area are a great number of different groups who share a very similar culture and social organization, and yet only a few have become intensive farmers. On the other hand, the hierarchical patrilineage organization seems to encourage individualization of farm organization characteristic of intensification, even in the extensive farming areas.

The intensive groups are acephalous, unlike much of the population living in extensive areas. It is true that the acephalous groups, with their segmentary lineages and lack of central political authority, encouraged a dispersed settlement pattern conducive to increased intensification of compound fields. It must be remembered, however, that it is probable that the centralized states, too, were once acephalous societies and that there is no evidence of abandonment of intensive systems. Rather, the indication is that intensity is increasing, even under indigenous, colonial, and national efforts at centralizing local political organization.

In Kusaok environmental limitations, especially water, are severe. Highly variable precipitation is confined to a single rainy season and surface water is scarce in the dry season. Soils are thin, lacking in nitrogen and organic matter, and highly susceptible to erosion. Land degradation is intimately related to the decrease in number of individual plants and plant species. To cope with the uncertainty and fragility of his environment, the Kusasi farmer employs a number of risk-spreading strategies such as mixed cropping, dispersed field system, crop rotation, use of a number of varieties of staple grain crops, migration, and local non-agricultural work options.

Farmers have also modified the environment to increase agricultural production by manuring of compound fields, terracing, and grass planting to control water, plus burning to increase fertility and promote pasture development.

It is highly significant that in Kusaok and the other intensive areas of northeast and northwest Ghana there are better soils, due to the nature of the underlying rock, than in surrounding areas, and it may be because of this that such intensive techniques described in this section have been able to support the high population densities. It appears, however, that the point has been reached in Kusaok where efforts to support this increased population density with the present technology of intensification are decreasing environmental potential because of deterioration of soils and associated plant communities.

The Kusasi use a hoe, a knife, and fire as the basic tools in their intensive agriculture, the same as those used by extensive farmers in the Mole-Dagbane area. They have knowledge of a wide variety of domestic plant species which they use to increase production by diversifying planting times, locations, and cultivation techniques.

The bullock plow, artificial fertilizers, and new crop varieties are the major technological innovations introduced by the government in the area. Adoption of all three has been limited by initial cost and returns to investment. The plow is restricted by the hilly and stony nature of many farms, by small dispersed holdings, and in valley areas, by the heavy clayey soils. Artificial fertilizers are limited by the need to apply limited supplies of organic matter in conjunction with them to prevent loss of soil texture and quality. The introduction of new seed varieties is limited by the different requirements of these varieties, often demanding more cultivation and a more regular and abundant supply of water than poor years can supply, and thus increasing the risk of failure for the farmers who use them.

Yet, when farmers see an economic advantage to available technologies they tend to experiment with and sometimes adopt them. This has been the case in recent years in Tenga where farmers have spontaneously planted experimental plots of the American dwarf sorghum, distributed in a food relief program. Good results in 1976 for a few farmers led to large numbers trying it in 1977, and requests for supplies of seed. The bicycle is considered to be a mark of prestige among the Kusasi, and is a new technology eagerly adopted by them to increase the distance and ease with which they can commute to wage laboring jobs and markets, as well as to visit relatives. Despite difficulties the plow, too, remains popular.

Evaluation of the potential of technological innovations in Kusaok should center around the economic value to the farm household in terms of the kind of cost/benefit analysis that farmers themselves do informally in order to assess the desirability of such technology.

Population densities in Kusaok and other intensive areas of the Mole-Dagbane region are higher than in extensive farming areas, and where densities for traditionally intensive farmers decrease, they take up more extensive methods. These observations, similar to those elsewhere in tropical Africa, suggest an important causal role for population density in the process of agricultural intensification. Intensive methods are not voluntarily adopted without the incentive of declining food supplies, except in cases of economic incentives, for the decrease in size of holdings as density increases demands increased inputs of labor per unit of land and food product.

There are other ways, too, of increasing food availability that may be more attractive than intensification, especially if the limits of the environment are being approached, and new technologies are either not available or too expensive. As wage labor or crafts and trade opportunities open up with the increase in local government administration and infrastructural operations, Kusasi farmers may be expected to participate in them more and more. Emigration is a method of increasing the supply of food to the emigrant, but its effect on the home community is not always certain. In Kusaok the loss of productive agricultural labor appears to outweigh the return of resources by the emigrant to his home. Indeed, one response to this may be an increase in fertility rates, making up the deficit in labor for intensive agriculture.

In Kusaok it is the pang of the empty stomach and not the lure of market profits that has led to intensification in the past and will continue to dominate for some time into the future. Attempts to introduce cash cropping, reinforced by head taxes, have been an overall failure among small farmers in Kusaok. This is partly because of the farmers' frequently justified mistrust of the cash economy. They prefer, for example, to use livestock as walking bank accounts and hedges against food shortages because of a corrupt finance sector, rampant inflation, and wildly fluctuating commodity prices. Cash crop enthusiasts in the government and development projects have generally failed to take into account the unfavorable change in risk factors due to adjustments demanded in labor organization, crop distribution, and to corrupt and inefficient government buying organizations, and the depreciating value of cash received for such crops in the face of inflation and food shortages. In Kusaok today the cash return realizable on equal units of land planted to cash crops (cotton or fiber) compared with food crops is much higher for food crops.

Slavery in Kusaok has little in common with European feudalism or the enslavement of Africans in the New World. Slavery was common among the Kusasis, but slaves soon became incorporated into the community, acquiring their own farms. Without the necessity of localizing populations to exert central control for military or exploitative purposes, there is no advantage to using slave labor for intensive agriculture when sufficient land is available for extensive farming, since returns for unit of labor are higher under extensive systems.

Coercive colonial programs were aimed at supplying labor to underwrite development in the south of Ghana and, secondarily, at decreasing population pressure in the intensive areas through resettlement programs. Nkrumah's attempts at large scale intensification with communal mechanized farms failed to increase agricultural production and undermined efforts to increase the output of subsistence farmers locally.

The most successful programs have been the ones that emphasize demonstrating the advantages of the new method to farmers on their own ground, a point that has been emphasized in northeast Ghana by field and extension workers since Lynn (1937). It has been consistently overlooked by large-scale development projects such as URADEP ever since.

Kusaok is similar to other areas of intensive agriculture in northern Ghana in being associated with high population densities and relatively fertile soils. Probably the most important direct cause leading to intensification is population pressure, while environment, culture, and politics have served to increase population pressures locally by concentrating people in certain areas. While intensive agriculture may have favored a dispersed settlement pattern, social organization was also conducive to small households separated from each other and resident in the middle of their manured compound fields.

It could be that it is only in such relatively fertile areas of rural rainfed agriculture that intensification can occur, and indeed, it is encouraged by the very fertility which would attract migrants and allow for higher population densities at first under an extensive system. Earlier in this century Kusaok was known as a food surplus area (Lynn 1937), and there has certainly been a pattern of decreasing use of bush farms and decreasing length of fallow on those remaining.

While the origins of intensification are difficult to know, we can be more positive about what is happening today. Under the intensive agricultural system in Kusaok and the other intensive areas of northern Ghana, there is increasing population, land degradation, emigration, and food shortage. As suggested by Rose Innes (1977), it may be too late to establish a self-sustaining agricultural system by the time intensification reaches the point it has in northern Ghana, for there is not enough land to incorporate the ley (the field which is rotated through intensive grazing to renew fertility). But even in the extensive farming area of northern Mossi country it may already be too late to stop the process of decreasing yeilds and soil degradation (Marchal 1977).

What else could the farmers do, and why aren't they doing it? It might seem as though farmers in such a situation could make better advantage of their resources, for example, by more careful control of fires in the dry season, by composting crop residue instead of burning it, by utilization of all animal and human waste, by spending more and more hours in the fields during weeding. There may be several reasons why this is not taking place:

1. The very process of intensification has allowed for an increase in population; public health measures and transport of food have also led to population growth at a rate faster than people can effectively respond to it, especially once land degradation sets in and reduces the return to increased labor input.

2. As food availability per capita begins to fall, agricultural productivity decreases because of hunger, and tiredness during weeding.

3. The market economy provides alternatives to increasing food availability by selling labor or crafts.

4. Emigration drains the local farming communities of their most productive labor.

We suggest that in northeast Ghana and similar areas of rainfed intensive (or extensive) agriculture where land degradation and economic decline (indicated by a high rate of emigration of the productive segment of the population) have already been established, it may not be possible for externally financed development to produce a surplus, i.e., to pay for itself, for a very long time. For if agricultural intensification is a positive response to increasing population density, it may also indicate a move over the threshold of sustained production toward a downward spiral of increasing poverty and economic stagnation which will only be speeded up by ill-conceived development projects that demand a relatively short-term return on investment to bolster a sagging national economy. In Kusaok and much of the rest of northern Ghana and Upper Volta, it is necessary to initially subsiduze development with inputs of food, credit, capital supplies, and land (resettlement) until farmers are no longer hungry.

The Hausa of Nigeria. The Hausa are a major ethnic group in West Africa, forming the predominant population of north-western Nigeria, especially in Kano, Bauchi, Kaduna, and Sokoto States. There is considerable Hausa settlement (Fig. 1) in Niger as well, and Hausa traders take part in an extensive commercial network reaching into southern Nigeria, Benin, Upper Volta, and Ghana. Hausa agriculture relies on a fairly standard inventory of Sudanic crops, but both shifting and intensive methods are used, varying in their relative proportions in different regions and even in the same community at different periods. Differential access to traditional cities and trade networks also characterizes various rural settlements. A wealth of recent studies by geographers, economists, and anthropologists allow both controlled comparisons within and among regions and some measurement of changes in agriculture through time.

The Hausa language is widely spoken as a lingua franca in the Sudanic region of West Africa, and Hausa is a part of the Afro-asiatic family of languages also including Berber, ancient Egyptian, Cushitic, and Semitic. An indigenous literature exists using Arabic characters to write the Hausa language. Most Hausa are Muslims as a result of conversion beginning in the fifteenth century and culminating in the conquest of the seven traditional Hausa states by Fulani religious leaders and Islamic scholars shortly after 1800. Hausa society has a long history of political centralization under kings or emirs ruling large, sedentary rural populations from cities with well developed administrations, systems of courts, and a military organization. The markets of cities such as Kano impressed the first European explorers in the nineteenth century with their large range of crafts, their use of cowries and other currencies, and the evidences of extensive caravan trade across the Sahara and connecting the Hausa with the traditional empires from Lake

Chad to the Niger bend. Unlike neighboring groups in independent communities or tribal enclaves, the rural Hausa have long been true peasants, socially and economically integrated members of a state. "Tax collectors and traders have for centuries been transporting the rural surpluses to the political capitals, and the tradition of surplus production for distant centers of consumption, through trading, taxation, and levies is deeply important" (Forde, quoted in Hill 1972).

When northern Nigeria was defeated and brought under British colonial control by Lugard in 1900, the characteristic settlement pattern of compact walled towns ringed by bush hamlets persisted. These territorial units continued to be administered by community chiefs responsible through various ranks of superiors to the head of state. The British policy of indirect rule officially accorded recognition to traditional chiefs and the existing framework of Hausa-Fulani government (Smith 1960). The settled, farming Hausa have long lived in symbiotic contact with Fulani nomadic herders, and those Fulani who settled in towns have intermarried with Hausa, becoming indistinguishable from them in dress and language (Hill 1972:3). Other non-Islamic ethnic groups were formerly assimilated into Hausa society by means of slavery, and Hausa culture continues to attract outsiders to a distinctive ethnicity based on common religion, language, a hierarchical polity, urban-rural relationships, a relatively well developed economy, and a large population with considerable political influence in modern Nigeria.

Hausa farmers live in a savannah environment with pronounced dry and wet seasons where they grow cereal crops of millet and sorghum supplemented by cowpeas, peanuts, cotton, and vegetables. Hand labor predominates with the short-handled Sudanic hoe as the principal tool. Agriculture provides both subsistence needs and cash.

Because most Hausa crops depend on natural precipitation, the amount and timing of rainfall is crucial to the agricultural system. Annual totals vary from 103-154 cm. (40-60 inches) in the southern part of Hausaland to 51-103 cm. (20-40 inches) in the north (Buchanan and Pugh 1955:26). Much of this falls during the April to October wet season, and the winter months of November through March are almost totally rainless as the climate is dominated by dust laden winds from the north and dry Saharan air masses. Early and late rains of the wet season often come as short, violent storms, and normally dry water courses may fill and flood. With declining total precipitation in the north, rain may be localized and increasingly variable in both annual and monthly distribution with greater possibilities of crop failure (Mortimore 1967). Drinking water is obtained from perennial streams or individual household wells. Low lying marshy areas with insufficient drainage allow the continuation of farming into the dry season. Temperatures rarely fall below 42° F, and thus they are suitable for plant growth the year round (Goddard et al 1971).

Despite the low esteem in which tropical soils are often held, the Hausa area appears to have reasonably fertile and easily worked soils. The Nigerian plains, "lying between the deserts to the north and the forest to the south, are analogous to the loess belt of Europe. Both have long been zones of easy movement, both are unusually productive and owe their fertility at least in part to soils derived from wind-and water-laid deposits that accumulated under climates differing markedly from those of the present" (Grove 1961). The drift deposits deriving from the desert sands of the last arid period are variable in depth and become finer in texture towards the southern margin. A band paralleling the northern border of Nigeria has coarse light sandy soils of buff or reddish color which are well suited to crops such as millet and groundnuts. Around Kano these freely draining sandy loams "have proved highly amenable to intensive cultivation" (Mortimore 1967). In depressions and alongside larger rivers there are alluvial and colluvial soils with larger clay/silt fractions and inferior drainage. The Zaria type soils farther south show a finer drifted material up to 14 feet in depth which are heavier and more difficult to work. They become waterlogged after a heavy rain and crack during the dry season, but they are favorable for growing cotton (Buchanan and Pugh 1955:39).

Much of Hausaland is a gently undulating plain 610 - 914 m. (2,000 - 3,000 feet) in altitude with mature streams flowing in broad shallow valleys separated by inconspicuous watersheds (Buchanan and Pugh 1955:18). The Sokoto Plains in northwestern Nigeria are monotonously flat except where trenchlike valleys carry tributaries of the Sokoto River through areas of ironstone surface capping.

The natural vegetation is savannah woodland with low orchard bush and scattered shade trees such as baobabs, silk-cottons, and ficu trees. Human activities have reduced areas of forest to a parklike landscape where trees with some economic value such as locust bean and shea butter are preserved. Vegetation is often used as an indication of soil quality, and trees such as Acacia albida are highly valued because crops do extremely well beneath them (Luning 1963).

In most of the Hausa inhabited area, the main agricultural activity starts with the beginning of the rains in May (Fig. 15). Fallow land has previously been cleared by cutting trees, uprooting bushes, and burning them. When the earth has been softened by the rain, it is turned with a heavy, curve-bladed short handled hoe or hand plow, making a pattern of parallel ridges three feet apart on the field. Millet and sorghum are sown onto the ridges. Maize is also grown, though it is a less important cereal. The grain crops are often interplanted, and groundnuts may be sown a month or more later in the same field. Weeding done during June and July with a lighter short or long handled hoe is the most demanding labor of the agricultural year. The triangular flat blade hoe is also used for various planting chores and for harvesting peanuts. When a field has been in use for several years, scoops of earth may be removed from the old ridge and deposited in the furrows from the previous year. When the seeds planted in this loose pile of soil have germinated and grown to a height of four to six inches, the old ridges are broken down and piled around the young plants. Both cultivation techniques involve the annual alternation of ridge and furrow

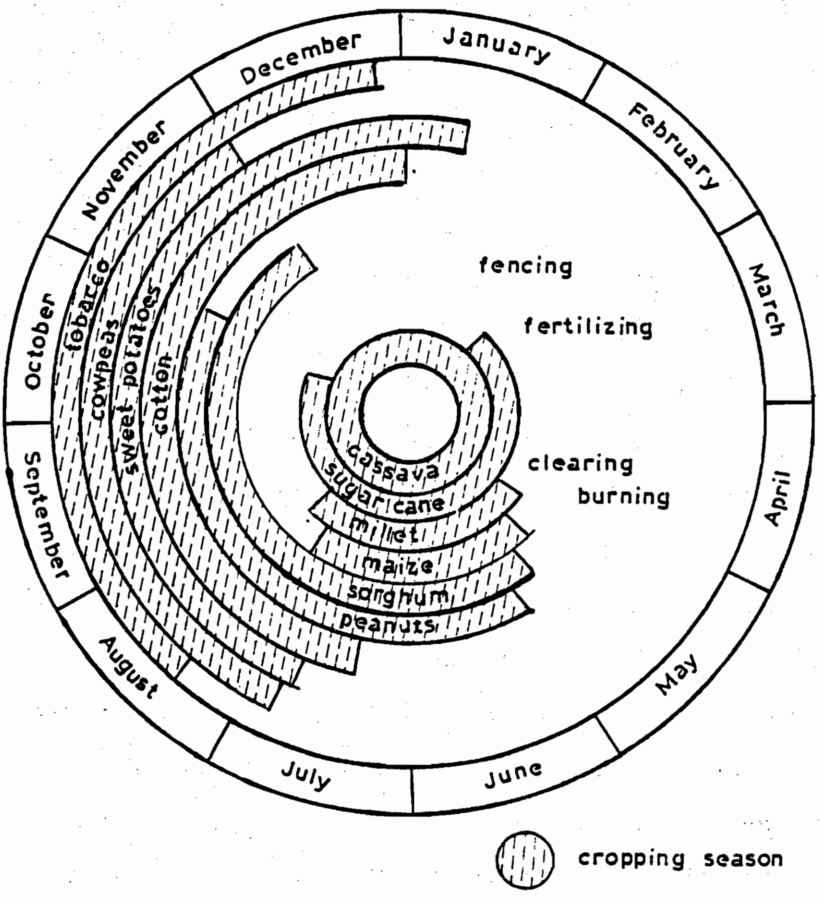


Figure 15. Hausa agricultural calender.

placement (Schultz 1976:138-9). Cowpeas are planted in the grain field during the second half of July, and by early August the millet is ready for harvesting.

Agricultural work tapers off after the end of the rains in October, and the harvest of sorghum, cowpeas, and cotton comes in November and December. Cassava and sweet potatoes may be grown in scattered mound gardens, and the swampy or river bank lands called fadama may support sugar cane, rice, tobacco, and onions. Kitchen garden crops like okra, eggplant, tomatoes, calabashes, and papaya are cultivated within compound walls and between the compounds. Only seasonally inundated land or that near enough to a water course to be irrigated with a shaduf (a bucket and rope attached to a counter-weighted pole) is capable of producing two crops a year or being kept in production during the dry season. Sugar cane may be planted as early as March and not harvested until December (Smith 1955:241). Fadama land is not ridged.

A sample of three Zaria villages indicated that food crops such as millet, sorghum, and cowpeas accounted for almost 60 per cent of the total cultivated acreage (Norman 1977). Major cash crops are peanuts, sugar cane, cotton, and tobacco, but their relative importance varies within the Hausa area according to environmental conditions and market prices. Small holders may delay planting of a cash crop like cotton because they give first priority to their subsistence crops (Schultz 1976:143).

Mixed cropping with two to six types of plants interspersed in the same field is common in Hausa agriculture. Only some 20 to 30 per cent of total acreage is devoted to pure stands, though sugar cane is invariably planted as a sole crop. Interplanting of this sort (Fig. 16) provides security through diversity, reducing the risk of disease incidence and of total crop failure (Norman 1977). Mixing nitrogen-fixing legumes with other crops (Mortimore 1967) also gives the advantages of an implicit rotation within each year rather than from year to year. Gross returns per acre are higher than those of pure stands by 62 per cent (Norman 1977), and average return per person hour of labor are also superior under mixed cropping. Multiple cropping in which two or more crops are grown in succession on a single plot during the same year also occurs frequently.

Hausa farmers make a fundamental distinction on the basis of the types of land and moisture conditions. Fadama is low-lying land subject to seasonal flooding or waterlogging along the banks of streams or depressions. Upland is always elevated relative to fadama, if only by a few feet (Goddard et al 1975). Because fadama is limited by

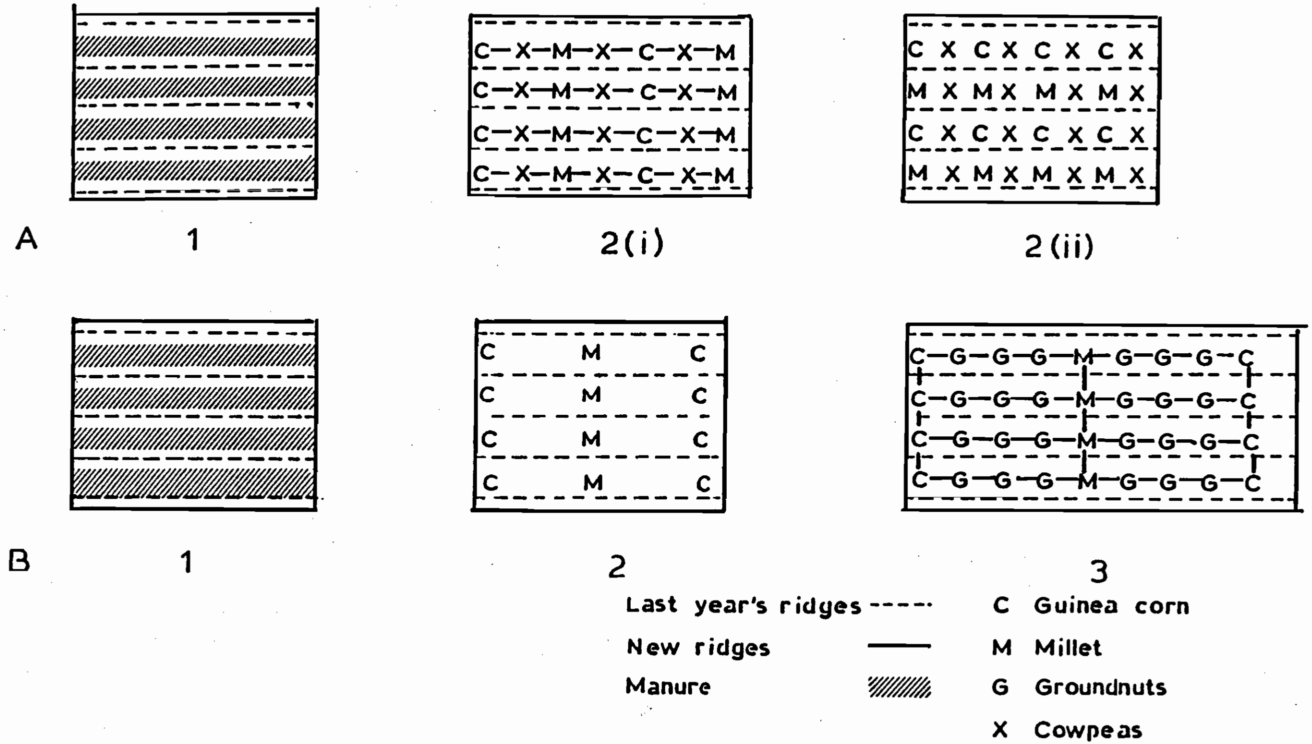


Figure 16. Common interplanting patterns
(from Martimore 1967).

the local topography, it rarely constitutes more than 10 per cent of the cultivated area. Where the water table is high, it can be used for cultivation year round, and it often allows the irrigation of dry season crops. Because it supports labor intensive cash crops such as sugar cane, rice, vegetables, and tobacco, and because only limited quantities are available, it has a high value. Upland is used during the wet season only for growing the grain staples plus peanuts, cotton, and cowpeas.

Upland may be further subdivided into infield and outfield types (Schultz 1976). Infield is manured land that is annually cropped while outfield land is fallowed periodically. The organic material applied to infield farms is made up of pen manure (a rotted mixture of animal excreta and straw bedding) and household refuse (non-edible food wastes, ashes of cooking fires, and compound sweepings). It is transported to the field during the dry season in donkey-borne bags or by headload in baskets. Organic material comes most frequently from a family's own compound and animals, but it may be purchased from other villagers or from city dwellers when the farm village is in the vicinity of a large urban center. The contribution of manure from Fulani cattle temporarily corralled on farm plots appears relatively insignificant (Schultz 1976:171).

Farmers recognize that organic material is necessary to prevent the declining fertility of infield land, but they also know that an application of manure leads to rapid weed growth and necessitates a third weeding of the crop (Schultz 1976:184). There is experimental evidence that the addition of two tons of organic material per acre permits annual cropping and a rate of three tons per acre gradually builds up soil fertility. Average application within Kano villages has been estimated at 3370 kg./ha. (1.5 tons per acre) and in the Soba District of Zaria at 12350 kg./ha. (5.5 tons per acre), but only four to twelve per cent of the infield plots may receive organic material in any one year (Schultz 1976:186, 188). Outfield land cultivated without manure depends on fallowing for the restoration of fertility. Short term grass fallows never exceeding two years exist alongside longer term bush rotation fallows (Goddard et al 1975). True shifting cultivation with considerable regeneration of bush and a low proportion of cropped to fallow land represents the least intensive system of land use (Morgan 1969). The same crops and crop mixtures appear to be grown on both infields and outfields with the exception of tobacco which is largely confined to the infield. Most rural Hausa villages maintain all of the above mentioned field systems, but the proportions of land devoted to fadama, infield, and outfield may vary widely. In the close-settled zone around Kano, the proportion of annually cropped land rises to 85 per cent and the outfield category disappears for all practical purposes (Mortimore 1967).

Field systems have long been recognized as forming roughly concentric zones of cultivation around traditional Hausa villages. Prothero (1957) distinguished permanently cultivated land within the village walls and extending one-half to three-quarters of a mile beyond them from rotational bush fallow one-half to one and one-half miles from the village (Fig. 17). An outer ring with a radius near one and one-half miles around the village was the zone of shifting cultivation. The location of fadama was dependent on the presence of streams and marshland, but that closest to the settlement was likely to be most intensively used (Grove 1961). The locational analysis of differing land use arising from the problems posed by distance and the economies of time and transport required by variations in agricultural intensity follows models of rural settlement proposed by von Thünen (Chisholm 1962). Infield plots receive greater inputs of labor and capital because less time and money are needed to work them, fertilize them, protect them from pests, and harvest their produce.

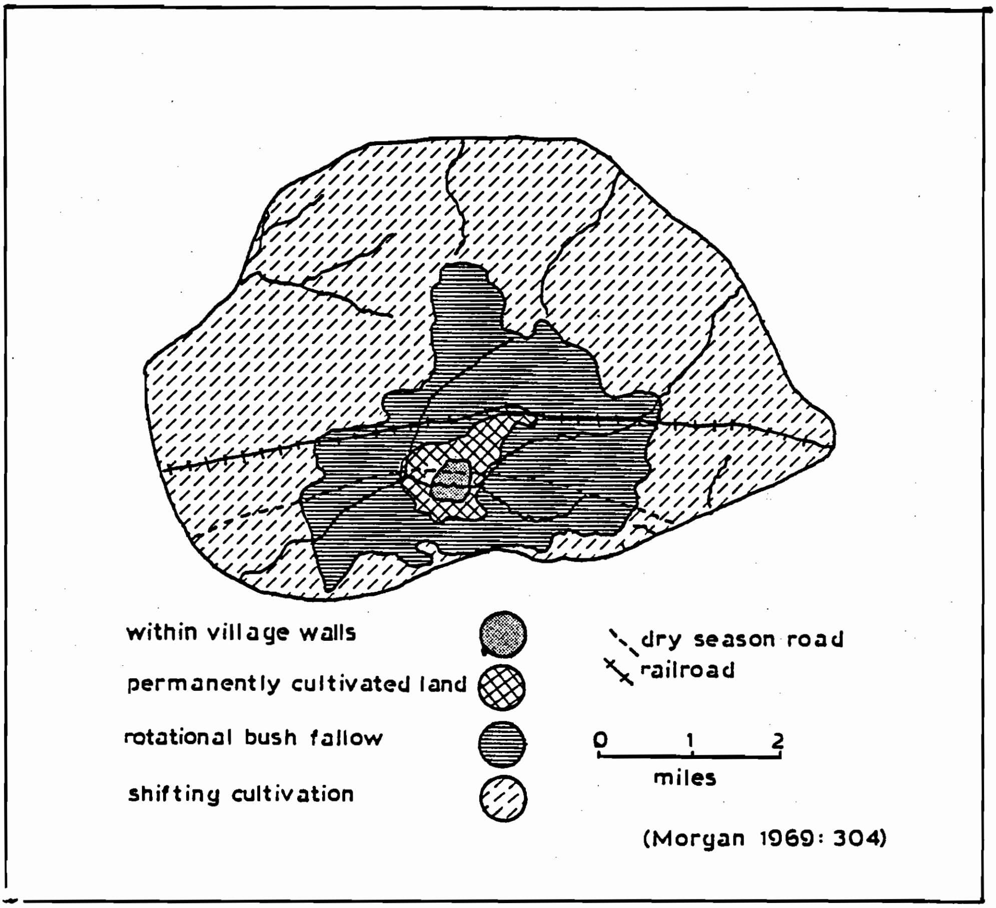


Figure 17. Land use zones at Soba, near Zaria.

The costs of production on the more distant outfield farms are higher, and the returns on the farmer's labor are correspondingly reduced (Morgan 1969, Goddard et al 1975). Transportation costs make the intensive cultivation of the farther fields unprofitable.

Average size of farm holdings varies widely in Hausaland. Hill's (1972:236) summary of 14 studies gives a range from 4.3 to 15.0 acres with the average holding in the survey areas commonly between 4.3 and 8.0 acres. Such findings are subject to error because of the difficulty of defining households that control land and the treatment of farms in fallow. Surveys in Sokoto (Goddard et al 1971) contrast three villages with average hectarages of 4.3, 2.7, and 2.25 (10.61, 6.68, and 5.56 acres) respectively, and three Zaria communities show a similar range of 4.8, 4.0, and 2.2 ha. (11.9, 9.8, and 5.5 acres) (Norman 1977). Average size of holdings near Kano City is 1.3 to 1.5 ha. (3.3 to 3.7 acres) (Goddard et al 1975). Local topographic conditions strongly influence the availability of fadama land which varies from an average of .01 to .1 ha. (.03 to .3 acres) in a six village Zaria study (Smith 1955:226), and the proportion of upland devoted to cash crops goes from 18 to 37 per cent in the same sample.

The sorghum that is a mainstay of the Hausa diet is said to average about 786 kg./ha. (700 lbs/acre) in production with a seeding rate of 17-22 kg./ha. (15-20 lbs/acre) (Hill 1972:224). Agricultural Department estimates (Smith 1955) give the following per acre averages: millet 562 pounds, cowpeas 100, groundnuts 524, cotton 224, sweet potatoes 1224, and sugar cane 10 to 20 tons. Grain yields for Hausa farmers in Niger are only 50 to 70 per cent of those in Nigeria (Raynaut 1976). A Katsina sample gave an average cultivated land per head of 1.3 acres that produced in a normal year 280 pounds of sorghum, 270 pounds of millet, 130 pounds of peanuts, plus some beans, cassava, and maize (Grove 1961). Basic per capita grain consumption is estimated at 318 kg. (700 pounds), leaving a shortfall of food to be purchased on the market. Millet-sorghum mixtures in Zaria provided joint yields of 960 kg./ha. (855 lbs/acre) as opposed to pure stands of sorghum giving 787 kg./ha. (701 lbs/acre) (Norman 1977).

Estimates of dietary intake and nutritional needs for rural Hausa populations vary wildly. One rule of thumb is that a mixed population of men, women, and children require 1 lb. per head per day, equivalent to 1,600 calories. Other calculations put requirements at 2.2 lbs. per day or 750 lbs. annually, and Hill suspects that though consumption in the poor village of Batagarawa may be only 1 lb. a day, requirements are much above that and the diet of the people is inadequate. The Hausa are not generally thought of as malnourished, but the facts of the matter are unclear.

In a careful study of three Zaria villages, Norman (1977) gives the total annual person hours (adjusted for age and sex) of work on the average farm as 1,753. 240 person hours per year are expended per cultivated acre, and men work an average of 5.0 hours per day. A male adult puts in some 141 days every year on the family farm (Norman 1977:69). Major differences in labor input occur with contrasting field types: whereas 204 hours per acre are devoted to upland fields, lowland fadamas receive 525 hours per acre, an indication of much more intensive cultivation. An adult male using a hoe is judged to be capable of cultivating 4 acres of upland, and labor appears to be the limiting factor during the June and July weeding of grain crops (Goddard et al 1971:34). Where population was sparse and extensive agriculture was practiced in one Sokoto village, 7.16 acres were farmed by each male or equivalent labor unit, but with higher population densities, only 3-3.4 acres are farmed, suggesting that land is the limiting factor (Goddard et al 1971). The amount of labor used per acre is inversely related to the number of cultivated acres on the farm (Norman 1977).

In contemporary Hausaland, women after the age of 15 are largely kept in seclusion according to local Moslem custom. Though they engage in economic activities such as processing food and trading through intermediaries, they do little agricultural labor. In the recent past, women took a more active role in farming (Hill 1972:43), but they are now seen in the fields only in remote settlements (Schultz 1976) and in parts of Niger where they also own significant amounts of farmland (Raynaut 1976).

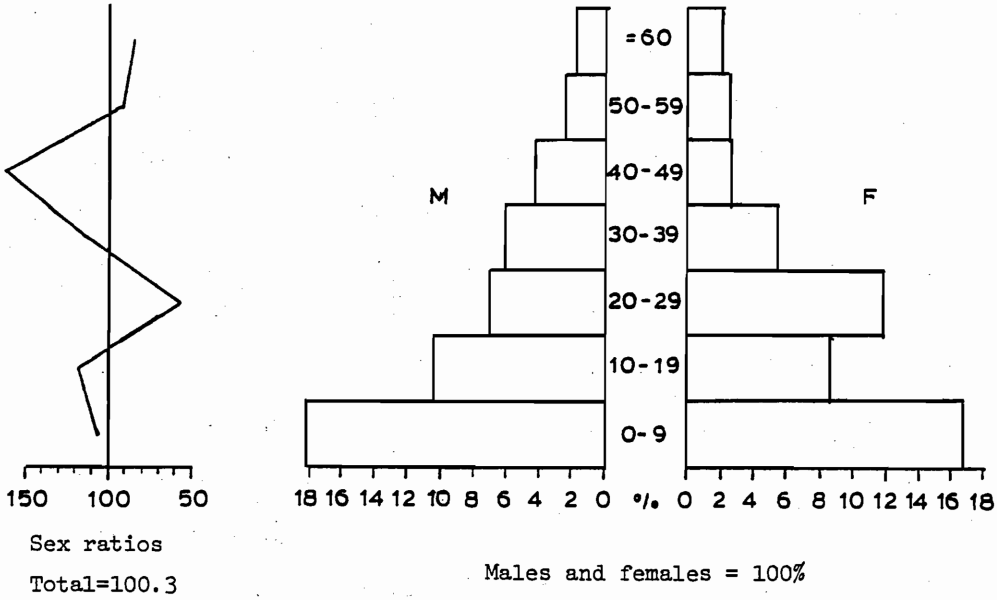
The social group most significant to Hausa agriculture has been called the "farming unit" (Goddard et al 1971). Most often this is a simple family of a man, his wife or wives, and their unmarried children. It is called in Hausa an iyali and is distinguished from complex units known as gandu comprising two or more married males and usually related to each other as father-sons or brother-brother. Families in the complex units may live together in one compound or apart, but they form a group for food production, consumption, or both. Conversely, a single residential compound may contain several simple or complex units that do not regularly cooperate with each other in agriculture. Simple farming units may develop into complex units as sons marry but maintain economic ties with their father. Complex groups may also fragment as the head of a gandu dies or as brothers decide to go their separate ways. Hausa social organization is often described as based on multiple family households practicing agriculture with the gandu, and indeed this does appear to be the traditionally preferred form of basic production-consumption unit. The gandu worked a common field under the direction of the gandu head who provided taxes, marriage expenses, and daily food for the other family members. Somewhat less inclusive forms of organization were the land gandu with a communal field and production but with subordinate members paying their own taxes and the cooperative gandu where land is held by individuals, communal farming operations are largely voluntary, and members provide their own food and tax money (Goddard 1973). In Zaria and Katsina where land is not yet in short supply, gandu composite units comprise about 30 per cent of all farming units and contain 47 - 54 per cent of all married men. In more densely populated Sokoto, only 19 per cent of the units are in gandu form, and these tended to be of the cooperative type where neither property nor produce was held in common (Goddard et al 1975). Gandu organization obviously depends on the availability of sufficient land to employ and reward the labor of members. Among Zaria small farmers with an average of 5.5 acres, 63 per cent of the farming units were simple. Large farmers with an average of 17.2 acres had 48 per cent of their households as gandu. Looked at from the other direction, composite family units had average holdings of 17.7 acres compared with 7.1 acres for the simple family type (Norman 1977).

The gandu farm was traditionally held collectively by the group, and members worked four days a week on it. Individual family heads were also allocated private farms which they and their children cultivated on other days and in the evenings. Among certain pagan Hausa, the grain from the special gandu granary was used to feed all families during the agricultural season, but during the dry months, the gandu members with private farms provided their own subsistence and took turns feeding the gandu head (Greenberg, cited in Hill 1972:39). Today gandu farms are effectively owned by the father, the granary is not necessarily closed during the dry season, and fathers may or may not give land to sons who decide to leave gandu (Hill 1972: 49). The proceeds from craft and other off-farm activities always belong to the individual (Goddard 1973). Such income becomes more important where there is a large and increasing rural population with attendant land shortages, and there is also less produce to meet food requirements of a large family (Goddard et al 1975). With growth in the money economy and the availability of consumer goods, young men are more concerned with earning cash, and less subject to the risks of crop failure from which gandu membership gave partial security (Goddard 1973). As members work less in gandu and derive fewer benefits from it, the structure of the composite farming unit weakens, and both its incidence and economic importance declines.

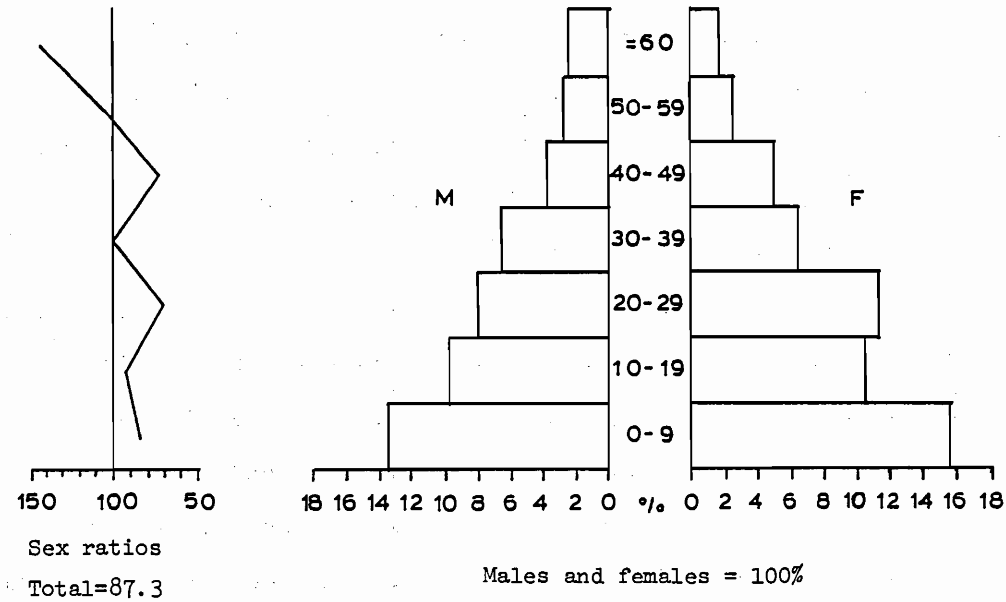
Because population figures determine relative political representation of regions within Nigeria and federal revenue sharing, they have been a source of bitter dispute at the national level. Serious questions have been raised about the accuracy of the last two censuses, but there is no doubt that population growth is rapid. The total for the three northern states with the largest Hausa populations has gone from 9.15 million in 1953 to 15.6 in 1963 and 26.19 in 1973 (Arnold 1977:178). Though the military government has cancelled the results of the 1973 census, it would appear that the Hausa are growing at a rate in excess of the 2.6 per cent per annum characterizing the country as a whole.

Dependable fertility and mortality rates are not available for Hausa populations. One comparison of completed fertility in two Zaria villages gave average number of live births in one as 8.1 and in the other as 3.99, suggesting biased data (Smith 1955:173). More accurate may be the estimate of 54 per cent of all live births surviving to reproductive age and an annual rate of population increase of 2.6 per cent (Smith 1955:174). The age-sex structure of local samples (Fig. 18) resembles that of other rapidly growing countries with about 50 per cent of the population less than age 20 (Norman 1967:5). Marked tapering of the pyramid after age 50 plus the high infant death rate suggest a fairly low life expectancy (Goddard et al 1971). In total populations, the numbers of males and females are practically balanced, but the relative absence of males in the 10 to 29 year age group may suggest outmigration, appearing as it does in the Sokoto but not the Zaria figures (Goddard et al 1971:9, Norman 1967:9). Men sometimes outnumber women in the age groups above 30, perhaps because women have the greater health risk of childbirth.

Local growth is based not only on natural increase but also on migration. Hausa farmers appear to move readily, becoming acquainted with new areas during seasonal labor migrations and responding to drought or local land shortage by taking up residence in more favorable environments. One Katsina district with limited land resources lost population between 1939 and 1951 while less densely settled areas



A. HANWA (Total = 723)



B. Dan Mahawayi (Total = 663)

Figure 18. Population pyramids and sex ratios of two villages in Zaria (from Norman 1974).

were growing by 50 per cent. The dry season exodus from Kano is 10 per cent in a good year and 60 per cent when the harvest is bad (Grove 1961). Where cash crops grow less well and access to the local urban market is limited as in Sokoto, 25 to 65 per cent of the male population 15 - 49 may go on dry season labor migrations, many traveling hundreds of miles to western Nigeria or Ghana (Goddard et al 1971).

Within the Hausa inhabited areas, there is considerable variation in the size and density of local populations. Though parts of southern Zaria may have no more than 50 people per square mile, the Kano close-settled zone with a radius of 25 miles from the city contains about 2.4 million with an average density of 500 per square mile, excluding Kano itself. Comparative studies of village areas in Zaria (Norman 1967), Sokoto (Goddard et al 1971), and Kano (Goddard et al 1975) use household survey methods to derive accurate counts for the districts considered. Sampled villages range from averages of 81 per square mile to 709. A historic change in local population has been charted in Schulz's 1976 restudy of the Soba area of Zaria earlier documented by Prothero (1952). We will discuss below the factor of population density as it correlated with agricultural intensification.

Variations in population density correlate in part with climatic factors. Toward the north along the present Niger-Nigeria border, mean annual rainfall declines to 20 inches and crop failure becomes more frequent. Population also thins along the southern fringe of Kano Emirate and in Zaria where dense woodland is infested with the tsetse fly carrying sleeping sickness. But the same area was also depopulated by slave raiding in the nineteenth century, and a long history of conflict accounts for the sparse settlement of the area between Sokoto and Katsina (Grove 1961).

Nucleated settlement patterns with walled towns and a hinterland of bush hamlets have been characteristic of Hausaland. In contrast, the very densely populated land around Kano has both small towns of 1000 - 1500 inhabitants and dispersed compounds with many farmers living amid their neatly hedged infields (Mortimore 1967, Hill 1977:4). This departure from tradition may relate to economies of distance and to the requirements of intensification. A farmer living on his own plot may devote more continuous effort to it, manure it more easily, time agricultural activities more precisely, and protect his maturing crops more adequately. Where land is individually held and worked, nearby residence also asserts a stronger claim to possession of the scarce resource (cf. Netting 1969).

Another distinctive feature of the Kano close-settled zone is the existence of "big houses," large compounds with as many as 20 constituent families and over 100 members. These do not represent land holding units or single gandu but rather related households individually cultivating their own farms and maintaining a common residence because of lack of alternative building sites, the provision of security for some dependent members, and the encouragement of internal trade and economic cooperation, especially among secluded wives (Hill 1977:180-99).

Hausa farmers have never been totally subsistence oriented. The food and fiber crops they produced always entered the market to some degree, rural handicrafts were widespread, wage labor was practiced, and most men had secondary, non-farm occupations (Smith 1955). The need to pay taxes and to buy cloth and other domestic and imported goods meant that all households had to have some source of cash. Agricultural goods had a market value, and their production could either complement or compete with other income-producing activities.

A major determinant of the relative profitability of alternative work opportunities in rural areas is accessibility of the market and the size of the population served by it. Large population centers developed around nodes of trade that were often also political capitals. Settlements on trade routes could participate in commerce and take advantage of protected movement and regulated exchange in regions controlled by major urban centers. The Pax Britannica extended this area of free movement, and the railroad completed in 1911 connecting Kano and Lagos allowed northern peanuts and cotton to enter world commodity markets. The extension of the road network allowed trucks to evacuate produce, and as all-weather roads were built, especially in the last 30 years, traffic could continue even during the wet season.

The rapid rate of growth in cash crop production among the Hausa in this century owes much to the stimulus of improved transportation and a favorable marketing situation. Growth in exports required both increases in labor hours and in the area of land cultivated by each farmer (Stryker 1976). Peanuts were in demand as a source of edible oils in Europe and they were sold through a state marketing board, but when the local free market price is higher than the official price, Hausa farmers simply cease selling to the state buying stations (Schultz 1976:278). In one part of Zaria, farmers decreased their cotton acreage between 1952 and 1975 because their labor inputs were not justified by prices set by the Northern States

Marketing Board (Schultz 1976:276). In the same area there was a pronounced increase in tobacco production, despite the labor required for preparation of seed beds, transplanting, weeding, and drying operations in addition to cultivation. These very intensive practices were accepted and commercial fertilizer was purchased because prices offered by the Nigerian Tobacco Company made them profitable. Extension services and an organization of production through Master Farmers who contracted with the company for tobacco were successful for the same reasons. Hausa farmers have demonstrated their eagerness to grow cash crops and their responsiveness to differential price incentives. Economic factors influence crop selection and the proportion of the various crops grown, but they do not radically alter the traditional agricultural system.

Increased exchange of food crops has accompanied the improvement of the transport network, and local specialization has become more evident. Kano farmers have found it more advantageous to grow peanuts for sale and purchase food grains rather than attempting to be self sufficient (Mortimore 1967). Where fadama land is in good supply, garden vegetables may be grown or rice and sugar cane produced, depending on distance and cost of transport to urban markets. Even bulky, low value goods may become profitable in the zone around the largest cities. It is estimated that 15,000 donkey loads of firewood per week move into Kano. Much of this comes from farm trees within a ten mile radius, and on the return trip the donkeys carry city manure back to the land (Mortimore 1967).

Though only major towns may have permanent stores retailing manufactured goods and a large daily market, many smaller villages have twice weekly markets with a variety of goods and services offered. On the periphery of large cities like Kano, secondary market centers may be rare, but a fair amount of trade takes place between and within individual compounds.

A great profusion of secondary employments characterize the Hausa, and they provide a significant part of the incomes of most farmers. Craftsmen, including weavers, dyers, blacksmiths, potters, butchers, mat makers, tailors, and leatherworkers, abound. Religious teachers, government officials, barbers, and drummers provide services. Traders may specialize in anything from cloth to kola nuts, and a variety of brokers handle sundries, food supplies, and livestock. Many men have several occupations. Where a village is relatively inaccessible to a city but has its own market, the emphasis may be on these kinds of traditional manufacturing, service, and merchant functions. In high density areas near cities, opportunities also exist in the modern sector for commission agents, drivers, messengers, and night watchmen. Such jobs are preferred as more remunerative than work in the traditional occupations (Goddard et al 1975). Secondary employments may actually be decreasing because of a declining demand for craft goods and the failure of rurally based long-distance trade (Hill 1972:190).

Hired agricultural labor is not uncommon, either paid by the hour or contracted with an agreed upon fee for the job. Communal work parties rewarded by a meal or a drink appear infrequent (Norman 1977). Hired labor is used throughout the year in a pattern similar to family labor. It is not specially mobilized for peak periods because there is no class of landless laborers to fill that demand and because the level of cash resources for most farmers is low during that period (Norman 1977). The wage rate for non-family labor remains the same throughout the year. So-called managerial farmers with income from salaried or business positions depend principally on hired labor and on land acquired by lease or purchase (Schultz 1976:266). Dry season migrants must necessarily seek wage work outside of agriculture in most cases, but Kano farmers sometimes compensate for their own land scarcity by renting unused fadama in the hinterlands and growing irrigated crops.

Dependable information on household economics is difficult to collect, but students of the Hausa have attempted to compile such budgets through individual detailed interviews (Smith 1955:121-149) and through third-person estimates of comparative economic standing within the village (Hill 1972:59). As expected, there are substantial differences in average income among villages, among individuals within a village, and in source of family income. Mean gross income for work units in seven sample Zaria communities was £60 with a range of £43 to £74 (Smith 1955:148). The proportion of this gross income derived from subsistence production alone varied from 33 to 65 per cent (Smith 1955:138). A more recent study of three Zaria villages (Norman 1977) gave average gross income in Nigerian pounds at 104, but small farmers (average 5.5 acres) had total family incomes of 65 while larger farmers (average 17.2 acres) had incomes averaging 134. Livestock income was negligible in both cases, but small farmers were more dependent on off-farm income, deriving 34 per cent of their income from such sources as compared to 20 per cent for large farmers (Norman 1977:79). Hill (1972:59 ff.) found that poorer farmers worked more as farm wage laborers, owned less manured farmland, produced less food, and suffered from hunger under drought conditions, indicating significant economic inequality within the village. The fact that most family incomes are low and that savings are very limited probably makes the quest for security and a conservative attitude toward change important components of agricultural decisions (Norman 1977).

The British policy of indirect rule in Northern Nigeria after 1900 sought to continue existing political machinery and maintain peace and order with an absolutely minimum investment of capital and manpower (Hill 1977). This meant in practice that there was little control of rural areas and that knowledge of Hausa agriculture and population was often lacking. Though the British collected taxes and decreed gradual freedom for slaves, their major contributions to the economy were (1) the elimination of local warfare allowing the movement of trade goods through a wider area and the settling of land previously exposed to raiding, (2) the creation of an infrastructure of roads and railroads linking Hausaland with the southern ports, and (3) the stimulation of private trade in agricultural commodities, particularly peanuts, and foreign manufactured products. Agricultural research was begun at the Institute in Samaru, but only a few large-scale agricultural development schemes such as mechanized rice growing in Sokoto were attempted (Meek 1957). Crops entering the market were produced chiefly by traditional methods and tools with the government providing only buying stations.

The only major innovation encouraged by the colonial regime was the ox-drawn plow, intended to save labor and provide manuring among Hausa farmers who were erroneously presumed to be mainly shifting cultivators (Hill 1977:307). From first plans in 1924, plow-using farmers increased to 621 in 1935, 1447 in 1937, 7000 in 1950, and 40,000 in 1965. The technique requires substantial capital for plows and a pair of oxen, and government loans were instrumental in the first stages of its adoption (Hill 1977:308). Plow owners tend to be wealthier members of the community and to acquire plows largely for hiring them out to others.

Information on agricultural policy in modern Nigeria is not easily accessible, but it appears that the basic production systems of the Hausa continue to operate with little change. Increases in plowing and the use of chemical fertilizers are coming about through rural communication networks and the operation of the market economy as well as through agricultural extension efforts. Permanent cultivation is still little appreciated by outside experts, but a series of excellent studies relating local cropping systems to population, land tenure, household organization, and alternative employments have been prepared by Mortimore, Goddard,and Norman working under the Institute for Agricultural Research, Samaru, which is affiliated with Ahmadu Bello University in Zaria.

Having established that permanent cultivation of manured farmland is an old, stable, and common agronomic system in Hausaland, Hill (1977:303-305) contends that this is due to a strong preference of farmers for this type of cropping, regardless of population density. Aerial photographs indeed show evidence of annually cropped farms even in areas with a population density under 50 per square mile, and new settlers plan infields near their compounds even when a wealth of land for shifting cultivation is available to them (Schultz 1976:310). However, when asked to choose between infield and outfield plots, Hausa farmers split almost 50/50 in their preferences (Schultz 1976:209). Unless forced to select one category, most informants would apparently have preferred to cultivate both. Only when the sample is broken down by population density do differences appear. Among those living in areas with densities under 100 per square mile, there was a strongly marked preference for outfield cultivation, while farmers in villages with populations over 200 per square mile found infields more desirable (Schultz 1976:210). It appears that farmers' perceptions are influenced by the requirements of their particular field system which is in turn contingent on relative scarcity of land. Though some permanent farms are found around all Hausa settlements, their relative proportions as a percentage of cropped land vary directly with population density. For example, 15 per cent of cultivated acreage around a low density village in the Soba area was infield, while a nearby medium density village had 40 per cent in the same category (Schultz 1976:241, 285). Without comparisons of this kind, the effect of generalized cultural values on the farmer's behavior and decision making under various constraints cannot be judged.

This is not to say that Hausa cultivators approach some abstract economic rationality in their activities. Religious and cultural prohibitions on adult females leaving their compounds certainly decrease the amount of labor available during critical periods of the agricultural year. The Moslem pork taboo effectively prevents the raising of pigs. The high value placed on married sons remaining in gandu with their fathers may hinder individual initiative and the most profitable allocation of labor, though there are indications that the importance of the composite work group indeed declines with population pressure. The assumption of rigid cultural rules that prevent adaptive agricultural change and decisively hinder economic flexibilit is not borne out by comparative, quantitative studies.

Intensification by traditional methods is everywhere limited but almost never prohibited by the physical environment of Hausaland. The seasonality of rainfall constrains the production of most of the land area, and there are definite topographic limits on the amount of lowland that will support crops through a high water table or irrigation in the dry months. Unpredictability of precipitation means that planting may be delayed, labor idled, and yields substantially reduced by factors completely beyond the farmer's control. The drift soils of northern Hausaland appear to provide distinct advantages of fertility and ease of cultivation, but they do not establish hard-and-fast limits on the areas suitable for agriculture. The historic movement into areas of sparsely settled bush, the rolling back of the tsetse fly belt, and the expansion of infield zones onto less favorable soils all attest to the possibilities of increased production from existing resources

The organic status and texture of soil along with its irregularities of slope may indeed be improved by manuring, hoeing, and the construction of simple drainage ditches that are regularly employed in Hausa infields (Schultz 1976:286). There is also evidence that fadama is being more completely utilized, and those areas that lack lowland may water vegetables from shallow wells.

Different regions obviously have different potential for intensification. Once the reserve of uncultivated land is exhausted, if shifting cultivation continues and the fallow is not replaced by increased inputs of fertilizer and manure, serious degradation of the land may take place. Intensification is not automatic, and in drier areas such as northern Sokoto, there may be a critical density of 200 - 250 per square mile beyond which deterioration may set in. The unfavorable environment and the lack of sufficient manure in the area means that insufficient land can be kept under annual cultivation and yields are low and declining, unlike the Kano close-settled zone (Goddard et al 1975). Areas with these conditions and an absence of lowland often become exporters of migrant labor as an alternative to intensification.

When expansion of infield cultivation is checked by the unavailability of fertilizer and the fallowing of outfield reaches minimally practical levels, village land use reaches a threshold (Schultz 1976:297). These limitations are usually met by the movement of farmers to less densely settled areas where their existing agricultural system can be perpetuated. Change to a close-settled zone permanent cultivation system may only take place when (1) land scarcity restricts movement and (2) the local terrain can sustain intensive use.

Agricultural intensification, as we have noted above, is not primarily a result of technological change. The use of organic fertilizers, crop mixtures, and multiple weedings to keep infields in annual production are all traditional Hausa techniques. Farmers have their own extensive, practical classification of soil types, land forms, and naturally occurring trees, and this knowledge is used in making decisions on field location and crops. Riverside seasonally inundated areas and marshlands are also brought into permanent use for dry season crops or successive plantings in the same year. Again the major tools are the locally made hoes, and water control is achieved through ditches, the shaduf, and shallow wells. These indigenous intensive systems have shown the capacity to extend from subsistence crops to peanuts, tobacco, sugar cane, and vegetables for which there is market demand.

Because of the "primitive nature of farming technology" as compared to the small-scale technology of Eurasia, Hill (1977:101) sees no possibility that the developing pressure of population on the land in a close-settled village near Kano might have led to a general intensification of agriculture. Though this area already has a very high level of permanent cultivation and is now beginning to grow well-irrigated onions on manured plots from which early millet has been harvested, Hill believes that the absence of labor saving devices and the "profound inefficiency" of other methods make intensification unlikely. Her data indicates, however, that a high degree of sustained production has already been achieved by heightened labor inputs, and that these may well have reached the stage of "agricultural involution" (Geertz 1963) where marginal productivity declines disastrously. To the extent that chemical fertilizers are easily available through market channels and their application is profitable for farmers with little capital, some increase in yields may take place, but it is not self-evident that mechanical technology alone could achieve a more favorable cost-benefit ratio. Animal traction and the plow have probably not been adopted in the most densely settled rural areas because the fields are too small for their efficient use and areas for forage are limited (Grove 1961, Goddard 1972). Only richer farmers with larger farms and extended family households can command the capital necessary to purchase oxen and equipment (Tiffen 1973). Where these constraints do not apply elsewhere in Hausaland, plow technology spreads rapidly and spontaneously.

Given environmental limitations and seasonal labor bottlenecks, there is limited potential for increasing income by reallocating the resources now committed to production (Norman 1977). Applied agricultural research should concentrate on testing new seeds, herbicides, and possibly small power tools under actual farm conditions with all operations undertaken by the cultivator. These experiments would allow more accurate judgements on how maximum profitability could be combined with the minimization of risk (the standard deviation of returns) so crucial to the calculations of the average farmer (Norman 1977).

The technological change that has already had the most influence on agriculture has been that of the developing infrastructure. Roads, truck transport, and marketing systems have elicited both increased production and new kinds of crop specialization. Labor movements and the opening of new lands have been facilitated. To some extent, this may have promoted the extensification rather than the intensification of agriculture as plentiful land makes shifting methods at least temporarily profitable (Netting 1968). On a local basis, distance may become a less important determinant of relative intensification. The necessary extra labor may be applied to fields several miles from the village center when the farmer saves travel time by riding a bicycle (Schultz 1976:311). Intermediate technology such as the bicycle and the plow may well propagate itself more rapidly through governmental improvements in infrastructure than through specific programs.

There can now be little doubt that among the Hausa as elsewhere in tropical Africa there is a broad correlation between population density and the intensity of agriculture. "The greater number of people both require and allow farming to be more intensive" (Grove 1961). The close relationship between density and land use is evident in studies of villages in particular areas where physical environment was held constant and population density was the independent variable. A comparison of three northern Zaria villages (Fig. 19) shows that as population per square mile goes up, the factors of average size of land holding and land farmed per resident decline. Land scarcity is compensated for by decreasing the percentage of land in fallow, increasing the application of organic fertilizer per acre, and increasing total annual person hours of work.

	Villages		
	A	B	C
Population/mi.^{2}	81	396	709
Land			
Average size of holding (acres)	11.9	9.8	5.5
Land farmed per resident (acres)	1.9	1.3	0.6
% fallow in holding	21.2	26.8	2.6
Labor			
Total person hours of work on average farm	1516	1634	2109
Inputs per cultivated acre			
Organic fertilizer (tons)	0.4	0.5	1.5
Person hours - upland	149.8	193.3	349.8
fadama	458.2	462.5	745.8
Income			
Net income per acre (shillings)	131.3	169.1	277.5
Disposable income per resident	290.6	227.5	214.9
Composition of total income (percent)			
Farm	76.2	87.6	65.8
Off-farm	23.8	12.4	34.2

Figure 19. Population, land, labor, and income in three Zaria villages (from Goddard et al. 1975:329).

Labor inputs per acre are always markedly higher on the intensively tilled fadama land, but both upland and fadama work rises with population. The results of the process of intensification can be seen in the changing proportions of land use types in Soba, Zaria as population doubled between 1950 and 1975 (Fig. 20). Though all types of cultivated land increased, the rates of change in infield and fadama were much more rapid than those of outfield or fallow. Outfield was being steadily converted to permanent use, and the fallow periods of remaining outfields had become shorter (Schultz 1976:290). Agronomic potential has not changed, but the pressure of population has shifted agricultural practices in the direction of greater intensity.

As the demand for land increases, so, understandably, is change introduced into local land tenure and the extent of permanent transfers. Three Sokoto villages (Fig. 21) show holdings shrinking in inverse proportion to population and a regular rise in the percentage of land obtained by purchase and the price per acre (Goddard 1972). Communal land disappears, and the village head has no land to allocate to immigrants. Sale has been common in the Kanc close-settled zone since before 1900. Field boundaries are marked by thatching grass or henna bushes (Goddard et al 1975). Though legal rights to land may be usufructuary,

	1950		1975	
Estimated population	2000		4000	
Estimated density/mile^2	103		300	
Land use type	Acres	%	Acres	%
Urban and residential	70	1.4	230	4.5
Infield	480	9	940	18
Outfield	960	19	1260	25
Fadama	15	0.2	140	2.7
Uncultivated/Fallow	1715	33.4	2000	39
Heavy bush	1880	37	550	10.8
Total	5120	100%	5120	100%

Figure 20. Land use in Soba village (from Schultz 1976:285).

Village	Population Per Km^2		Average Holding-size Acres	Ha.	% Purchased	Price (N₤) Per acre	Ha.
Gidan Karma	322	124	14.82	5.43	19.06	3.27	8.08
Takatuku	538	208	7.18	2.87	23.20	7.22	17.83
Kaura Kimba	557	215	6.68	2.67	29.39	7.84	19.36

Figure 21. Land tenure in three Sokoto villages (from Goddard 1972).

	Pop. density per sq. mi./ farmland	Accessibility to city	Upland/ fadama ratio	Migrants as % of men 15-49
Kaura Kimba	557	6 mi. away	1.60	16.13
Takatuku	538	11 mi., on main road	41.85	45.26
Gidan Karma	322	22 mi., no motor road	57.89	65.90

Figure 22. Accessibility and migration in three Sokoto villages (from Goddard 1972).

as the resource becomes scarce, tenure is individualized in practice if not in law. One result is that the degree of economic inequality among farmers becomes more pronounced (Hill 1972, 1977; Norman 1977). Immigrants from high density areas are often willing to rent or buy land. Thus the Kano and Plateau people entering the Soba area introduced changes in local land tenure and at the same time set an example of highly intensive cultivation on limited plots (Schultz 1976:291).

When some members of the community lack sufficient land to meet their needs for food and cash, they may either intensify its use or seek supplemental income from other sources or both. Cottage industry becomes increasingly important when individuals have inadequate land. An association has been noted between weaving and small holdings near Kano (Mortimore 1967), because weaving requires less capital than the purchase of additional land. The percentage of families deriving some income from secondary occupations goes from 48 in an outlying village to 100 within 5 miles of Kano where population density is 609 per square mile (Goddard et al 1975). There is almost more emphasis on growing peanuts for the market in the central village. In Zaria, large farmers in one community spend less time in off-farm occupations and use a larger percentage of hired labor than do small farmers (Norman 1977).

If demographic factors appear to push the Hausa into agricultural intensification, economic factors may support this tendency or run counter to it. A profitable cash crop may require very intensive means for its cultivation, even when land remains reasonably plentiful. A change from growing cotton to producing tobacco might lead to more emphasis on manured infield, even if population and all other factors were held equal. Accessibility to market influences net return on crops by affecting travel costs. Sugar cane, for example, is too heavy to transport long distances without motorized vehicles, but a village on a main road can do better using fadama for cane production than engaging in dry season off-farm activities. In Sokoto, the most accessible village to the city also had a high proportion of fadama land, cattle that grazed on riverine floodplains, and the opportunity for dry season fishing (Fig. 22). The village on the road is well situated for trade, and weavers sell their fabrics in Sokoto (Goddard et al 1975). The least accessible village with little fadama land has the highest rate of migration and the longest absences of its men (Goddard 1971). Though the presence of land that will support intensive cultivation and nearness to an urban market may promote intensification, they would not necessarily do so in the absence of population pressure.

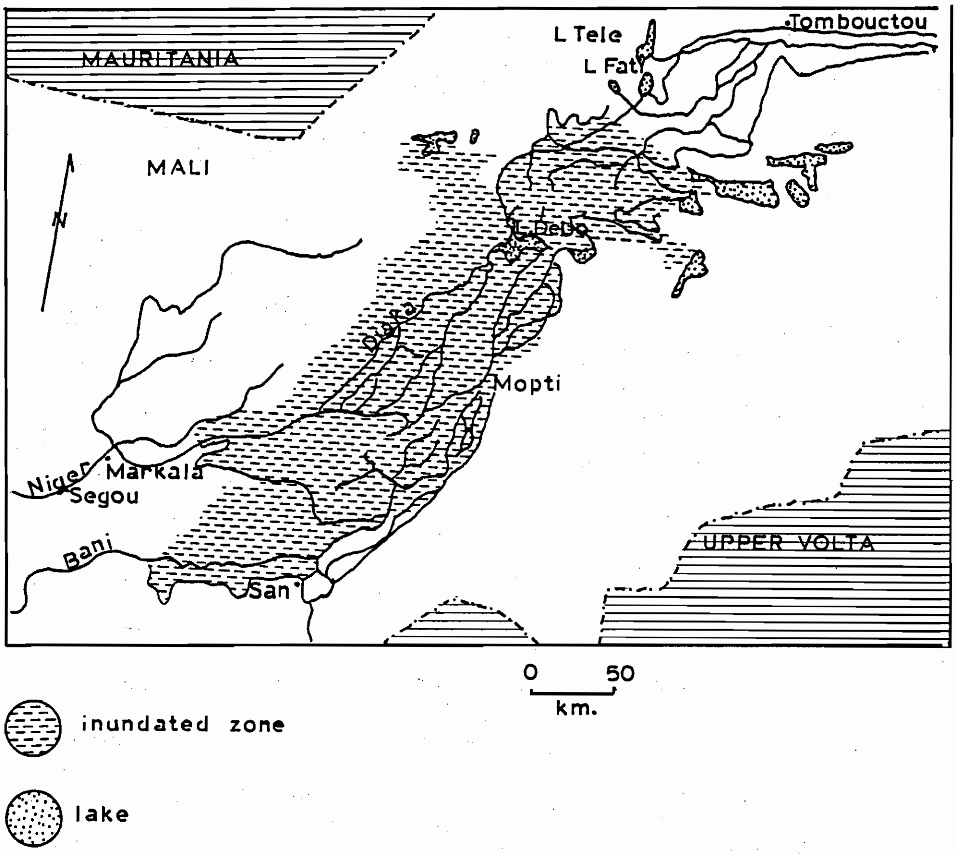
Secondary occupations and labor migration may supplement agricultural activities or they may be alternatives to further intensification. That more intensive farming on smaller holdings is a matter of expediency rather than preference is shown by the Zaria data (Fig. 19). Though heavier labor and fertilizer input have more than doubled income per acre, the disposable income per resident has declined. Where nearness to a city made modern jobs available, these may provide a better income than farming, but traditional crafts and services provide somewhat lower average remuneration (Norman 1977). Seasonal labor migration produces the lowest income. "Neither local off-farm activities nor labor migration are adequate substitutes for a substantial farm income in maintaining or raising living standards for the majority of the rural population" (Goddard et al 1975). The Hausa farmer is generally not confined to one of these options, and indeed the combination of agriculture with one or more secondary occupations may make the fullest and most profitable use of his labor time as well as cushioning him against climatic and economic fluctuations. Nevertheless, if land availability and market accessibility allow, the intensification of agriculture appears a more profitable alternative than crafts or services and than labor migration.

The contention that control and exploitation of others is a requisite for agricultural intensification is not borne out by the Hausa case study. Though slavery was widespread in the pre-colonial period and slave estates were controlled by an urban elite in certain areas, there is no indication that this institution was functionally related to certain farming techniques or field systems. Indeed the role of slaves was similar to that of married sons in gandu with the exception that slaves had no rights of inheritance (Hill 1977). Slaves could farm their own subsistence plots and engage in secondary occupations. The same conditions of land shortage that require increased labor inputs and lead to smaller households, fewer gandu, and more individualization of tenure would presumably have decreased the profitability of slavery for the average smallholder. If land is not in short supply, the most efficient means of production are those of bush fallowing, and these are likely to be practiced whether there is servile labor or not.

Governmental intervention to secure intensification among the Hausa is most likely to be effective in indirect ways, for example the building of a more viable infrastructure and the stimulation of market incentives for producing crops by intensive means. Agriculture experimentation and the dissemination of tested new techniques is also the province of government. Where traditional methods no longer suffice to increase production for home consumption and for export, the government should introduce additional methods for intensification in those areas where the process is already taking place. Kano State now has the primary agricultural objective of bringing into perennial production a very extensive area within the close-settled zone by irrigation from dams on the Kano River and its tributaries. "If it works, this will extend the growing season throughout the year, double production, and develop commercial farming beyond the constraints previously imposed by the prior needs of subsistence" (Goddard et al 1975).

Interior Niger Delta of Mali. This section will discuss the ecology of rice cultivation in the interior delta of the Niger River, located in southern Mali (see map, fig. 23), concentrating on traditional agricultural methods, on the organization of production, and on the effects of colonial and post-independence development programs on cultivation. It will thus be possible to see what forms of intensification have been practiced in the past, to assess proposals by agronomists and by planners to improve cultural practices, and to examine the reasons for the success or failures of these programs.

Figure 23: Interior Delta on the Middle Niger-Mali

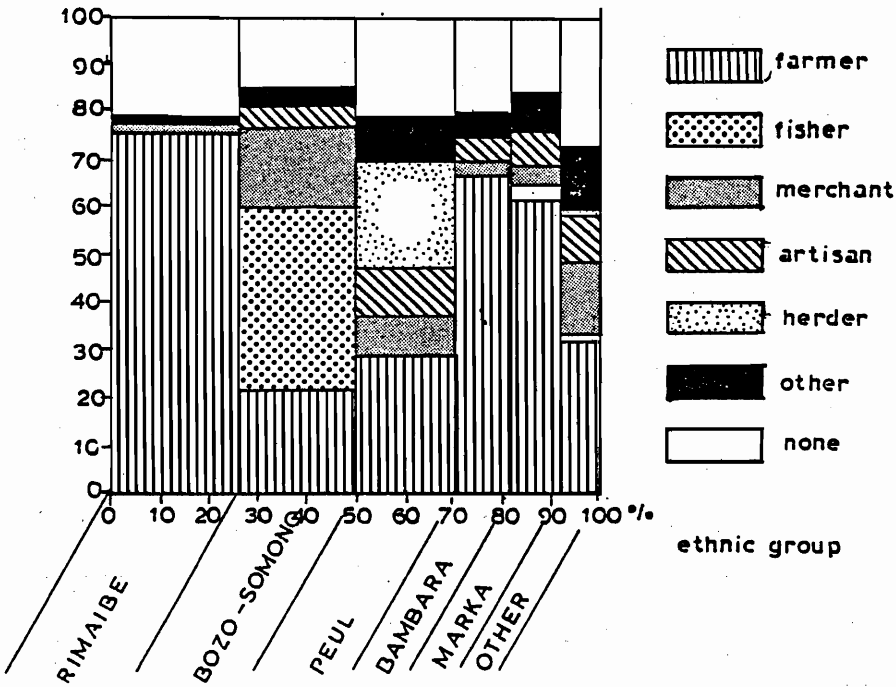


The interior Niger delta is a vast expanse of annually flooded marshes and plains, within a complex fluvial network. It is a region of great ethnic diversity, in which groups having different economic specializations have long been interdependent. The percentage distribution of principal occupations for ethnic groups is shown in Figure 24. Throughout the history of the region, conditions of trade with national states have had important effects on the character of agricultural production in the region, as well as on the density of human populations, and on settlement patterns. The interaction of ethnic groups in this region is best introduced in its historic setting.

From earliest times, immigrants to the interior delta have become assimilated, taking on the ethnic identity of groups already resident there, and so ethnic labels should be taken as cultural and occupational designations, rather than as racial ones. The autochthonous inhabitants of the delta, the Bozo, were fishermen and probably cultivators of the native small grain <u>fonio</u>, <u>Digitaria</u> <u>exilis</u>. The next to arrive on the scene were the Nono (who are presently included within the Marka), and they were the probable domesticators (Gallais 1967:80) of indigenous West African rice, <u>Oryza</u> glaberrima, some 3500 years ago.

Archaeological remains of the pre-Islamic period show possible trade contact with the Ghana kingdom (9 - 11th

Figure 24: Ethnic group by principal occupation - Inland delta - Mali



(M.I.S.E.S. 1961 b:55)

century C.E.), and subsequent growth of Diaka and of Djenne as commercial centers (Gallais 1967:82). The Islamic empire of Mali conquered the region in the first half of the 14th century, and Djenne gained importance as the intersection of trade routes from the north (carrying salt), and from the south (bringing slaves). The fall of Mali, and subsequent conquest by the Songhai empire and by Morocco did not diminis the delta's prosperity. In the period 1450 - 1650, the interior of the delta was densely populated (Es'Sadi, cited in Gallais 1967:86), and produced an abundance of rice, barley, cattle, fish, cotton, and cotton cloth (Leo Africanus, cited in Gallais 1967:85).

Two other ethnic groups began to enter the region in this period, the Peul (pastoral nomads) and the Bambara (cultivators of millet using slash-and-burn methods). These waves of immigration, which continued over three centuries, established the Peul in a complicated pattern of seasonal transhumance, while the Bambara occupied the unflooded embankments which surrounded the delta. Peul captives, the Rimaibe, formed agricultural villages near base-camps of the Peul and specialized in rice cultivation. Over time, in many parts of the delta, there grew up a mutual interdependence between herders and agriculturalists. For the region as a whole, however, political authority was fragmented.

In 1818, Chiekou-Ahmadou unified the delta under an Islamic theocracy. He tried to reduce inter-ethnic frictions by establishing permanent villages of Peul, allocating pastures, and regulating the routes to be followed by the herders in their seasonal migrations. This period of relative stability ended with the Tukolour invasions (originating in Senegal), in 1861. In the course of the incursions that followed, much of the left bank (north-west) of the Niger was laid waste, while the right bank, which received many of the refugees became much more densely settled. This difference in occupation density has persisted to the present.

With the French conquest of the delta in 1893, the left bank was administered from Djenne, while the right bank remained under indirect rule until 1902. The French emancipated the Rimaibe, who settled mostly on the left bank, occupying much of the best land for rice cultivation.

About a quarter of the population of the interior delta depends primarily on rice cultivation (M.I.S.E.S. 1961b:58) for subsistence -- these are mostly Marka and Rimaibe. Some Bambara and Bozo cultivate rice as a supplementary crop. We will see, however, that rice farming is not always a reliable subsistence base. Precipitation patterns and flood patterns vary greatly from year to year --

a field which received optimal water levels one year may be outside the survival range for rice plants the next. Even trained hydrologists have not always correctly predicted flood levels; indigenous farmers have an even greater margin of uncertainty. Like gamblers, farmers must try to hedge their bets, e.g. to plant several fields at different elevations, to sow a mixture of seed types having different water requirements. This case study will try to find out how the element of risk affects prospects for intensification.

Figure 26 shows the amount of variation from year to year in total annual precipitation. The distribution of the rainfall can be as crucial for agriculture as its quantity. Figure 25 shows a typical distribution, but inter-annual variation can be considerable. For example, Figure 25 shows that the date of first significant rainfall (i.e. 3 mm., followed by a similar rain within a week) can vary between mid-May and the beginning of July. Similarly, the date of the last significant rainfall can vary between mid-September and the end of October.

To discuss these data, it is necessary to have a rough idea of the yearly cycle of rice cultivation on the inundated plain. Figure 27 shows the seasonality of precipitation, flood levels, and the rice cultivation cycle. Rice fields

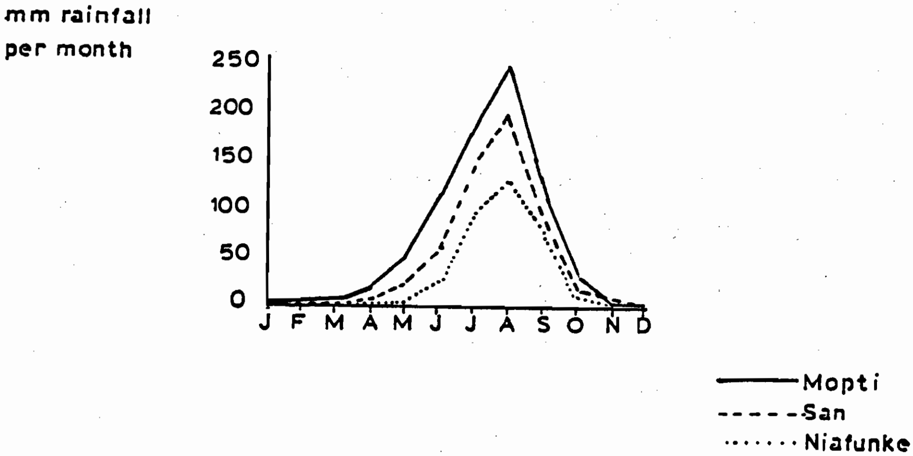
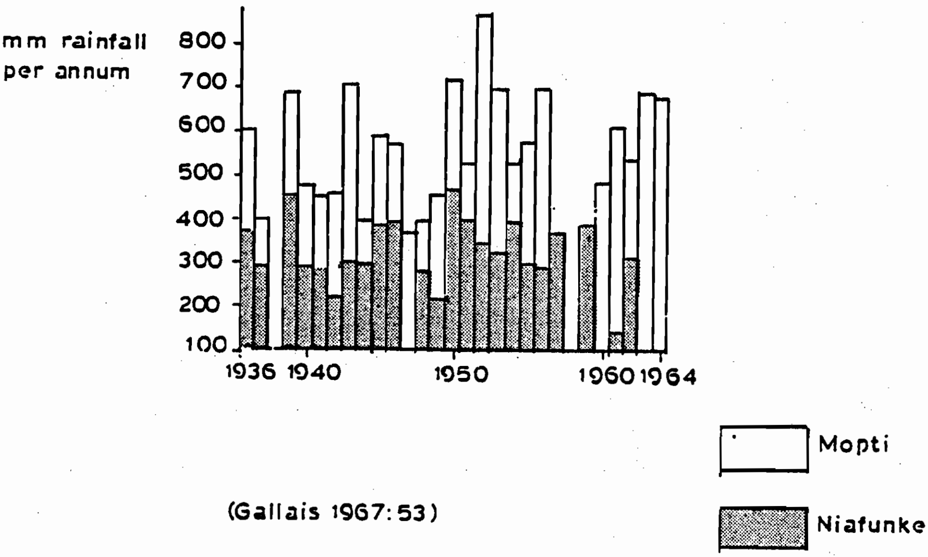
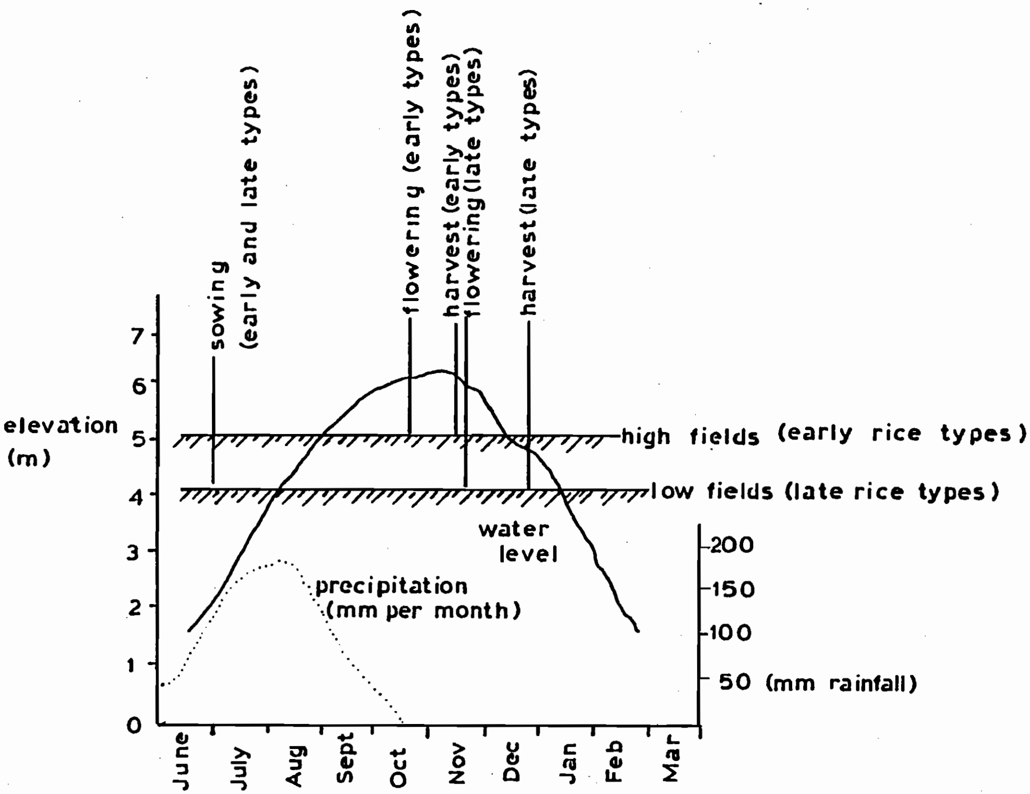


Figure 25. Monthly rainfall



(Gallais 1967:53)

Figure 26 Interannual variation in rainfall



(Viguier 1930: 29)

Figure 27. Flooding, precipitation, and scheduling in rice cultivation

are sowed at or near the start of the rains, in order to give the plants as much time as possible to develop before being submerged. If sowed too long before the rains, the seed will not germinate, and will be eaten by sparrows and ducks (Gallais 1967:220). However, late sowing increases the risk of plants being submerged before they are well developed; if flooded too early, the plants may be asphyxiated, and rice-eating fishes may do great damage (Viguier 1939:86). Low-lying fields are, of course, most liable to early submersion.

The date of the end of the rains can also be crucial. Figure 27 shows that, typically, rains taper off as flood levels are rising, so that high-elevation fields are submerged just before rainfall becomes inadequate for the plants. If, however, there is a gap of more than a few weeks between the end of the rains and the inundation of the fields, the young rice plants will be dessicated before the flood waters reach them. High lying fields run the greatest risk in case of an early termination of rains, or late onset of flooding.

The waters of the Niger and of the Bani are a source of soil nutrients, as well as a supplement to the insufficient rainfall of the interior delta. Measured at Segou, the waters carried concentrations of: 0.1 mg/l. P_2O_5, 0.5 mg/l. K_2O, and 0.2 mg/l. CaO (Angladette 1966:220). While these concentrations are far lower than, for example, the Mekong or other rivers in southeast Asia, nutrient levels are not negligible.

The two rivers which water the delta are the Bani (originating in the north-west Ivory Coast with a catchment area of 101,600 km^2, Gallais 1967:56), and the Niger (originating in the Guinea highlands with a total catchment area of 120,000 km^2). On the average, the inundated area of the delta is about 19,000 km^2, but this area can vary by about 3,000 km^2 from year to year (Gallais 1967:84 ff). The timing of floods also varies from year to year. Three flooding situations are especially hazardous for agriculture:

1. Early rapid inundation -- most dangerous on the south-west floodplains. The young plants are drowned, or eaten by fishes.

2. Unusually low water levels -- plants in higher lying fields will be dessicated.

3. Early recession of the waters -- if fields are left dry while rice grains are still forming, yields will be low, and there will be greater loss due to grain breakage during hulling (Gallais 1967:220).

Rice cultivators have several possible ways to minimize crop loss: they can choose varieties that are resistant to asphyxiation and to herbivores, they can construct irrigation canals and protective dykes, and they can plant several fields at different elevations. Figure 27 shows the timing of flooding for high and for low-lying fields.

The upper limit of elevation for rice fields will be imposed by two necessities:

1. The field must be flooded within two weeks after the last useful rain (i.e. more than 3 mm.).

2. The field must be flooded for at least two months.

The lower limit of elevation in which rice can be expected to produce will be governed by two factors:

1. The maximum depth of inundation must not exceed 3 m. (for Oryza glaberrima) or plants will be asphyxiated.

2. Inundation must not start until after (approximately) 200 mm. of rainfall, in order that root systems of rice be established, and in order that the plants be resistant to rice-eating fishes (Gallais 1967:223).

Figure 28 shows the upper and lower "safe" elevations for rice fields, in four parts of the delta. Although these data are not complete, they give an idea of the extent of interannual variation. Fields which lay within the safe zone during one year, may well be outside it in the next. Figure 29 shows the location of rice fields for a single Rimaibe village near the Diaka during periods of weak flooding (1943 - 1949), higher flood levels (1950 - 1955), and resumed weak flooding (1956) (Gallais 1967:234). Each time the flood cycle changed, farmers had to obtain and to clear fields at a different elevation.

Two sorts of perspectives are possible in discussing soils and their agricultural potential: the viewpoint of the

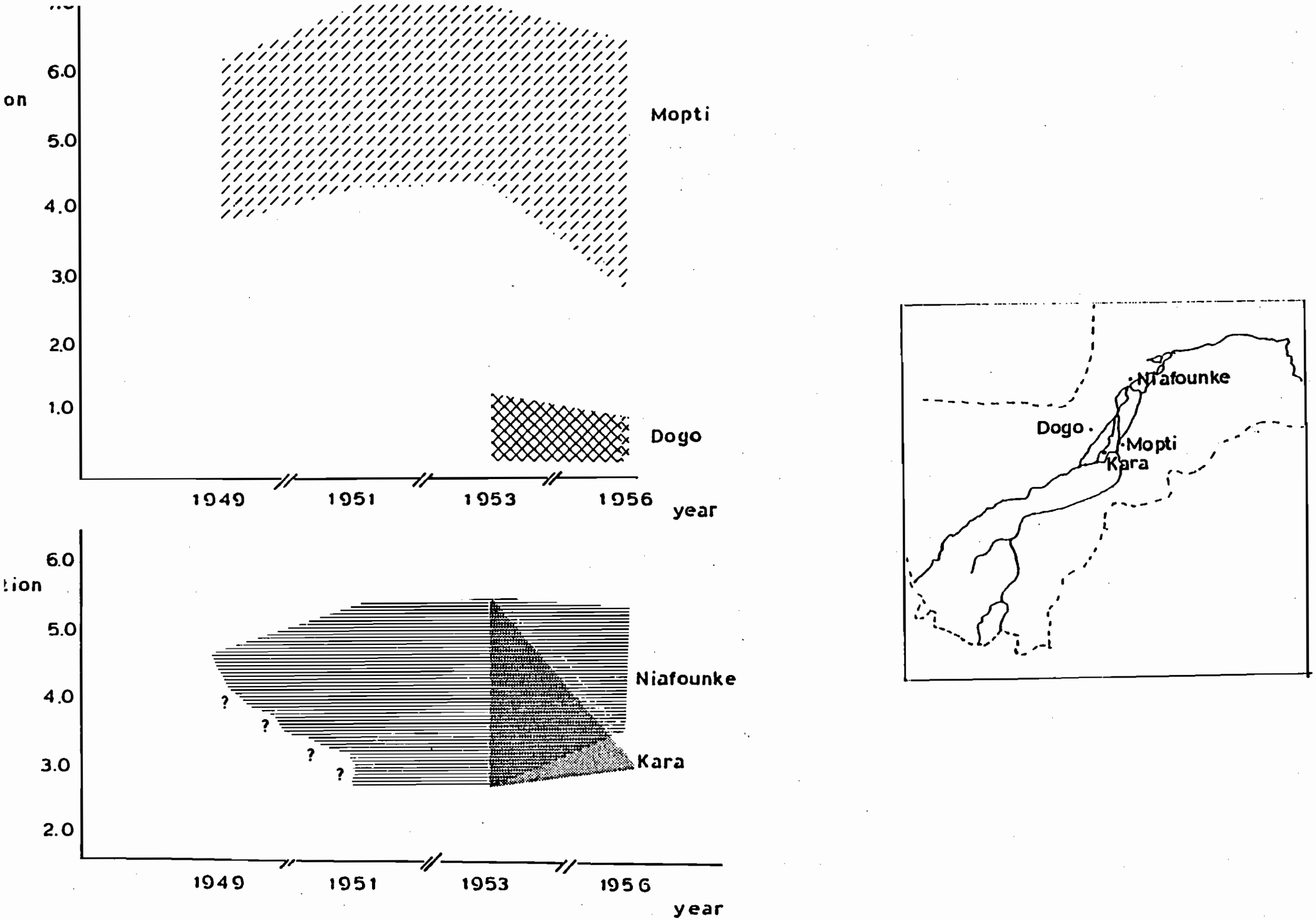
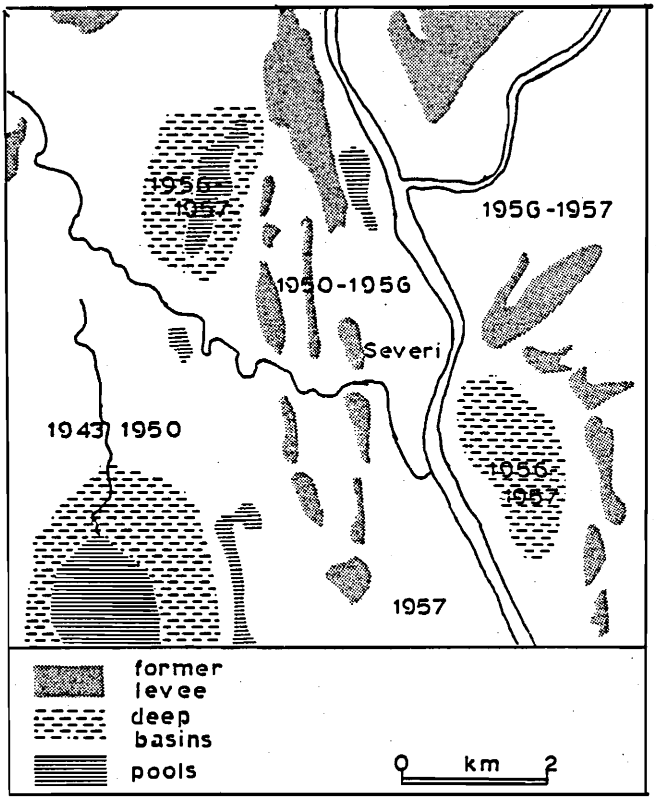


Figure 28. Interannual variation in "safe" elevations for rice fields in four locations (Gallais 1967: 222f)

Figure 29: Location of inundated rice fields
1943-1957 Severi (Mali)



1943-1950 weak flooding-cultivation of low lying land
1950 1956 strong flooding- cultivation of lands between former levees and on present levees
1956 1957 weak flooding

western agronomist, or that of the indigenous cultivator. The agronomist finds from physical analysis that, overall, soils of the delta are compact, and predominantly composed of clay and silt (Viguier 1939:15). Chemical analysis (Viguier 1939:17) shows them to be rich in humus and nitrogen, poor in lime, and slightly acid (Gallais 1967: 200). Experiments with fertilizer response of Oryza sativa showed optima in treatments with: a) ammonium sulfate (75 kg/ha) + rice bran (1,500 kg/ha), and b) NPK + rice straw, plowed under (Angladette 1966:349, 352).

For mechanized agriculture, the greatest problem with the delta soils is their poor structure - many soils turn into fluid mud when wet (Guillaume 1960:285), and become cementlike when dry. Thus, tractor plowing during the dry season is difficult, and does not improve structure. Mechanical harvesting is difficult due to poor drainage. Cotton, a crop which demands well drained, aerated soils, grows only with difficulty in most regions of the delta.

The Rimaibe recognize four types of soils:

Leydi diarendi -- a sandy soil found in fluvial deposits and around ancient dunes. It is most easily worked just after the floods have receded.

Leydi daneri (white earth) -- richer in silt and in organic matter than leydi diarendi. It is found on contemporary or on ancient levees. Once dry, the soil is very hard to work.

Leydi boderi (red earth) -- clayey soil, which develops deep cracks when dry. When wet, it adheres to the hoe and cannot be worked.

Leydi baleri (black earth) -- soils with a high humus content, overlying gley soils (Gallais 1967:200).

Cultivators take the differential friability of soil types into account when planning fields, using partly diarendi and white earth types (which must be worked before fully dried), and partly red earth and black earth types (which are best worked after drying).

Vegetation in the interior delta has been strongly influenced by human habitation. Pastoralists have repeatedly burned vegetation of the ancient floodplains, which now show mainly pyrophilic species. In the first decades of this century, woodcutting for steamships on the Niger river stripped the levees and ancient dunes of their wood cover; now, wood is used mostly for fish smoking.

On the floodplain, vegetation types depend on the duration of flooding: areas submerged less than three months have dense growth of Vetiveria nigritana; areas where flooding lasts 3 to 6 months have dense, pure stands of Oryza perennia (a close relative of cultivated rice, and a particularly pernicious weed); and areas submerged for more than 6 months of the year have an association called bourgou (extremely dense growth of Echinochloa pyrimidalis, E. stagnina, and

Panicum stagnium, important as dry-season pastureland). Burning of floodplain grasses, unlike the burning of higher-lying ground, is probably beneficial. It rids the land of dead straw, and encourages quick regrowth. Grazing on these lands also encourages the growth of new shoots. Vegetation types act as indicators of soil fertility, for native cultivators. Stands of Oryza perennis (they say) denote land that is fertile for domestic rice cultivation. However, the appearance of O. breviligulata is a sign of soil exhaustion, and cultivated fields infested with it will be put to fallow.

Oryza glaberrima Steud. is the species of rice traditionally cultivated in the interior delta. Although O. sativa was introduced in 1914, it is still of secondary importance. Only small differences in glume pubescence and in ligule size separate the two species (Purseglove 1972:161). Botanists consider that both O. sativa and O. glaberrima are descended from Oryza perennis, which persists as a weed on rice fields. Although agronomists consider O. perennis harmful, and recommend that farmers extirpate it, the seed can be harvested (although with difficulty, since the rachis, or stem bearing the seeds, shatters easily), and contribute significantly to the diet when other crops fail (Viguier 1939:44).

Many agronomists (e. g. Grist 1975:190; Chabrolin 1977:18) consider _O. glaberrima_ to be inferior to _O. sativa_. Its maturation period is long (150 - 180 days for most commonly planted varieties, see Fig. 30); its yields are relatively low (approximately 800 - 1100 kg/ha; Bourke 1965:46); it is not responsive to nitrogen fertilizer; its straw is weak; the rachis tends to shatter at harvest; and, finally, the pigmented pericarp is difficult to remove by milling so the cooked rice has a distinctive red color. However, the varieties of _O. glaberrima_ which are cultivated are the result of long selection. Since rice is self-pollinating, it is relatively easy for cultivators to develop strains suited to local conditions.

> "Much red rice (_O. glaberrima_) is grown under conditions where chance plays a larger part than is usual in agricultural practice in determining the size of the harvest...In bad years, which may mean that the floods are either too large or too small, some areas may yield no harvest at all. Nevertheless, red rice can withstand much rough treatment and still give a reasonable yield. In a favorable year, the farmer is well repaid for his work, and even when yields are low it should be remembered that under the same conditions the less vigorous white rice might have been a complete failure" (Bourke 1965:44-45).

The varieties traditionally grown in the interior delta are floating rices (roots remain in the soil, heads "float" on the surface of the water): they can grow extremely fast -- up to 10 cm/day, to keep pace with rising flood waters

Indigenous name	Linnean subspecies	variety	subvariety	vegetative period (days)	field level	period able to withstand complete submersion	adherence of grains to rachis	productivity	consumer preferences
Early rices									
lemo	vera	breviglumis	fluitans	135	- -	not resistant	moderately good	average	not well liked
kamanko	vera	breviglumis	fluitans	135	high	- -	good	average	
kesirime	vera	longiglumis	fluitans	135	high/low	not resistant	good	average	well liked
tikirouel	confusa	breviglumis	fluitans	135	- -	not resistant	good	average	not well liked
Late rices									
pogo	vera	breviglumis	fluitans	180	low	2 - 4 days	good	excellent	
houssadiamou	vera	breviglumis	fluitans	180	low	3 - 4 days	bad	average	grains prone to break
karosapia	vera	breviglumis	fluitans	170	low	3 - 4 days	- -	excellent	less well liked than simo
tomo	vera	breviglumis	fluitans	150	low	not resistant	moderately good	good	less well liked than simo
simo-raneo	confusa	breviglumis	fluitans	170	low	2 - 3 days	moderately good	excellent	very well liked - grains not prone to break
simo-baledio	confusa	breviglumis	fluitans	165-168	low	2 - 3 days	moderately good	excellent	very well liked
simo-onadeo	confusa	breviglumis	fluitans	180	low	2 - 3 days	moderately good	excellent	less well liked than simo-baledio
simo-bourou	confusa	breviglumis	fluitans	170	low	3 - 4 days	- -	excellent	

Viguier (1939:41-83)

Figure 30. Agronomic characteristics of cultivated varieties of Oryza glaberrima grown in the inland delta - Mali.

(Bourke 1965:46). Botanists (Viguier 1939:46 ff) recognize two series for O. glaberrima, each having two varieties, and each variety having both floating and non-floating sub-varieties, i.e. eight categories in all. Indigenous farmers recognize 41 varieties in all, and many of the varieties have names in several languages. Farmers of all ethnic groups divide cultivated varieties into two broad categories: early rices (with a maturation period of 115 - 140 days), and late rices (with maturation in 150 - 180 days). The early rices, which give relatively low yields, are planted on a small scale, for local consumption. They are important because they mature during the period when the stores of the previous year are almost exhausted, while the main harvest is still unripe. (Approximate scheduling for early and late types is shown in Fig. 27).

Fig. 30 gives some of the important physiological characteristics of 12 varieties commonly grown in the interior delta. The optimal elevation for fields of early and late types is governed by two considerations:

1. Early types are not resistant to submersion and so are grown on higher ground.

2. Late types require a longer period of inundation, and so are sowed on lower ground.

Adherence of the grain to the rachis influences the ease of harvest; where the grain scatters, cultivators must choose between harvesting slightly before maturity, and risking losses when the grain is gathered. Taste and breakage of grains in decortication govern the marketability of the final product.

Discussion of the agricultural cycle will be based on a detailed account of a Rimaibe household in the village of Daga, to the south of Tenekou (Gallais 1967:200 - 228), as well as on more general descriptions (Viguier 1939, Bourke 1965). Figure 31 shows the seasonal cycle of agricultural work.

The decision of where to establish rice fields should ideally be made almost a year in advance of planting, since clearing methods depend on flooding to kill vegetation. Generally, if a year's harvest has been satisfactory, the fields will be reused the next year thus avoiding the labor of clearing new fields.

If the farmer has decided to clear new fields, he has the choice of three methods. The most effective is <u>bala-sa</u>, which requires burning a field before the start of the rains, and letting the empty field be flooded. In <u>balagou</u> clearing, the cultivator cuts the vegetation in August or September -- before the floods, in order that weeds be asphyxiated. When the floods recede, the farmer pulls any surviving

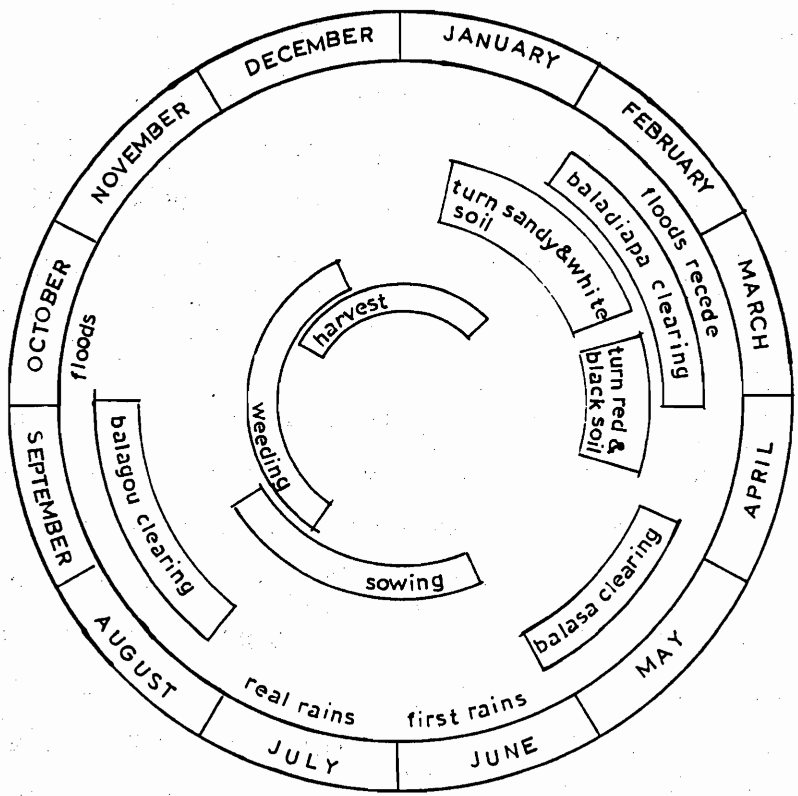


Figure 31. Agricultural calender for Rimaibe rice cultivation

rhizomes, and burns the dead stems. Ideally, then, a farmer clears fields more than a year before they are to be planted. If the farmer was unable to clear before the floods, the method used is called _baladiapa_, and begins when the waters start to recede. He cuts the stems of vegetation, letting the cut material float on the water's surface, thus killing most above-ground growth. This method, however, does not kill weed rhizomes, which must be extirpated after the waters have receded.

Soils differ in the ease with which they can be worked. Thus, _leydi diarendi_ (sandy soil) and _leydi daneri_ (white soil) will be worked while moist; while _leydi boderi_ (red, clayey soil) and _leydi baleri_ (black earth) will not be worked until they are dry. It should be noted that the first two types of soil are much easier to work -- they require 30 - 35 man-days/ha -- while red and black soils require 60 - 80 man-days/ha (Gallais 1967:206). The work is done with a _daba_, a heavy pointed hoe. Viguier (1939) noted differences between ethnic groups in the care with which initial ground working was carried out. Marka and Bambara (ethnic groups predominating on the relatively densely settled right bank of the Niger) used more care in cleaning clods of rhizomes than did Rimaibe (who are concentrated in the sparsely settled left bank). After being turned, the soil is left to dry until the fields are sown. Drying in the sun helps kill any surviving rhimzomes (Bourke 1965:44), and the early rains help somewhat to break up the clods.

Faced with several unknowns, the farmer generally chooses to plant early at the start of the rains in the hope that the rice plants will be sufficiently well developed by the start of inundation to withstand rice-eating fish, and to avoid asphyxiation during total submersion. Experiments have shown (Chabrolin 1977:16) that plants require 30 - 45 days to reach this stage. If, as sometimes happens, the first rains are followed by a long, rainless interval, and if the young plants die during that interval, the farmer replants.

In sowing, the seed is broadcast, generally after being soaked in water for 24 hours (Bourke 1965:44). The clods are broken with a hoe to cover the seed, and to protect it from rice-eating birds: _Anas quer-quedula_ and _Plectopterus gambiensis_ (both ducks) and sparrows (Viguier 1939:96). The dates for planting early and late varieties of rice are the same. In areas where the young plants are endangered by rice-eating fishes, the cultivator will often seed more densely. Thus, within the interior delta, seeding densities range from 60 - 125 kg/ha; while, in the upper valley of the Niger (where rice-eating fish are not a danger), seeding densities seldom exceed 30 kg/ha (Viguier 1939:85). For the same reason, low-lying fields (usually planted to late varieties will be more densely seeded than will higher ones. To reduce the risk of total crop loss due to adverse conditions, the farmer often sows each field with a mixture of seeds having different water requirements.

In general, fields are weeded twice. High fields are weeded once when the rice is approximately 30 cm. high, and again after flooding (usually in September). Low-lying fields are weeded once at the beginning of the floods, and again in October. The first weeding requires considerable skill, since two of the most common weeds, O. perennis and Saccolepis interrupta, are virtually indistinguishable (when young) from young rice plants. There is, however, great variability in the intensity of care given to rice fields. Sometimes, the first weeding is accompanied by hoeing (Gallais 1967:209); sometimes the uprooted weeds are carefully piled on the boundaries of the field, creating, in time, dykes some 40 cm. high (Viguier 1939:87). Small fields individually owned (especially owned by women) may be weeded as many as five or six times.

Harvesting begins in October (for early varieties), and continues until January (for late varieties). In most years, the fields are still flooded when the grain matures, and so the harvest must sometimes be carried out from canoes. The panicles are cut with a sickle, bound in small bunches, and placed on racks to dry. In years when the floods have already receded at harvest, the rice will be cut about 20 - 30 cm. from the ground, and bound into sheaves.

The timing of the harvest is crucial, since the rachis becomes brittle at maturity, and scatters the seed. The situation is made more difficult by the fact that *O. glaberrima* is photoperiodic (that is, its flowering and maturity are triggered by a specific day length, no matter what the total amount of time since germination). Thus, some localities (Gallais 1967:210) harvest each cultivated variety at a specific date on the solar calendar. Farmers have two ways to cope with the scheduling requirements of harvest: they plant several varieties of rice with different maturation dates, and they also exchange labor among themselves (Gallais 1967:210). When the harvest has been gathered and the straw in the fields is dry, the fields are burned, and the cycle begins again.

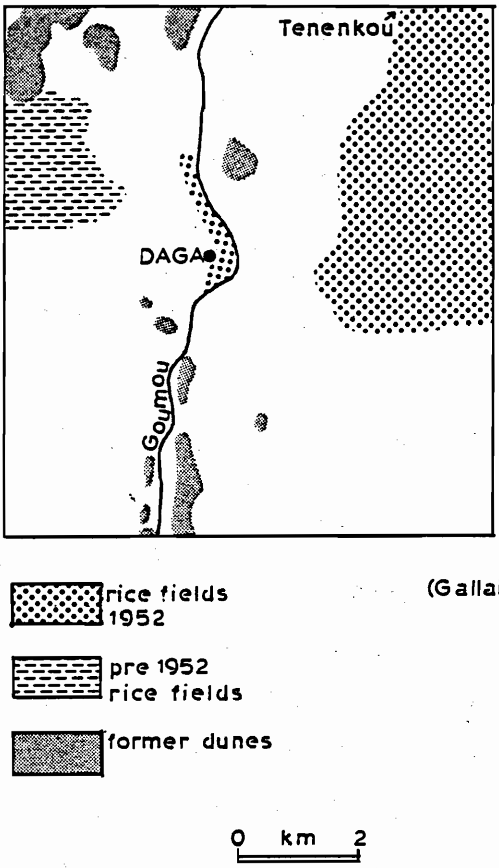
The cut sheaves are often left in the field for several days, then gathered and placed on drying racks, covered with straw to protect the rice from birds, and surrounded by thorny branches, to protect against other herbivores. The grain is threshed when thoroughly dry, using a flail, and the rough rice, or paddy, is bagged or put into granaries.

Almost no information is available on garden cropping methods. The main crops are corn, karite, peanuts, cotton, tobacco, and fruits and vegetables (cultivated primarily by women) (M.I.S.E.S. 1961a:49).

Within partial irrigation projects animal traction is used for plowing, just after the first rains, and then for harrowing. Seed is broadcast and the field is harrowed again. After the seedlings are 45 days old, gates in the dyke are opened, and the field is flooded (Steedman et al 1976:232).

Within a total irrigation project tenant farmers pre-irrigate fields (according to Bourke 1965:49), and then use animal traction to plow to a depth of 4 - 6 inches. Seed is broadcast by hand between 15 May and 30 July. After being sown, the field is immediately flooded and drained. After the plants are 2 - 4 inches tall, the field is flooded again, and water levels are maintained until the plants' maturity.

Rimaibe villages where rice is cultivated are usually located on waterways, and their rice fields also border the streambanks (Fig. 32 shows the location of Daga, with its fields). Members of an extended family participate in two types of agricultural production: collectively during five days of the week they cultivate one or more <u>foroba</u> (communal) fields; individually during the remaining days they cultivate



(Gallais 1967: 201)

Figure 32. Location of Daga with respect to present and former rice fields

kourga (individual fields, whose produce is mostly destined for the market.

For our sample family (which has 11 members), the cultivated area is divided as follows: 5.52 ha. in communal fields 1.81 ha. in individual fields, and 0.01 ha. in garden plots (galle, cultivated by two women, in which was grown corn and a type of millet used for dyeing). In all, the family works 7.33 ha., or 0.66 ha/person (Gallais 1967:204). For rice-cultivating inhabitants in the traditional zone of the central delta as a whole, the average cultivated area is 0.649 ha/person, of which 0.61 ha. is planted with rice (M.I.S.E.S. 1960:36).

However, the importance of individual cultivations may be greater than their small size would imply, in that they seem to be worked more intensively than are communal fields. For example, Viguier (1939:61, see Fig. 33) estimated that rice yields from small garden plots might be four times as high as average yields from large plots. Speaking of Mali in general, Jones (1976:281) noted that individually worked fields were often manured with households' wastes, and often irrigated from wells (see also Ernst 1976:104). Of an area-wide sample of farmers in the interior delta, M.I.S.E.S. (1961a:48) found that agricultural products other than rice and millet contributed, on the average, 11.7 per cent of income from agriculture for families owning a plow (many of whom live in the main rice cultivation areas), and 23 per cent of agricultural income for families not owning a plow (many of whom live on the margins of rice cultivation areas). These figures do not, of course, include income from sales of grain from individual crops, and so it is probable that they understate the production of individual plots.

Figure 33 shows three sorts of production figures for rice: estimates of the ranges of yields, planned targets, and actual average yields. The figures come from several different sources, and seem, at first glance, to show a good deal of variation. Actual averages for yields of _O. glaberrima_ using traditional methods seem to fall at the low end of the estimates of Viguier and of Bourke. Production targets in the Five Year Plan 1961 - 66 seem to have been unrealistic, when compared with actual production at the end of the plan. Plow-owning farmers obtained slightly higher yields (116%) than farmers without plows, while large-scale irrigation projects (growing _O. sativa_) showed yields that were considerably higher than for traditional agriculture.

In assessing proposals to improve the lot of traditional cultivators, dietary intake studies have an advantage over

species	yield (kg/ha)	area	notes
Oryza glaberrima (estimates)	700-800	Niger River	"satisfactory yield" (a)
	1500	Niger River	"excellent yield" (a)
	3000	Niger River	possible in intensively cultivated gardens, with traditional techniques (a)
	790-1120	west Africa	range of yields for traditional techniques (b)
	900-1460	west Africa	approximate range of yields (c)
unspecified	1025	inland delta	farmers in the traditional zone using a plow - 1958 (d)
	885	inland delta	farmers in the traditional zone not using a plow - 1958 (d)
	830	Mali	(not including Office du Niger) - 1959 (e)
	800	Mali	lands without water control - 1966 (f)
	887	Mali	lands under partial water control - 1966 (f)
	1800	Mali	"reasonable" yield on lands under partial water control (f)
	1400	Mali	"possible" yield for polder, using animal traction, and improved seed (g)
	1900	Mali	above + seeding in lines, cultivator for weeding, chemical fertilizer (g)
Oryza glaberrima	2000	Office du Niger	fields managed by Office du Niger, not using transplantation (1930s) (a)
	3000	Societe Civile de Dire	using transplantation (a)
	630	Daga	Rimaibe cultivator using traditional methods (h)
Oryza sativa	1709	Office du Niger	(Niono-Molodo) full irrigation 1958 (d)
	1426	Office du Niger	(Kokry) full irrigation 1958 (d)

(a) Viguier (1939:61)
(b) Bourke (1965:45)
(c) M.I.S.E.S. (1960:37)
(d) M.I.S.E.S. (1960:39)
(e) Jones (1976:274)
(f) Jones (1976:308)
(g) Steedman et. al. (1976:232)
(h) Gallais (1967:216)

Figure 33. Yields for Oryza glaberrima and O. sativa.

yield figures, in that they come closer to examining the well-being of people in different situations. Extensive surveys, carried out in 1958, tried to assess the effect of the introduction of ox-drawn plows, and the effect of irrigation agriculture in the Office du Niger, on the daily nutritional intake of people participating in the programs. Some of the results form Figure 34.

Overall, the investigators concluded (M.I.S.E.S. 1961b: 19) that they had no evidence for grave deficiencies, except for a relative scarcity of vitamins A and C. They found seasonal variation in the composition of food intake, with millet and sorghum contributing a greater part of total calories in the rainy season than in the dry season (when rice contributed relatively more). Seasonal variation in total calories was relatively slight (M.I.S.E.S. 1961b:17). Within the traditional zone, farmers owning a plow had higher daily caloric consumption (3,329 compared with 2,204), and a higher level of protein intake (93.8 g./day compared to 67.5 g./day) than did farmers without a plow. Comparing the Office du Niger with the traditional zone as a whole, settlers in the Office du Niger had only very slightly higher consumption levels. Overall, however, the investigators felt that persons in the traditional zone had a more varied diet, and a higher intake of high-quality protein from animal sources.

	Rice cultivators (trad. zone)	Traditional zone (total)	Office du Niger
Calories	2,370	2,315	2,370
Protein (g)	70.8	70.5	70.7
% animal protein	28.7%	25.0%	15.5%
% of calories in protein	11.9%	12.1%	11.9%
Rice intake (g)	478	378	340
Millet and sorghum (g)	82	173	268
Meat (g)	14	14	15
Milk (g)	46	40	
Fresh fish (g)	57	49	11
Dried fish (g)	36	16	14

M.I.S.E.S. (1961b:17)

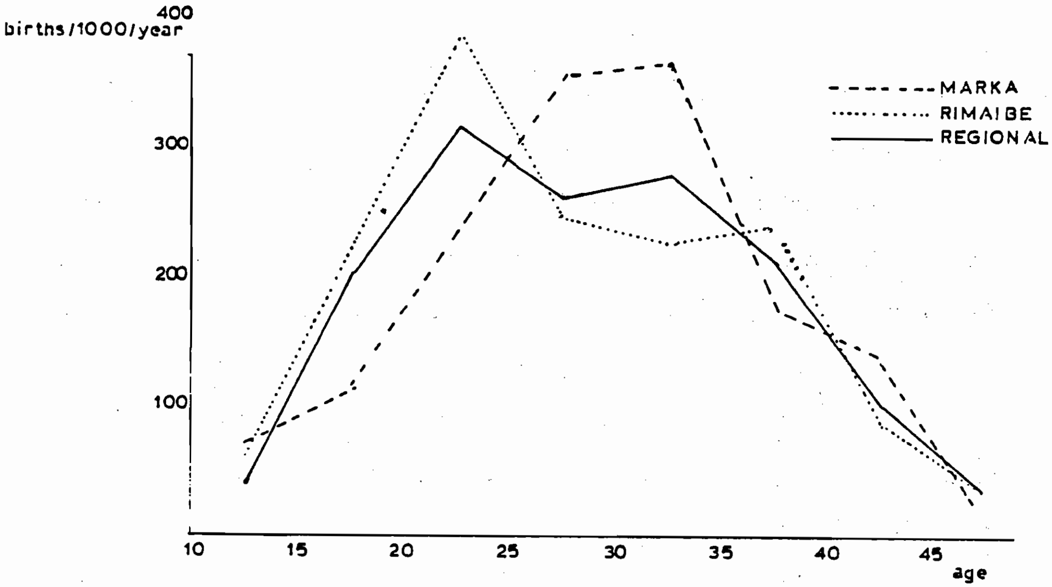
Figure 34. Daily per capita intake for the traditional zone of the interior delta (Mali) and for the Office du Niger.

In the Rimaibe household described by Gallais (1967), women participated relatively little in the cultivation of the communal fields, helping only with the weeding. Most of their time was taken up with processing the rice after harvest, with small scale vending, with crafts production, with food preparation and with gardening. The household described had a relatively short supply of women. Further ethnographic work in the delta is necessary to permit any generalizations about the actual extent of womens' participation in agriculture.

The labor requirements of the main agricultural tasks were estimated as follows: turning the soil (60 - 80 man-days/ha for red and black soils; 30 - 35 man-days/ha for sandy and white soils), weeding and hoeing (7 - 10 man-days/ha). Figures are not available for time spent in harvesting, but all together each hectare required 76 man-days for cultivation (not including the time necessary for sowing, some 14 man-days/ha additional) (Gallais 1967:217).

Crude birth rates for the Marka (56/1,000, M.I.S.E.S. 1961:II:151) and for the Rimaibe (54/1,000, ibid.) fall at the midpoint of the CBRs reported for ethnic groups of the interior delta. However, examination of Figure 35 (from

Figure 35: Age specific fertility interior Niger delta



M.I.S.E.S. 1961:II:132) shows that age-specific fertility for Marka and Rimaibe women was considerably higher than for the region as a whole. Graphs of total completed fertility (ibid.) show that average numbers of live births are considerably higher for Marka women than for Rimaibe women. In regional terms, average total live births (women 45 - 54) is considerably higher on the right bank (6.37) than on the left (4.84, op. cit:129).

Crude death rates are considerably higher for Marka (55/1,000, M.I.S.E.S. 1961:II:153) than for Rimaibe (33/1,000, ibid.), compared with 41.5/1,000 for the region as a whole, and 26/1,000 for the Office du Niger. These figures, however, were collected just after epidemics of smallpox and of measles; Gallais (1967:167) felt that 33/1,000 was a more reasonable estimate of CDR for the delta as a whole. Child mortality was extremely high for the region as a whole; less than half of live-born children survived to age five (M.I.S.E.S. 1961:II:153). For infant mortality, communities which were predominantly Marka had a far higher rate (311/1,000) than did communities with a majority of Rimaibe settlers (244/1,000, M.I.S.E.S. 1961: II:156).

Although little information is available on the health status of the region, it is possible to make some general comments. Respiratory infections (during the rainy and cold seasons), malaria, schistosomiasis (haematobium type, diagnosed in one-half of school children observed), and leprosy were some of the widespread problems. The Bani flood plain was an endemic focus of trypanasomiasis and onchocerciasis. Smallpox and measles epidemics claimed many lives as late as 1956 - 57, being most destructive on the right bank of the Niger (Gallais 1967:168).

The demographic inquiry calculated a natural rate of increase for the region as a whole of 13/1,000. In the time since the inquiry, however, it is possible that the NRI may have risen: an agricultural study (1970-71 cited in Diawara and Traore 1975:19) showed that the rural population in the administrative region of Mopti, which includes the interior delta, increased by 19.8 per cent between 1964 and 1970. We will see, however, that in-migration to the region is an alternative explanation for the rise in the rate of population increase.

Data on temporary and permanent migration are more difficult to collect than data on natality and mortality. Ideally, a study of migration would be able to trace each move of every person born within the study area, but in practice, data on long-distance moves and permanent emigrations are difficult to recover. Thus, the M.I.S.E.S. study did not include persons absent more than five years.

The pattern of immigration to rural communities in the study region (M.I.S.E.S. 1961:I:15) showed a much larger proportion of women immigrants than of men, with the largest group of female immigrants at age 20 - 30, and a steady decline after that age. It is reasonable to infer that women migrate mostly at marriage, often returning to their birthplace if widowed or divorced.

In contrast, data on temporary absentees showed that, for the whole delta, men were more likely to emigrate than women (65.6% of absentees were men). Of male absentees, 63% were outside the interior delta; the corresponding figure for women was 52%. Figure 36 shows the age-sex distribution for Marka and Rimaibe absentees. It is apparent that men emigrate more often than women, and that the bulk of migrants are of working age. It is important to try to assess the effects of emigration on the agricultural work force.

For the nation as a whole, the proportion of agricultural population (those who list agriculture as a part-time or full-time occupation) to the total rural population showed little change between 1964 and 1970 - 71, and 90 per cent of the total population was rural in 1970 - 71 (Diawara and Traore 1975:46). However, age-specific sex ratios for the agricultural population changed dramatically in that

Age	Rimaibe male	Rimaibe female	Marka male	Marka female
0-9	17.5	27.4	8.6	20.4
10-19	24.3	25.3	24.4	27.8
20-29	25.3	27.0	28.9	21.3
30-39	17.5	11.4	25.5	21.3
40-49	9.8	3.9	5.4	9.3
50-59	3.4	3.6	4.5	
60-69	1.6	0.1	2.6	
Totals	2490	1405	1330	540
% of total	(9%)	(5%)	(11%)	(4%)
(male and female population by ethnic group)				

M.I.S.E.S.(1961:II:115)

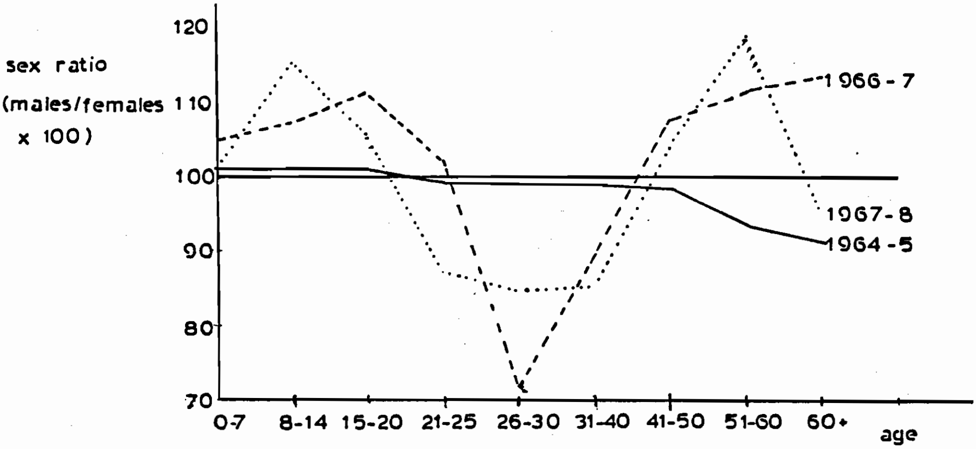
M.I.S.E.S.(1961:II:23)

Figure 36. Age distribution of absentees (1957-1958) by sex and ethnic group (%).

period. Figure 37 shows that in 1964, for ages under 40, the sex ratio for agricultural workers was near 100. Starting in 1966, however, the sex ratio for workers between 21 and 40 (i.e. those most able to do heavy manual labor) plummeted, and the pronounced deficiency of men in these age groups continued through 1971. In 1971 - 72, the interior delta and the Office du Niger were both classified as regions where shortage of agricultural workers (rather than shortage of land) was a limiting factor for agriculture (Steedman et al 1976:20).

Although age-sex data by ethnic group are not available for the interior delta, the data were tabulated (M.I.S.E.S. 1961:II:37) for the de facto rural populations of the northern and southern regions of the delta, and these pyramids are shown in Figure 38. The shape of the pyramids, in general, shows the wide base and narrow apex typical of regions with rapidly growing populations. Several peculiarities can be attributed to difficulties in ascertaining ages of the persons censused. The most important observation for these pyramids, however, is their asymmetry -- the deficiency in male cohorts, starting with the 15 - 19 age group, due to the migration patterns discussed above.

In a country where almost all farms are owned and operated by a family unit, the demographic structure of



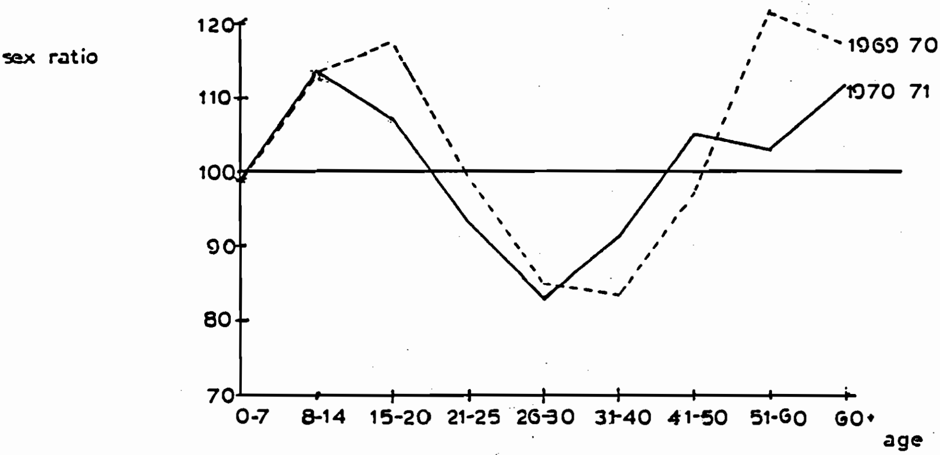


Figure 37. Change through time in age specific sex ratio of agricultural population

(Diawara and Traore 1975: 49)

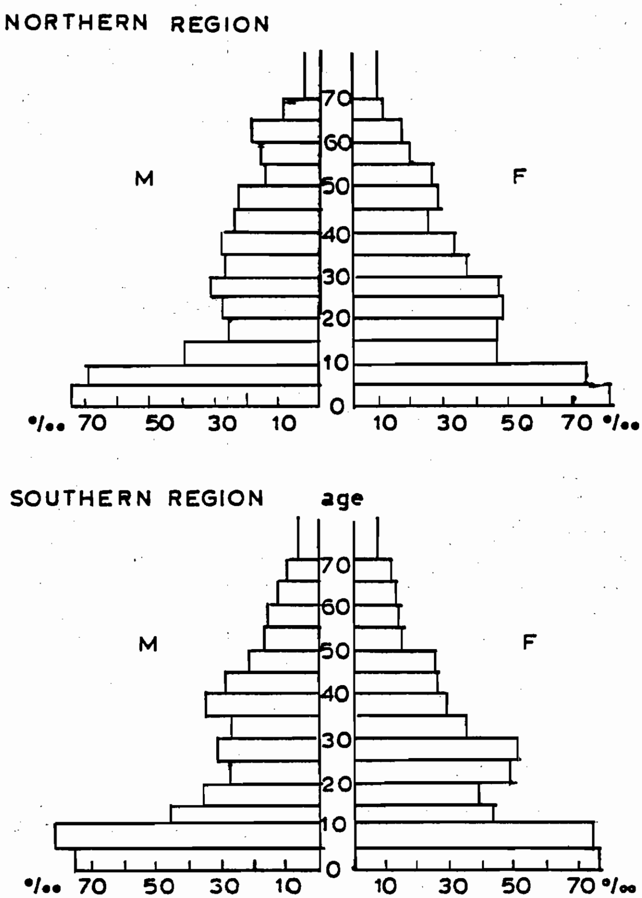


Figure 38. Age sex pyramids - rural interior delta Mali

the family has obvious importance for its effect on the amount and type of labor available for agriculture. Some writers (e.g. Ernst 1976:133) go further, and assert that the size and structure of the family as a productive unit affect productivity and also willingness to invest in equipment like plows and oxen.

A Marxist view of the situation in Mali as a whole (Ernst 1976:121 ff) sees households as representing a continuum of decay of the extended family: (1) the extended family, acting as a single production unit; (2) several production units within the extended family, which continues to exist as a social unit; (3) nuclear families as economically independent production units, still forming part of an extended family, and still exchanging labor among themselves, and (4) the nuclear family as a completely independent economic and social unit. The power behind the fission of the extended family is the growth of individual production at the expense of communal production:

> "As the economic importance of the...(individual field) can only grow at the cost of the...(communal field) i.e. of the traditional system of production and distribution, this leads to a conflict sooner or later between the producer and the extended family.... Basically, it is the social expression of the contradiction between the necessity of the productive forces to develop and the historically out-dated character of existing production relations" (Ernst 1976:122).

The demographic inquiry for the interior delta as a whole showed that, in rural areas, family size was relatively small (average 4.3 persons (M.I.S.E.S. 1961:II:172), and usually monogamous (49%, cf. 9% polygamous, 19% including persons outside the nuclear family, 18% with one or more spouse(s) absent). On the average, household (defined as the persons cohabiting in a compound) size was small -- most families held 0 - 4 (45.7% or 5 - 9 (36.8%, M.I.S.E.S. 1961:II:182) persons, with an average of 1.4 families per household (op. cit. 189). In general, the relationship between married males was son-father (9%, op. cit. 164), or brother-brother (14%); 64% of households contained only single families.

Unfortunately, only a study of budgets (M.I.S.E.S. 1961a:16) from the interior delta discusses the relationship between economic factors and family size. Overall, cultivators of rice had smaller household size (average 8.7 persons) than did non-rice-cultivating households (10.5 persons on the average -- mostly cultivators of millet on the unflooded plains). Within the group of rice cultivators, households owning a plow were, on the average, larger (11.1 persons) than were households without a plow (7.6 persons average).

Two sorts of demographic data are available for the interior Niger delta: administrative censuses were carried out over a period of years between 1948 - 58 (summarized in Gallais 1967:18 ff), and detailed studies were carried out by the Mission Socio-Economique du Soudan (M.I.S.E.S. 1961) in sample communities of the traditional part of the delta. Gallais (1967:19) estimated the total population of the delta to be 423,500.

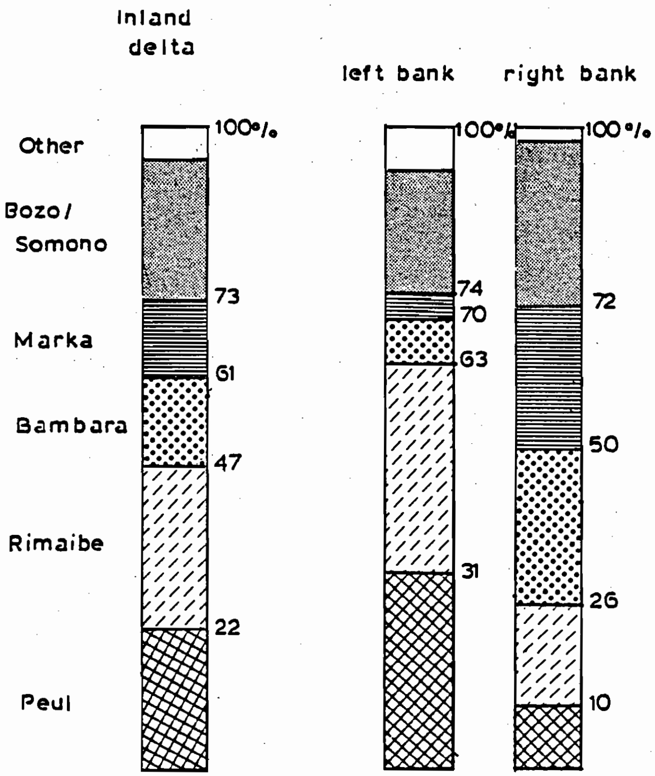
As with most regions in third world countries, population size shows the effects of a colonial regime. Famines, caused by drought or by the predation of _Locusta migratoria migratoides_ had been frequent until 1940 - 45 (Gallais 1967:164 ff), as had epidemics of smallpox, cerebral meningitis, and flu. Under the French smallpox vaccination campaigns started between 1930 - 40, and other improvements in health care followed. During WW II, the French put pressure on farmers to increase grain production, and to set up village granaries. In addition, they introduced manioc, which, having underground tubers, is not susceptible to locusts. The effect of these medical, agronomic, and administrative rulings was, predictably, to lower mortality rates.

Taken as a whole, the interior delta shows low population density, some 14/km^2 (1959 Gallais 1967:19). This is notably less than, for example, Kano province in Nigeria, or the Serer region of Senegal (Lericollais 1972) -- both regions of dense settlement and of intensive cultivation. Indeed, the interior delta of the Niger is less densely peopled than the upstream Niger valley, or than the basin downstream.

Population density is not uniformly distributed over the region. When one omits urban population (as well as excluding land area covered by lakes), the general rural density is 10.94/km^2 (Gallais 1967:177 ff). However, calculating local density (in 36 km^2 quadrants), one finds that, even outside cities, population is clustered, with 59.8% of the rural population living in areas with local density above 25/km^2. In terms of environment types, the banks of the major waterways (the Niger, Diaka, Bani) are densely occupied, holding large, nucleated villages of fishermen and boatmen (mostly Bozo and Somono). The marshlands, in contrast, are only sparesely settled. The rivage -- the band between the marshes and the high, unflooded plain -- is densely inhabited on the right bank, but only sparsely inhabited on the left. The same pattern holds true for the high plains which border the inundated regions. Gallais attributed this difference in density of human settlement to geographic and historical factors. The right bank is morphologically "younger" than the left: there is more variation in relief, and micro-environments are better defined. In addition, one of the important waterways of the left bank had filled with silt in the recent, pre-colonial past, so that it no longer flooded. The historical differences between the regions stem from the 19th century; it will be remembered that the left bank had been laid waste by the Toukolour, while the right bank had prospered.

Figure 39 shows ethnic composition: it will be seen that, of the groups concentrating on rice agriculture, Rimaibe predominate on the left bank; Marka on the right bank (M.I.S.E.S. 1961:I:12). Our typical Rimaibe village, located on the left bank, is small, consisting of some 100 inhabitants. Marka villages tend to be larger, some 400 - -500, and are often located on or near the marshes (Gallais 1967:173).

From the mid-15th to the mid-17th century, when Timbouctou and Djenne were important markets in the trans-Saharan trade, the agricultural productivity of the interior delta has been high. At this time, chronicles record use of money to pay for agricultural and herding products (Gallais 1967:85). This sort of trade continued until French conquest, although political unrest and military conquest weakened its importance. The history of the marketing structure established by the French is complicated, and will not be discussed here (see Suret-Canale 1971:155-300),



(MISES 1961:II:25)

Figure 39. Ethnic composition of the inland delta by subregion

except to say that not all policies were disadvantageous to the producers. Prices for rice were actually subsidized.

The reports of the 1957 - 58 budget inquiry (M.I.S.E.S. 1961a) will form the start of our discussion. The aim of the study was twofold. It sought to compare income levels and household budgets for people living within the Office due Niger with those of people living outside it (i.e. the "traditional" zone of the interior delta). Within the traditional zone, the study wanted to compare household budgets for those engaged in different kinds of agriculture (i.e. rice cultivation on the inundated zone with slash-and-burn cultivation of millet on the unflooded borderlands), and also to compare the production levels and incomes of families owning an ox-drawn plow (an innovation advocated by French administrators), with production and income of families lacking a plow.

At the time of investigation, family budgets showed that cash needs included taxes (6 - 11% of cash income) and a variety of imported manufactured goods (8 - 34% of cash income). The plow was already in widespread use: 47% of Rimaibe households owned one.

The two most important routes between Mali and the coast are the Bamako-Dakar railroad, and a rail and road route between Abidjan and Bamako (Steedman et al 1976:51).

Transport along the Niger River from the central delta to Bamako is not always possible; one section of the river is impassible during parts of the year (Suret-Canale 1971:206). Although primary road networks are sufficient in many parts of the country, feeder road networks are not, and many villages are inaccessible during the rainy season. On the interior delta, the rice-cultivating village of Daga was accessible only by canoe, during five months of the year. Steedman and others (1976:53) contended that the state of the transport system seriously constrained the marketing of crops. In some cases, transport costs exceeded the prices paid to producers.

At the time of the budget study (1957 - 58, M.I.S.E.S. 1961a:47), cultivators in the traditional zone of the interior delta gained the largest part of their income from the sale of rice (56.8% of cash income for families owning a plow, 37.1% of monetary income for families without one). Millet ranked next, as a cash crop, followed by garden crops (corn, karite, peanuts, cotton, tobacco, fruits and vegetables). A national study, roughly contemporary with that of M.I.S.E.S., (cited in Ernst 1976:121) found that 15.6% of the area of fields worked by the whole extended family were devoted to cash crops, while, for individually owned fields, the proportion was

23%, divided between cotton (4.1%), peanuts (12.8%), and rice (6.4%). Much of the marketing is on a small scale; for example, rice is traditionally sold by household members who prepare a few kg. of paddy each week, spending the proceeds mostly on condiment ingredients (Gallais 1967:206). To discuss more recent developments in crop marketing, it is necessary to digress, and to describe national policy on agricultural prices.

After independence, Mali established state trading organizations, with monopolies on the buying and export of agricultural products, and on the importation and wholesaling of consumer goods (Ernst 1976:141). On the local level, cooperative and mutual aid societies were formed, and private trade was outlawed by 1964-65. Figure 40 shows official producers' prices for white paddy, as well as total estimated annual rice production, for this period.

During this period, the prices paid for agricultural products by the government were deliberately kept low, in order to keep down (urban) consumer prices for staple foods (Jones 1976:299-300). At the same time, however, the general price index rose from 100 (1959) to 168 (1966) for goods the farmers themselves bought. The general price index actually understates the inflation experienced by farmers, since their consumer cooperatives

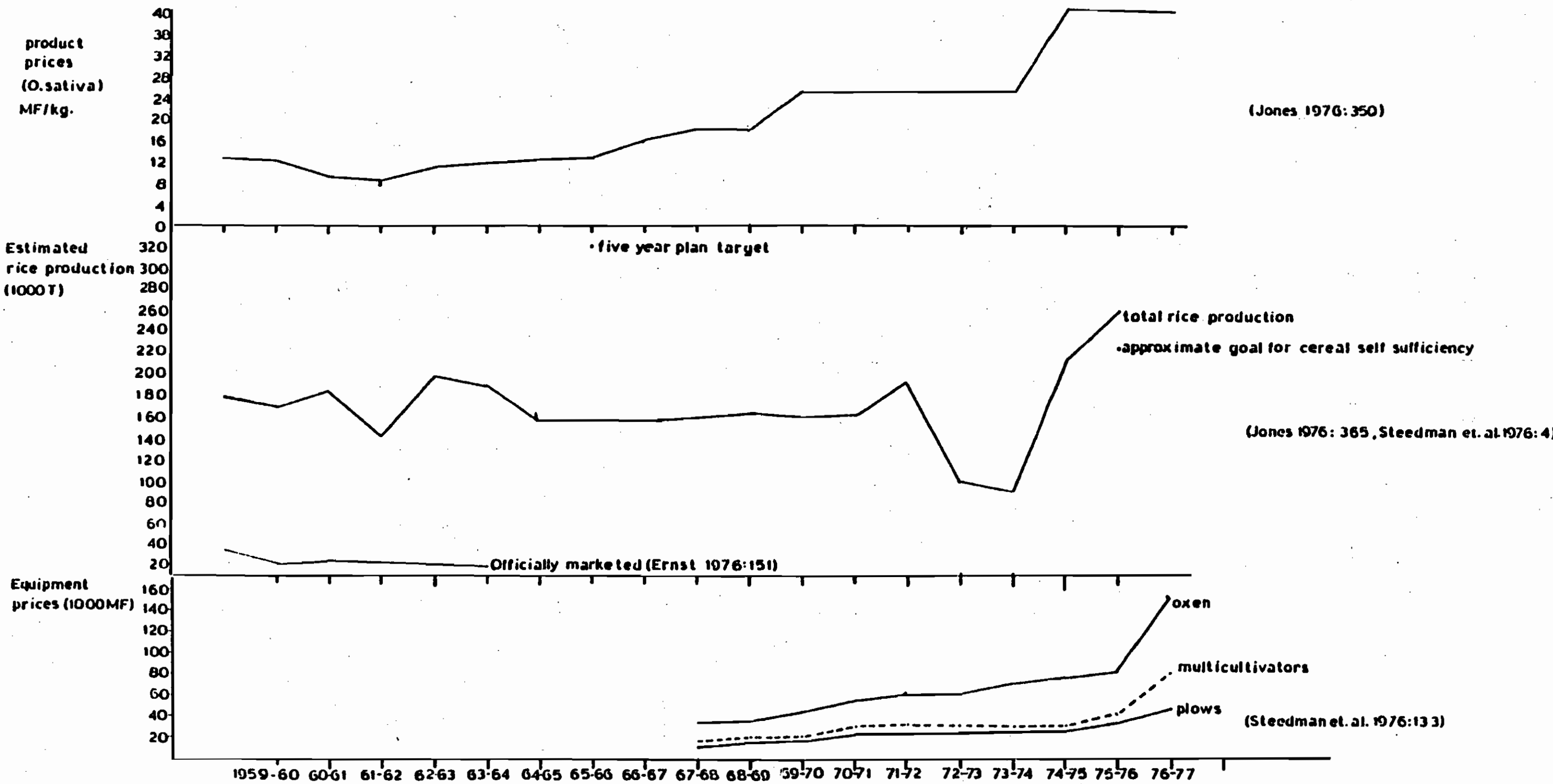


Figure 40. Producer prices and total production of rice - Mali 1959-1977.

seldom received goods to be sold at official prices.

Looking again at Figure 40, it is evident that declines in rice production coincided with the suppression of private trade, and also that only infinitesimal amounts of rice produced were being marketed through official channels. In most commodities, black market (or parallel market) trading expanded, and prices on the parallel market soared. By 1964 - 65, official estimates were that 85% of rice produced (outside the Office du Niger) was traded on the black market (Ernst 1976:147).

In the years after 1966, however, government prices were raised and production increased, somewhat. The share of the state trading company, OPAM, in total marketed cereals has varied between 15% (1968 - 69) and 50% (in the years during and after the drought). In its efforts to stabilize grain prices, however, OPAM has been hindered by organizational problems. For example, financing for grain purchases is often delayed until well after the start of the harvest (when prices are most depressed). Another problem has been that administrative marketing "quotas" are inflexible (and often underestimate surplus). Private traders still fill an important role (Steedman et al 1976:109 - 115) because they can buy more flexibly than can OPAM.

Steedman and others (1976:x) describe the situation after the drought:

> "Producer prices were raised in 1974. However, despite inflation and the existence of significantly higher prices for the same crops in neighboring countries, they have not been raised since. Meanwhile, the government has removed subsidies from agricultural implements, and their prices have risen substantially in the past two years. Fertilizer prices have also gone up. These developments have given to some the impression that the Malian farmer is supporting the rest of the population, which in effect means townspeople. As one official expressed it to us, "the farmer has had enough of subsidizing everyone else."

After the sale of agricultural produce, a second important source of income for cultivators in the traditional zone of the interior delta is fishing. For cultivators owning a plow (1957 - 58, M.I.S.E.S. 1961a:48) the sale of fish represented 21% of money income, while for those not owning one, the contribution was much smaller (9%, M.I.S.E.S. 1961a:48). The reason for the discrepancy is that fishing is carried out at the end of the dry season, when waters are lowest (see Fig. 31). Cultivators owning a plow completed their land preparation earlier than did those without a plow, and so had leisure to fish. Plow owning farmers also, sometimes, traded surplus rice for fresh fish, then smoked the fish and resold it.

For members of households without plows, commerce in local products and in products from other parts of Africa (particularly kola) played a larger role than in households with a plow. The production of matting -- for wrapping fish -- also contributed to household income.

Because of differences in the timing of agricultural tasks for millet and for rice, it is possible for cultivators from one zone of the interior delta to work in neighboring regions. Thus, after the start of the rains, and after the first weeding of rice, many rice farmers work hoeing the millet fields, and are paid in cash (100f/day, Gallais 1967:210). After the millet harvest is finished, many of the millet farmers help with the rice harvest, which follows. They are generally paid in kind (1/10 of the harvest, M.I.S.E.S. 1961a:42).

During the dry season (ibid.) it was common for cultivators to go to nearby urban zones (Mopti and San) and to the Office du Niger, seeking work in house repair, dyke construction, and road repairs. Migration to more distant parts, to more developed agricultural areas (like peanut-growing regions along the Kayes-Bamako railroad, or cotton-producing districts around Segou-Koutiala) within Mali, and to agricultural labor in cocoa, coffee, palm products, and rice in the Ivory Coast, is widespread. There is anecdotal evidence that emigration from rural areas increased as real income for farmers in those regions declined, during the 1960s (Jones 1976:301).

In spite of methodological problems with the M.I.S.E.S. budget studies (1961a), the data are valuable as order-of-magnitude estimates. It is also possible to make rough comparisons among groups, and to compare data with 1971-72 estimates of per capita agricultural income (Steedman et al 1976:14 ff).

In total income, farmers in the Office du Niger (9684 FCFA/cap/year) exceeded those in the traditional zone (6957 FCFA/cap/year). Most of the difference was in cash income rather than in subsistence crops consumed within the household. Within the traditional zone, for rice-cultivating Rimaibe, per capita annual cash income of members of families owning a plow was considerably higher (2118 FCFA) than for members of families not owning one (1193 FCFA, M.I.S.E.S. 1961a:41), as were on-farm consumption levels. In fact, consumption of foods produced on the farm were as high for plow-owning farmers within the traditional zone, as they were for farmers in the Office du Niger.

When per capita income for all families within the traditional zone was tabulated by ethnic group, there were only relatively small differences among groups (M.I.S.E.S. 1961a:35). Interestingly enough, there were inter-ethnic differences in per capita income among colonists of the Office du Niger. The Miniankas, a group from southern Mali (who, in their homeland, practice an infield-outfield type of cultivation similar to the Hausa (Malgras 1960) had the highest per capita income of ethnic groups within the Office du Niger. Instead of farming rice and cotton exclusively, many of them had concentrated on horticulture, and sold garden produce to the other settlers (Dumont 1957:107).

Of course, one of the reasons for differences in income between groups of farmers is that some -- those in the Office du Niger, and those owning plows -- were using greater capital inputs to farming. Any generalizations on their overall welfare must include capital costs in family budgets. Office du Niger colonists were given cash advances at their entry into the project, and their indebtedness was steadily mounting at the time of the M.I.S.E.S. study (to an average of 39,300 CFA/family in 1957, M.I.S.E.S. 1961a:44). By the mid-1960s (de Wilde 1967:254), advances in credit totaled some 164,000MF per settler, which had to be reimbursed to the Office within 2 - 3 years. In addition, the Office levied charges on rice cultivators of 400 kg. of paddy/ha, in addition to 10 per cent of the harvest charged for threshing (<u>ibid</u>:267).

Figures are not available for the cost of ox teams and plows during the colonial period, but maintenance of equipment alone took 32.6 per cent of cash income during the period January - April, for farmers owning plows (for non-owners, the figure was 0.1%, M.I.S.E.S. 1961a:66). Prices for ox teams, multicultivators, and plows are shown on Fig. 40 for 1964 (within the Office du Niger), and for 1967-1977. During much of the 1960s, credit was not easily available (Jones 1976:303) for equipment purchases. Prices on equipment had been subsidized until 1976 (Steedman et al 1976:87 ff), and credit could be extended for a maximum period of two years. When subsidies were removed, the repayment period was often extended for three years.

Recent data (1971-72, cited in Steedman et al 1976: 15-16) for per capita annual income in rural areas shows the Delta zone to have extremely high levels (39,700 MF, net of taxes, cf. 29,800 MF for Office du Niger, and 19,900 MF for Mali as a whole). These figures, however, include income from livestock, and so are not strictly comparable to incomes for rice cultivators. It is likely that current income levels are less high than those for 1971-72 because of the effect of the drought on livestock populations.

By the 1930s, French agronomists (Viguier 1939) knew most of the problems of traditional rice cultivation methods in the interior delta. The varieties used (floating types of *Oryza glaberrima*) were unresponsive to fertilization, could not be mechanically cultivated, harvested or threshed, were low yielding, and were unacceptable on the world market. The flooding regime of the delta was irregular, and crop failure was common. Cultivation was carried out entirely by human labor; methods were haphazard, and the year-to-year displacement of rice fields precluded soil amelioration.

By the end of the 1940s, a number of approaches to these problems were being tried: introduction of *O. sativa* varieties, the use of ox-drawn plows, partial, small-scale water control systems (polders), and large scale irrigation works. Near the end of the colonial period, these programs were evaluated in the M.I.S.E.S. studies, and in those of M.E.A.N. (Mission d'Etudes d'Amenagements du Niger, reported in Guillaume 1960). Assessments of different programs makes it possible to clarify the alternatives available to Malian planners at independence.

The first program to introduce *O. sativa* varieties started in 1914, and efforts have continued to the present. Unfortunately, *O. sativa* is much less tolerant of submersion than were "late" types of O. glaberrima, being able to withstand only one meter (Gallais 1967:230, Viguier 1939:124). To some extent, O. sativa varieties have been accepted by native farmers as substitutes for the "early" O. glaberrima varieties, and are planted in high fields, or in areas under partial water control.

The ox-drawn plow was introduced to the delta in 1925 (Gallais 1967:231). Although adoption was slow until 1945, the plow rapidly gained popularity after that date until, by 1957-58, 47% of sampled rice farmers owned one (M.I.S.E.S. 1961a:10). The hope was that the plow would permit deeper working of the soil, the ownership of oxen would increase use of animal manure, and the increased efficiency of land preparation (5 - 10 ares/day/worker, instead of 2 - 5 ares/day/worker with the daba hoe), would permit each worker to cultivate a greater surface. There is evidence that families owning plows had higher income, and higher consumption levels than those not owning plows. The question remains, however, whether this correlation meant that plows raised agricultural productivity, or that prosperous families were the ones who could buy plows.

To answer this question, a detailed study was carried out in Severi (a predominantly Rimaibe village near

Wandiaka; Gallais 1967:233 ff), between 1949 (when plows were used for 25% of cultivated area), and 1958 (when the proportion was 86%). During that period, however, overall per capita cultivated area in rice declined, partly due to a succession of poor flood years. In addition, the distribution of cultivated area per capita became more uneven: compared with 1948, there were many more people in the highest and lowest groups of per capita cultivated land, and amount of land per capita corresponded to lineage prestige (i.e. the rich got richer and the poor, poorer). What had happened was that plow owners were, in many cases, lending equipment and oxen to prepare the fields of others (often families where some members had emigrated in search of work), in return for help during other parts of the agricultural year (particularly at weeding and harvesting).

Land preparation, although arduous, can be carried out over a relatively long period (see Figure 31). In contrast, hand weeding and hoeing must be completed within a short period, and harvesting is even more exacting in its scheduling. It is these operations which are the bottlenecks in traditional rice farming (where water control is absent): by hand, a worker can prepare 2.5 - 5 ha, but he can only hoe and weed 2.0 ha, and can harvest perhaps 1.5 - 1.6 ha

(Gallais 1967:241). Thus, the use of plows alone cannot greatly increase productivity.

Several means to bypass the bottleneck of weeding have been tried. In the Office du Niger, deep plowing with tractors was tried (see below) to extirpate O. perennis; instead, it exacerbated O. brevigulata infestation. Pre-irrigation of fields, followed by transplantation of rice, proved too costly in labor. Within polders, seeding in lines has been tried, followed by animal-driven cultivation before the area is flooded (Steedman et al 1976:232). However, outside water control projects, no method has been found to mechanize weeding. As for harvesting, the use of combines on the lands of the Office du Niger proved disastrous (Dumont 1957:105), and harvesting in pilot projects is still carried out by hand (Steedman 1976:232).

A third approach to improving rice cultivation, suggested by Viguier (1939) was through partial regulation of the floodings. The timing of the start of flooding is important: if the fields are flooded too quickly, the young rice plants are liable to asphyxiation and to the predations of rice-eating fish. If waters recede too rapidly at the end of the floods, yields suffer. Polders, protective dykes surrounding fields, with adjustable gates (equipped with a grill to keep out fishes) permit the farmer to regulate inflow (retarding flooding), and can retain waters after the floods' recession. Often, polder dykes could be planned to utilize previously existing natural levees.

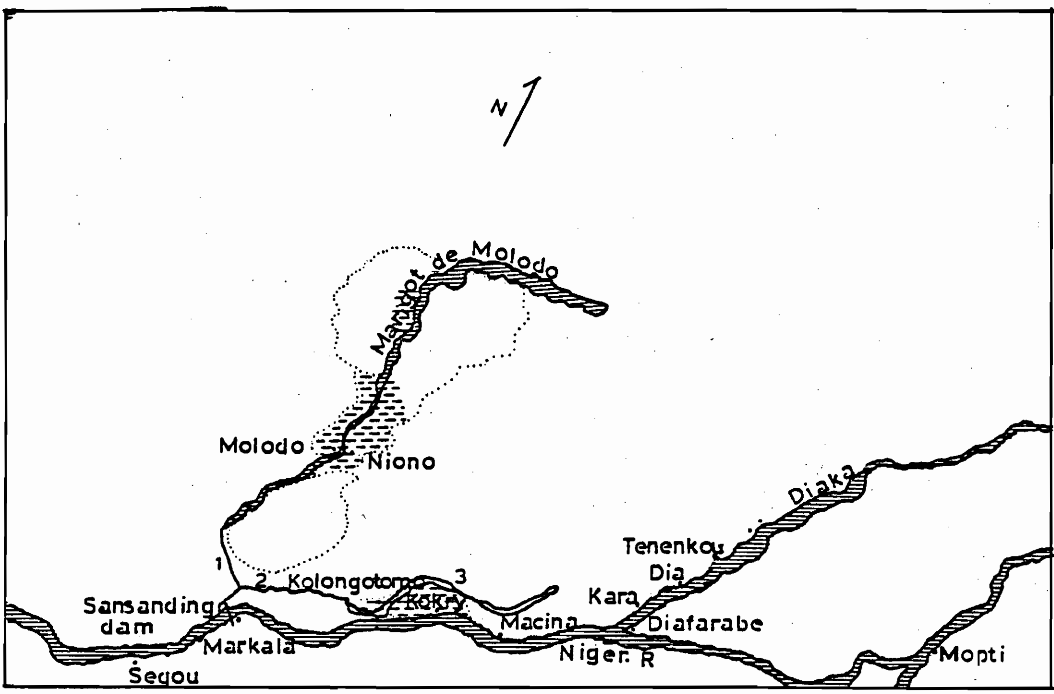
Between 1943 - 51, small-scale polders were constructed, containing in all some 49,350 ha. However, the builders did not take into account the extent of possible variation in flood levels. Thus, when the floods of 1951 surpassed records for the previous decade, the dykes were not sufficiently high to afford protection. Another problem was that lands within the polders were not leveled, and drainage was often poor. In all, only some 13% of the area protected by these polders had been brought into cultivation by 1957 - 58 (Gallais 1967:243).

Sometimes, however, these projects had unexpected successes. Construction of one particularly large polder (planned before 1950) had not been completed by 1958. However, farmers, on their own initiative, had occupied the high ground bordering the canal, had planted mixed gardens of O. sativa, maize, manioc, and millet, and were irrigating the gardens by cutting through the canal walls. Yields were excellent -- up to 2.5 t/ha (Gallais 1967:245).

There is, however, some evidence that within polders there was a larger increase in cultivated area per worker when farmers were given plows (2.05 ha/worker without plow, 2.98 ha/worker with a plow, in Diaka; Gallais 1967:249).

In spite of the problems with polders, at least one evaluator (Guillaume 1960:397) felt that, with development costs of about 35,000 fr/ha, assuming yields in the polders of about 1.2 t/ha, polders gave a better return to investment (41.4%) than did larger-scale irrigation projects like those at the Office du Niger, discussed below. Influenced in part by this assessment, the national 1961 - 66 five year plan for Mali invested heavily in development of new polders, and the results of these will be discussed below.

The largest and the most expensive project initiated by the French was the Office du Niger. Since it has been much evaluated (M.I.S.E.S. 1961, 1961a, de Wilde 1967, Jones 1976:305 ff, Steedman et al 1976:222-26), and since much of the literature is in English and is easily available, discussion here will be brief. The original proposal, made in 1929, utilized two natural waterways which had been closed with alluvial and aeolian deposits, the Fala de Molodo and the marigot de Boky Were (see Figure 41, Guillaume 1960:274 ff). Lands fed by the Fala de Molodo were to be used mostly for cotton production, while those on the marigot de Boky Were, where soil was heavier and



1 Sahel canal
2 Macina canal
3 Marigot de Boky Were

(Guillaume 1960:274)

.... limit of irrigation system

irrigated area

Figure 41. Irrigated areas of the Office du Niger

had higher clay content, were to be devoted to rice.

Much of the construction work for the project was carried out by forced labor from Mossi country (Suret-Canale 1971:249). Work conditions were poor, and discipline was harsh. When forced labor was abolished in 1945, many seized the chance to leave (de Wilde 1967:252).

The project, as established in 1932, had three aims: to relieve the dependence of the French textile industry on imported cotton, to provide a dependable grain supply to relieve local famines, and to relieve over-population in the Mossi country of Upper Volta. In its lifetime, however, the project has served another purpose -- it has been a testing ground for a number of innovations aimed at intensifying land use: cotton production as a cash crop, various sorts of crop rotations, capital-intensive mechanization, and rice cultivation with transplanting, in addition to irrigation itself. The Office du Niger has cultivated lands itself (with the help of wage laborers), as well as cultivating lands through settlers recruited from outside the delta. Originally, most settlers were Mossi, but after 1950, new colonists were predominantly Bambara and Minianka (de Wilde 1967:252).

Many of the initial problems of the system were due to the fact that design of the irrigation infrastructure was, in some ways, based on insufficient knowledge (ibid. 262 ff). For example, an attempt to grow Egyptian long-staple cotton failed because rainfall had been badly under-estimated (Guillaume 1960:282). Another problem was that the system, as planned, could not compensate for lack of rains at the beginning of the growing season. Original plans did not include information on micro-relief, and fields were not properly leveled. Farmers were unable to clear and to level land with hand tools and ox-plows, and, by 1948, 9,000 ha out of 25,000 ha cultivated land had been abandoned.

Starting in 1948, tractors acquired under the Marshall Plan were used for clearing, leveling, and plowing the fields of colonists. In addition, the Centre rizicole mecanise (CRM) was established at Molodo, for direct, mechanized farming, using wage labor. On fields worked by settlers, the use of tractors proved extremely expensive and, in some cases, harmful (e.g. deep plowing, mentioned above, aimed at extirpating Oryza perennis, actually exacerbated O. brevigulata; Guillaume 1960:290). Overall, yields for rice (1,805 kg/ha) and for cotton (868 kg/ha) were only slightly higher in the Office du Niger for the period after mechanization (1949-55) than they had been before (1941-48 1,671 kg/ha rice, 668 kg/ha cotton;

Guillaume 1960:305). Although costs for mechanized cultivation rose substantially between 1950 and 1958, prices for cotton rose only slightly, while those for paddy actually fell (ibid:304). Starting in 1958, management tried to persuade settlers to return to the ox-drawn plow. Mechanization in direct farming fared no better -- costs at Moldo were extremely high, and, without hand weeding, the fields became badly infested with weeds (ibid:308). Yields were low for the Molodo project, and the operation required subsidies until its abolition in 1960 (de Wilde 1967:283).

Attempt to intensify land use in the Office du Niger through crop rotation all met with failure. Originally, cotton lands were to be planted in a cotton-sorghum-peanuts rotation, but soils were not well enough drained for sorghum, and peanut yields were poor. The use of a green manure (e.g. Crotalaria retusa) during fallow periods of rice cultivation was similarly discontinued within a short time (Guillaume 1960:295). It was thought (ibid:297) that a rice-cotton rotation, in which rice straw was plowed under, would improve soil structure and would help control weeds. However, the two crops demanded different types of soil preparation, and had differing water requirements. Under that rotation, rice yields declined slightly over several years (1954 - 58), while cotton yields declined 26 - 55% (ibid:298).

By 1960 it was possible to evaluate the project and its effects. Studies by M.I.S.E.S. had shown that, although the income of colonists was higher than for residents of the traditional zone, settlers were under a crushing burden of debt. Although nutritional intake was much the same as in the traditional zone as a whole, animal protein comprised a smaller part of the diet, and diet was less varied than for the traditional zone. The costs of land development alone had been immense: 185,200 fr/ha for cotton-rice land, and 183,000 fr/ha for rice land (Guillaume 1960:288). The total investment had been approximately 44 billion CFA (in 1960 value; de Wilde 1967: 247), or $175 million, and administrative costs were enormous.

Evaluating the Office du Niger in terms of its original aims, Guillaume (1960:394) found that, after 25 years, cotton production was still extremely low, and that the CDFT (Compagnie francaise pour le developement des fibres textiles), after only seven years, was having far better success in encouraging non-irrigated cotton production in the higher rainfall zones of southern Mali. In terms of rice, the Office du Niger was too distant from the coast to compete effectively on world markets. In terms of production for local use, polders gave a far higher return to investment than did the Office, assuming normal flood conditions. Of the estimated total irrigable surface of 960,000 ha, only 48,430 ha had been brought under cultivation (ibid:275-79).

After independence, the first five year (1961 - 62 to 1965 - 66) plan for national development, as it affected the central delta, aimed at a continuation of agricultural policies under the French: encouragement of the use of ox-drawn plows, expansion of rice areas under polder (by 52,000 to 67,000 ha), and expansion of irrigated land at the Office du Niger (by 60%; Jones 1976:272 ff). In addition, cotton production on the Office lands was to be intensified, and yields raised to 2 T/ha, by use of "super-leveling," insecticides, and fertilizer. Rice yields were to be raised to 2.5 T/ha, by the use of transplanting. Mechanized farming was to be encouraged on Office du Niger lands.

Of these programs, adoption of the plow had the greatest success, for the nation as a whole. Demand was strong for plows, carts, and chemical fertilizer, and, indeed, import levels were too low to meet it (Jones (1976:303).

In spite of distribution problems, number of plows in use increased by 148% between 1960 - 61 and 1966 - 67.

By the end of the plan, targets for area to be developed in polder has been exceeded, but only a small part (estimated 29 - 42%) of the land within polders was actually under cultivation. Poor planning seems to have been partly responsible; for example, one polder was so high that, in average years, it received no flood waters at all. The land seems not to have been well leveled, and farmers using the new polders received little or no technical advice. At the end of the plan, average rice yields from polders were only very slightly higher than those for areas with no water control.

Within the Office du Niger, intensifying rice production through transplantation was supposed to reduce weed populations, and to allow a longer vegetative period (rice plants could be started earlier, since nurseries required less water than did fields; de Wilde 1967:267). However, the time requirements of transplanting (105 - 125 man-days/ha total, compared with 45 - 60 man-days/ha total for direct-sown rice) were formidable. Moreover, transplanting coincided with the peak in labor needs of cotton. Few settlers adopted the practice, and area under transplantation declined after 1962, being negligible by 1964.

Intensification of cotton production faced some of the same problems, and was really only successful in one settlement (Niono, de Wilde 1967:296), which had always been unusually prosperous and well managed. Total area cropped in cotton on the Office du Niger actually declined by 36% during the FYP (Jones 1976:275).

Looking at Figure 40, where the 1966 target for the FYP is compared with actual production of paddy rice, it is obvious that reality fell far short of goals. Most of the shortfall was in polder cultivation (where production was 17% of goal), and in the Office du Niger (which achieved 47% of production goals), while traditional rice production exceeded plan targets (Jones 1976:308).

In the years after the first FYP, Mali began to establish "Operations," or regional agricultural development projects (Steedman et al 1976:33). For the interior delta, the important Operations are Riz Mopti (which receives funds from the World Bank), and Riz Segou (funded in part from the European Development Fund), as well as the Office du Niger. Polders of the two Operations were expanded from 23,000 ha in 1972 to 40,000 ha in 1975 (ibid:10).

During the drought years of 1972-73 and 1973-74, production in these polders was low. Only 20% of the area in the Riz Segou polder was harvested during those years. The Office du Niger, in contrast, was able to cultivate the same area as in 1970 - 71, and its contribution to total domestic rice production increased to 65% (1972 - 73, compared with 26.5% 1968 - 69; Steedman et al 1976:223).

In the years since the drought, Mali aimed at self-sufficiency in cereals by 1979; in rice, production goals are shown in Figure 40. National planners (ibid:41-43) have favored increases in per capita rice production because: (1) rice (because it is grown in relatively few locations, and because it requires milling) is more easily government controlled than other cereals, (2) total irrigation permits cultivation even during drought, and (3) rice production is more intensifiable than millet or sorghum.

The use of animal traction in the projects Riz Segou, Riz Mopti, and the Office du Niger had increased, overall, between 1968 and 1972 (ibid:97). Steedman and others (1976:95) found evidence that the rate of adoption of animal traction had accelerated, in the years since the drought, in spite of increases in prices for equipment and for oxen.

By 1970, the use of chemical fertilizer in rice cultivation had been introduced in the Office du Niger, and in the polder projects. In the years since then, fertilizer use in the Office du Niger increased (ibid: 106 - 7). In the polders, however, the low proportion of land harvested during the drought made farmers reluctant to apply fertilizer. In addition, fertilizer exacerbated the problem of weeds, and extensionists recommended its use only to farmers who were seeding in rows (and able to use horse-drawn traction for weeding).

By 1975 - 76, rice production exceeded the goals set for 1979. Steedman and others (1976:122) attributed the surplus to: farmers' hedging against another drought year in 1974 plantings; price increases in 1974; and to deliveries of drought-relief grain after 1974. They summarized:

> "Even with a return to more normal circumstances, we conclude that Mali is basically in a position of self-sufficiency today....Cereals, it would appear, are being produced and stored in quantities that are still unmeasurable and in response to dictates that are still imperfectly understood; but the capacity to produce seems to be in place."

Detailed, ethnographic descriptions of single communities are not available; the focus for the studies we have discussed here was regional rather than local. Farm management data are also lacking. Available information on the interior delta was, for the most part, gathered in order to explain the success or failure of a number of technological innovations. It is easier, therefore, to discuss intensification in terms of technological change, rather than in terms of demographic or economic factors.

It is difficult to assert that the reason for failures in planned intensification programs were due to ancient, deep-seated disinclination on the part of the residents of the delta. Historically, there had been a period (1450 - 1650) when the delta had prospered, and when production had included crops (barley, cotton) which have not been successfully re-introduced since.

Rice appears to be a "culturally preferred" food. Dietary studies (M.I.S.E.S. 1961b:13) showed that rice dominated the intake of all ethnic groups within the inundated zone of the delta. Figure 30 summarized local consumer preferences in types of indigenous rice. On a wider scale, income elasticity of demand for rice (0.5) is estimated to be greater than for millet and sorghum (0.2, cited in Steedman et al 1976:42), so that it is likely that increases in levels of income will lead to substitution of rice for other cereals. Bourke noted (1965:48) that, in many other parts of Africa:

> "The attraction of the rice crop is such that it has led to the abandonment of ancient tribal customs whereby rice cultivation was restricted to women."

In general, however, rice farming in the interior delta has traditionally been extensive. The locations of fields is shifted in accordance with rainfall and flood levels and labor inputs to rice cultivation are relatively low. There is, however, evidence that there is internal variation in the intensity of traditional cultivation. People seem prone to start garden plots on the canal banks of an unfinished polder project. In addition, there is evidence that cultivation techniques for small, individually-owned garden plots are more intensive than for larger, communal holdings. Unfortunately, the literature on agriculture in the interior delta gives little attention to garden cropping. We know almost nothing about yields, and about prices paid to producers in the marketplace, and we have no detailed information on techniques used in gardening.

The last question for this section is whether some ethnic groups "naturally" farm more intensively than do others, as, e.g. Viguier (1939) suggested. As we noted, however, the inter-ethnic differences he suggested could plausibly be explained by differences in population density between regions.

This case study started by discussing the risks involved in rice farming in the traditional zone of the delta.

Techniques for lessening the risk of total crop failure included cultivating fields at several elevations, changing field locations to compensate for changes in flood levels, and planting a mixture of rice varieties in many fields.

This diversity of techniques and spreading of risk runs counter to the needs of capital-intensive, mechanized farming. While wild rice (*Oryza perennis*) can be tolerated, to some extent, on traditional rice fields (and, indeed, can be harvested in times of crop failure), wild rice infestation on mechanized fields reduces yields substantially, and no successful means have been found of ridding fields of this weed. *Oryza sativa* is the crop of choice for mechanized agriculture, but it is less hardy than *O. glaberrima*, and less tolerant of variations in flood levels. Thus, outside the Office du Niger, *Oryza sativa* has won only limited acceptance. Most important, though, large-scale projects seem to lack flexibility in decision making. Climatic and hydrologic variation from year to year require that farmers schedule tasks carefully, taking into account variations in micro-relief. In the Office du Niger and in many of the early polder projects, micro-relief variations were not taken into account, yields suffered, and land leveling proved to be expensive.

Three of the main technological innovations tried in the interior delta were: total water control schemes, partial water control schemes, and use of the ox-drawn plow. Although total water control proved by far the most expensive of these innovations (in human terms as well as financially), it was also the only method that produced during the worst of the drought years.

The idea of partial water control (Viguier 1939) was a good one; it was based on detailed study of traditional rice techniques and their problems. In execution, however, there were difficulties: incomplete knowledge of the hydrology of the delta, poor construction, and lack of technical assistance to farmers relocated on the polders. Some of these problems seem to have been overcome since the FYP, and Steedman and others (1976:193, 232) recommend a "package" of partial water control combined with use of animal traction for plowing and cultivation, and use of planters for seeding in lines. Overall, they felt that partial water control schemes were a less costly alternative to total irrigation. The main disadvantage to polders is their inability to compensate for drought conditions.

The ox-drawn plow had first been introduced to Mali (Jones 1976:271) as a means of enabling farmers dependent on rainfall to cultivate a single plot permanently, with the use of crop rotation and application of manure. As a means of intensifying land use in rainfall-dependent agriculture, animal traction was not popular.

When introducing the plow to the inundated zone, planners hoped to increase cultivated area per worker, as well as to intensify cultivation by increasing use of animal manure. Their expectations do not seem to have been realized: cultivated area/worker was only slightly greater for plow-owning families than for those lacking plows, and yields were only increased slightly. However, as a means to decrease the human labor necessary for land preparation, the plow had sustained success. Often, plow users were families lacking workers: it would be interesting to investigate a link between regional emigration rates, and rate of adoption of animal traction. At any rate, the standard of living for plow-owning families was high: their income levels approached those of settlers in the Office du Niger (without the burden of indebtedness), and their nutritional status was comparable to that of the colonists.

In order to see whether intensification in the interior delta can be understood in terms of population push, it would be necessary to gather data on the intra-regional covariation of population density, age-sex structure and farming techniques, cultivated area/capita, and duration of cultivation and fallow period. Some of these data might be obtained by re-working the M.I.S.E.S. studies (1961, 1961a, 1961b), but the published analysis does not permit such efforts at correlation.

As a whole, the delta is less densely settled than regions where classic intensive cultivation is carried out (Serer, Kusasi, Kano province, etc.). Indeed, shortage of labor is often given as an explanation for the failure of intensification. The sorts of innovations which have been adopted (particularly animal traction, chemical fertilizer in the Office du Niger) are probably best viewed as an attempt to use low-level capital intensification to compensate for lack of labor. If there is a demographic factor influencing this sort of intensification, it is probably the exodus of the rural work force from the countryside, rather than increase in total population size.

There is evidence that farmers' production responded to changes in producer prices, and that policies of low prices for agricultural products acted to reduce the amount marketed through official channels, to reduce the cultivated area, and to increase the rates of exodus from the work force. It is also possible to argue that choice by farmers of cultivation techniques can be analyzed in economic terms.

A good example of this is in the response to pressure to adopt transplanted rice techniques. Figure 6 shows typical average and marginal products (in kg. of wheat equivalent/man-hour) for different levels of labor input. It will be noted that average product for direct sowing of rice in the Office du Niger (taking into account deductions for irrigation costs, etc.) fall at relatively low levels of labor input where (in Gambia, for example), marginal product has begun to drop sharply. Where the marginal return for labor in agricultural production drops below the return for labor used another way (e.g. wage work), it is to be expected that farmers will refuse to intensify. Another reason behind the failure to transplant, which was not taken into account by planners, is the increased risk of schistosomiasis infection for the workers.

If developers are to learn from the difficulties of planners under the colonial regime, and immediately following independence, they must realize that successful intensification can only be brought about through the use of market incentives, and through the use of innovations which find acceptance without political sanctions. Such planning must start from the assumption that indigenous farmers know the extent of environmental fluctuations and are better prepared to make production decisions than are administrators with jurisdiction over a wide area.

Recent organization of agricultural development in Mali has been followed by impressive improvements: widespread use of animal traction, better constructed partial-water control systems, and large, recent increases in production. It must be through means which find spontaneous acceptance, and through the use of market incentives that these successes be consolidated.

Prospects for Intensification

In this section we discuss limits to, possibilities for, and repercussions of intensification to increase production in the West African savannahs. We consider the three related approaches of intensifying land-use, increasing technological efficiency, and stimulating a higher labor input/unit land emphasizing data that can be used to judge the prospects for intensification in a given area. We also suggest possible approaches for projects aimed at intensification and the problem of measuring responses.

It is not possible for us to provide a checklist for judging whether a particular area or a local population will spontaneously adopt intensive methods or respond to outside initiatives for a more permanent and productive agriculture. But it does appear to be the case that certain factors are regularly connected with the process of intensification. Given a local environment where soil, water, and health conditions allow for more intensive land use, the process will move fastest where population pressure is growing and where the economic rewards of farming are most obvious. We advocate an ecological viewpoint that includes those geographical, technological, demographic, economic, and political variables that directly affect the decision making of the smallholder and that can only be gathered in most cases from observations in the field.

The most common soils of the savannah area (ferruginous) are quite vulnerable to degradation under intensive cultivation because of their thinness, the presence of indurated layers, and the lack of organic content. The high temperatures and amount of sunshine and the extremes of wet and dry prevent the build up of soil organic matter from the light vegetative cover. These soils are, however, responsive to manuring and can be productive under good management. When enough land is available for grazing and fodder, so that sufficient manure is produced, indigenous intensive systems can maintain adequate production without serious land deterioration. This appears to be the case in Nigerian Hausaland today, and was probably so in Kusaok 75 years ago. Soils vary spatially, however, and there are some areas with very high potential for agricultural intensification, e.g. the eutrophic brown soils and the alluvial soils of river valleys whose utility is sometimes limited by the presence of onchocerciasis vectors, and, in the south, trypanosomiasis vectors.

The extreme variability of rainfall both spatially and temporally, which also affects surface water availability, e.g. in the Niger delta irrigation scheme, sets a limit on agriculture intensification and is dealt with by range of risk minimizing activities.

Farmers seek to minimize risk so that sporadic distribution of rainfall, variation in amount of rain from year to year, high winds, locusts and other pests do not completely wipe them out. They adopt a mix of strategies for spreading their risk such as dispersed fields, mixed cropping and changing varieties from year to year. They also modify the environment locally by manuring, crop rotation, and water control, for example. They must balance area planted against labor supply (mainly for weeding), and expected production against the amount of food needed to feed their families.

In the savannahs the indigenous and spontaneously adopted innovations provide a base of technical skills for dealing with the fluctuating environment, and must be considered in any program of intensification. This has often been overlooked. For many years it was assumed that mono-cropping was better than mixed cropping, and only recently has the error in preconceptions of developers been exposed. The careful use of manure and household wastes in northeast Ghana and northern Nigeria illustrates the perception on the part of the farmers of the necessity for maintaining soil structure and nutrient content under continuous cultivation.

Throughout our discussion of agricultural intensification, we have emphasized the regular and generally predictable process by which population pressure on resources and the economic benefits of market participation move farmers in the direction of more permanent land use and increasing labor inputs. Intensification took place in the past and proceeds today using indigenous crops, simple tools, and well-known local methods. In practically every farming society of the semiarid savannah, there are evidences in certain field systems, garden plots, or money crops of intensive techniques. On the principle that it is always easier to develop what exists rather than substituting another practice or demanding radical change, the most effective way of promoting intensification may be to encourage what smallholders are already doing. A woman's vegetable garden on a refuse heap may perhaps be improved with better seeds and protected by minimal fencing. The few plants of tobacco a man carefully tends for his own use may well be multiplied if he gets a good price for them in the market. There is often a considerable range of cultivation activities within a single area, and many observers have commented on the experimentation done quite spontaneously by local farmers. Perhaps extension might disseminate the best of such home-grown methods for inter-planting, composting, water control, or scheduling. Farmers often have an excellent idea of what they need for more effective intensification and, given an opportunity, they will request treated seeds, shallow wells, or feeder roads for the evacuation of produce (Benneh 1975). An initial strategy of intensification might well leave the choice of crops and their proportions to local smallholders and promote methods that had already been proven under local conditions.

Those best qualified to successfully demonstrate intensive cultivation are obviously the people with previous experience. As we would expect, they are likely to come from areas of higher than average density such as mountainous regions, peri-urban concentrations, rich river valleys, areas of exceptionally fertile soils, or centers of states and kingdoms. Such farmers often have the skills for intensive agriculture as well as the incentive of improving their standard of living. The opening of less densely settled land which is at the same time accessible to high population areas allows the zone of permanent land use to expand. This may produce more rapid and sustained effects than attempts to encourage intensive methods in areas of sparse population where shifting cultivation still provides an adequate livelihood. The seasonal movement of farmers from around Kano to the Soba area first brought some of the fadama land into use for sugar cane and introduced concepts of land rental, and the whole complex then passed smoothly into the local system. Permanent settlers from the Jos Plateau in Soba are the biggest users of chemical fertilizer (Schultz 1976). Even in such planned operations as the Office du Niger, some Minianka settlers have begun to grow vegetables on the dykes, using intensive techniques familiar to them from the past.

If people practicing their own brand of intensive agriculture have a repertoire that can be expanded and techniques that can be spread both within and among communities, it is also possible that they are the most willing recipients for productive innovations from elsewhere. Just as the Kusasi planted and recognized the potential in American dwarf sorghum distributed to them as food, so the Kofyar borrowed a new variety of maize from their Fulani neighbors and acquired tomato seeds from Europeans, growing the new vegetable by novel irrigation methods. Intensive cultivators are alert to the differences in yield or hardihood that new crops display, and recognize the value of increasing labor inputs, both in terms of quantity and quality. More efficient use of scarce land resources has been crucial to their subsistence, and they respond to innovations that can demonstrably achieve such results. Rural development can thus build on techniques already present and mobilize the experience and motivation of farmers with a tradition of intensive cultivation. In our view, a major component of agricultural change is the presence of the right human resource -- individual farmers whose environment has led them to use intensive methods in some phase of their agricultural operation, and who have developed habits of work, investment, and calculation appropriate to these activities.

Many indigenous adaptations have either (1) been altered by the impact of colonialism and nationalism or (2) been rendered less suitable by a changing environment. Therefore it is not feasible to simply attempt to extend or intensify local practices without first examining their actual efficacy. It is, however, possible to select and encourage those local practices that are demonstrably most productive and show economic promise.

The population of the savannahs is not contributing its potential of labor to agricultural production because of malnutrition and disease. This is especially important during the labor bottleneck that occurs in the rainy season, when long hours must be spent in weeding, when food availability is at its lowest and malaria, dracunculiasis, and other infectious diseases have their highest rate of incidence.

High dependency ratios are caused by high mortality, high fertility,and a high incidence of adult morbidity (e.g. leprosy and blindness). In many areas, too, there is a high rate of emigration of the most economically active sector (males 15 - 45), further increasing the effective dependency ratios.

Besides weeding, the main input into intensive rain-fed agriculture is manuring, which implies animal husbandry.

Lack of capital and credit prevent restocking of animals after a drought period when they wither, die off, or are sold to purchase grain. This limits the labor that could potentially be used in non-weeding times in kraaling animals, caring for them, bringing in fodder, and scraping out and distributing the manure.

High population densities are often considered to be a positive factor in promoting agricultural intensification and consequently increased food availability (Boserup 1965).

There are others who also see possible positive aspects to population growth in the savannahs, pointing to the rapid rise in population that paralleled the industrialization in Europe and North America. Some (Engmann 1975 e.g.) see the problem as mainly one of distribution, pointing to the extensive areas of relatively sparsely populated savannah. These people often encourage resettlement, without considering the failures and tremendous expenses that have characterized past experiments with resettlement in West Africa.

The history and environment of West Africa today is vastly different from that of the industrialized countries during their own period of rapid population growth (Caldwell 1975a), however, and there is no doubt that colonialization and neo-colonial economics undermine the ability of farmers in densely populated areas to remain self-sufficient. As Amin (1976) points out, African economies were developed as satellites to industrial economies during the colonial period, which mean that increased production was drained off to promote economic growth in Europe, and was not available for indigenous intensification and economic growth. The pattern has been somewhat modified today in that many of the rural resources go to supporting the burgeoning urban populations and prestige projects.

The point to be made here is that intensification and increased food availability/person do not necessarily go together. Pullan (1969) even considers intensification as indicating a breakdown of the extensive systems which are capable of maintaining soil fertility. In the Kusasi area we have seen that very high population densities are associated with and have undoubtedly encouraged an intensive system that is not now capable of supporting the population nor of maintaining soil fertility and production levels. Caldwell (1975a) notes that for West Africa in general there is not an association between population density and economic development.

Obviously crude population density is not an adequate indication of the propensity for intensification. Densities must be modified by considering the quality of the resource base (soils, water, cultigens, livestock), the technology applied, and the quality of the labor available. Labor quality will be affected by the health and nutritional status of the population and its age and sex structure. To make these determinations in an absolute fashion is extremely difficult and time consuming. Perhaps an indirect way to judge the potential of an area for intensification is to examine the age and sex structure of the population as an indication of the proportion of economically active (15 - 45) members who are leaving the area but this is open to criticism. When coupled with a survey of the areas concerned, conclusions reached can be much more reliable.

In northeastern Ghana, for example, population densities are high, populations undernourished, and land deteriorating. Sex ratios which are very low in the 15 - 45 age group clearly indicate that this area has passed the point where current techniques of intensification are capable of keeping pace with increasing population. Large numbers of migrant males are a sure sign that outside labor is more profitable than farming, and that local labor intensification may well not be a viable option.

This instance is perhaps an extreme, but again the method would be most useful when used in comparing areas with similarities. Most societies in the savannahs have age-sex classifications which can be used in rapid surveys to build up population pyramids and sex ratios. This was done during preliminary work in Tenga (Kusaok) and produced results very similar to that obtained later by using much more accurate methods of determining age.

In overpopulated areas like Kusaok, increased labor not only adds increasingly small increments to production, but absolute production is falling, so that food availability per person also diminishes. In such situations either massive subsidy of the population with food, inputs, medical care, and credit is required, until the degradation of land can be halted and reversed and the physical condition of the population restored, or resettlement has to be undertaken. Both types of solutions have been and are proposed for northern Ghana and the results and future prospects analyzed.

In areas where the system can still absorb and adequately nourish increasing numbers of people and livestock the problem of increasing labor input per unit of land becomes one of improving the quality of the labor and the amount devoted to agriculture. Quality is improved primarily by decreasing disease through public health programs, which must, of course, be integrated with the agricultural development. A long term goal may be to decrease the dependency ratio so that a larger proportion of the work force is putting in highest quality labor. This means decreasing birth rates at the same time that disease prevention will be decreasing death rates. Increased survival means that a great deal less time will be lost to pregnancy, lactation, and child care for children who never grow old enough to contribute to food production on the family farm.

Making more labor available to agricultural production is approached in two ways: spreading out the labor requirements of the year (see section below on economics), and decreasing time spent in subsidiary tasks (grinding mills to replace stones, e.g.) or increasing efficiency of time spent in agricultural tasks (plow replaces hoe).

Increasing opportunities for cash income through wage earning opportunities or crop markets will increase the ability to purchase some of these technological items that can increase the quality and quantity of labor available for intensification.

Attempts to increase production based on periods of unusually favorable environmental conditions can lead to increased population and areas cultivated so that when poorer conditions return there is real disaster. Such appears to have been the case during the current dourght in the savannah. It is necessary for planners to consider as much information as is available on long term trends in precipitation, ground water and surface water availability when planning for intensification, since such plans must always be linked directly with water supply.

If water supply is to be made more reliable by the building of dams and reservoirs or the use of irrigation ditches and flooding of fields, then the likely possibility of increase in water-borne diseases should be understood, and provisions made in development plans to prevent it.

Large scale schemes at controlling the environment are inevitably dependent on the efficiency of an administrating and technical organization. Problems in the Office du Niger project, and the failure of the large scale mechanized farming program in Nkrumah's Ghana show how easy it is to overextend administrative and technical capabilities to end with negative results. The possibility of small scale, long term programs of soil and water conservation should be considered, perhaps based on techniques already in use locally. In the Kusasi area, for instance, this could include the planting and nurturing of trees by farmers on their own fields, contour terracing, use of grassed run-off areas, and well irrigation.

Increased land use, whether by decreasing fallow, increasing labor input per unit of land or increasing mechanization increases the vulnerability of soil and vegetation to degradation. Whenever intensification is considered, it must be remembered that since more is being taken out of the soil, and it is being left for increased amounts of time without vegetative cover, provisions for protection and replenishment must be made. Failure to do this in the valley rice production in northern Ghana has led to widespread deterioration of land resources.

Intensification programs often emphasize the increased production of cash crops, and this can have adverse effects on nutritional status, as these crops begin to compete for food crops with the available land, labor, and capital input. Cheap, high calorie, low nutritive value crops and products (e. g. cassava) tend to be substituted in the diet for more nutritious indigenous crops like sorghum and millet. Nutritional status can suffer and decrease the effectiveness of labor input (Haswell 1975). There is some indication of this in the Office du Niger development project in Mali (M.I.S.E.S. 1961a).

Any program aimed at increasing intensity of agriculture and thereby hopefully production per person, also has the potential of increasing local population by attracting immigrants, decreasing death rates (as nutritional status improves and money available for medical care increases), and perhaps of increasing fertility rates as well. With annual growth rates of about 2.5 per cent (implying population doubling rates of around 30 years) increases in production may soon be swallowed up by increasing demand for local consumption. It is imperative, therefore, that any program of intensifying agriculture include a component to monitor population growth and its components, and to incorporate an intensive family planning program in conjunction with the medical and public health programs. The same problem is faced by resettlement schemes, since the reduction in population densities may act as a spur for increased population growth. Since numbers removed will be so quickly replaced by natural increase, resettlement alone will never be the answer.

Rather than specifying what kinds of indigenous systems must be present or which types of technology should be introduced to move agriculture in the direction of intensification, we want to discuss the tendency of these methods to either expand or contract the range of options available to the individual farmer. Our contention is that every smallholder in some sense negotiates a compromise among his resources of land, labor, and capital and the needs of his household over time. No expert can say unequivocably that a new method will work to the advantage of a particular farmer, but if it increases income without seriously undermining traditional production or increasing risk, there is little doubt that farmers will try it out. Technology that is additive rather than substitutive, such as improved seeds for familiar crops or chemical fertilizer for mixing with compound sweepings, can be integrated easily and gradually into a cropping system. Where the benefits are obvious, as they may well be where the fertility of an infield is declining, farmers may decide to adopt them. Whether such inputs are used for cash or food crops and what levels of application are needed on different soils are problems perhaps best left to the cultivator. The kind of effort required for intensive agriculture is largely voluntary, and methods that restrict the choices available to the farmer or force him to neglect food in favor of market crops may be seen as unwelcome or even dangerous constraints. The value of an expanding infrastructure is that it gives the farmer the chance to produce for the market without coercing him to do so or deciding how much of his time should go into such activities. Price incentives may elicit both increased supplies of some commodity and, indirectly, the intensive techniques by which it is most effectively produced (e.g. the local market demand for sugar cane leading Hausa farmers to put more time into fadama). Such development may be slower than that of planned projects, but it grows on a more solid base and brings the kind of change to rural populations that benefits them directly.

Though we have refused to identify intensification with a reliance on modern, high-energy machinery, we think the possibilities for intermediate technology in furthering this process are quite good. Again, African cultivators can show us the way. There has been a striking growth in the use of plows and animal traction in many savannah areas from Senegal to Nigeria. So-called mixed farming with increased yields due to the plow's thorough turning of the soil and the provision of additional manure has also given the farmer a source of cash in his mature draft animals and the ability to transport loads over longer distances. If some of the plots are too small, irregular or hilly (as in the area around Kano and in northeast Ghana), or long fallowed, the advantages of animal plowing may be less. The initial investment in buying and training oxen may also be too high for most farmers. But experience in northern Benin has shown that when people supply their own animals and are given access to standardized, locally repairable equipment, the technology diffuses rapidly (Eicher et al. 1976). To avoid the indebtedness and frequent defaults hampering many such schemes, one year trials were allowed, after which a farmer could either drop his participation with no further costs or commit himself to purchasing the equipment over the next five years. Other farmers can hire the service of a plow and team, and the plow owners benefit both by better tilling of their own fields and a cash income to repay their capital costs. Where cultivation is limited by seasonal needs for rain or irrigation, the plow may substitute for limited labor, and this advantage has been recognized by many of the rice farmers of the Niger inland delta and many rain-fed farmers in Kusaok.

The contrast between introduced technology widening and restricting farmers' economic options is clearly visible in projects on the Senegal River in Senegal. Though all have the aim of promoting irrigated rice production with a second dry season crop, the capital intensive developments with diesel powered pumps, miles of canals, and heavy reliance on tractors often demand resettlement of workers, rigid scheduling of labor, and sales of produce to government agencies to which the farmers may also be indebted. In the area of Matam, however, Toukoulor farmers are offered the services of simple mechanical pumps mounted on rafts if they will clear, level, and ditch irrigable land. Gas for the pump engine and a fund for replacing it are also responsibilities of the farmers and must be paid for in cash. Wet rice has been merely added to a local agricultural inventory already including flood recession gardens, upland millet fields, livestock, and fishing. Farmers choose to become members of an irrigation group and then decide among themselves how the necessary labor and capital will be invested. The produce is consumed or sold through local market channels. Decisions as to whether the rice crop should be followed by corn, wheat, or tomatoes are made by the farmers themselves. Both the investment in equipment and in expatriate staff for the project is kept low, and its substantial growth in recent years can be traced directly to individual profitability. For local cultivators, irrigated rice represents diversification rather than specialization, and it provides another means for limiting the ever-present risk of drought. Agricultural intensification on a small scale is an obvious strategy which need not interfere with tested subsistence techniques that continue to be practiced. It is true that such a project may require per capita increases in labor and the addition of arduous tasks such as transplanting, but as we have indicated, the most feasible route to intensification involves higher labor inputs. African farmers do not seem reluctant to make such contributions as long as they have some control over the conditions of their work and as long as the rewards are commensurate with their increased efforts.

A failure to change agriculture is often credited by both developer and farmer to cultural impediments, but, in fact, groups from many different backgrounds have engaged in it. In the same circumstances, pagans and Moslems, town dwellers and countrymen, native and migrant groups, and almost any ethnic type (including settled Fulani herders) have taken up some form of intensive agriculture. Though nuclear family household organization and more individualized land tenure may show a statistical relationship to highly intensive system, there is nothing to indicate that they are <u>prior requirements</u> for a change of this kind to take place. Indeed it seems to us that alterations in family form, marriage patterns, lineage or class institutions, and land tenure emerge gradually as a response to the labor requirements and economic strategies that accompany intensification. Customs that deny continuing rights in property to someone who has improved that property or that prevent the farmer from enjoying the fruits of increased production would certainly delay intensification, but these are less likely to arise from local cultural values than from the manipulations of regional or national governments. The rights of migrants to cultivate intensively on fallow land belonging to an indigenous group may certainly become a matter of dispute, but if environmental and economic conditions are favorable, it is unlikely that the process will be long delayed.

In attempting to estimate which sections of a community will accept innovative technology and increase their production, "common sense" may not be a particularly good guide. Though one would expect older farmers to be more tradition-bound whereas younger men would more quickly appreciate improved methods, studies among Hausa showed that age was not significantly correlated with acceptance of change (Tiffen 1973). Social class may influence movement into the market economy but not in any simple way.

Cancian (1972) discussed the relationship between social position within the community, and willingness to adopt government innovations (improved roads, and establishment of government receiving centers for agricultural crops), in a small, Maya village in lowland Mexico. He felt that two factors related to social position would govern willingness to innovate: first, those with relatively greater status (and relatively greater wealth) will be more able to marshal the productive inputs necessary for innovation, but also, that a sort of "middle-class conservatism" makes people of middle social status more risk-aversive than either high-status or low-status persons. His results showed that initially those of middle rank were, indeed, reluctant to adopt innovations, but that with time, they became more willing to participate. DeWalt's (1975) field studies in a community near Mexico City confirmed, for the most part, those of Cancian, but he stressed the necessity to consider investment and opportunity costs for each innovation separately.

In the beginning of this paper, we gave three definitions for intensification, and this section will deal with the third of them, where intensification is viewed as "increasing yields by raising inputs of energy (principally labor) on a fixed area of land." From this perspective, intensification means a change in the farmer's allocation of productive resources. The case studies have discussed some of the factors which enter into farmers' decision-making in specific situations. The case studies also stressed the need for planners to understand the farmers' production constraints when proposing changes in agricultural techniques and cited examples (e.g. rice transplantation in the Office du Niger) where these constraints had not been fully taken into account. It remains, however, to suggest how the planner might best get information on the allocation of resources in farming, in a field situation where time and resources are limited, to discuss the state of our knowledge about how subsistence farmers make production decisions, and how they will respond to suggestions for innovations. The case studies described instances where factors like changes in prices paid to producers, risk from change in flooding levels or rainfall, and transport difficulties have affected allocation of resources in production. This section will generalize on the effects of these, bringing in literature from other parts of West Africa, and from outside regions, and will discuss the implications for policy-making.

Cleave (1974), Upton (1973), Clark and Haswell (1970), and Collinson (1972) summarize much of the recent work on agricultural production in smallholder farms in West Africa, and all treat allocation of labor in detail. In general, the relatively short period where rainfall is available means that agricultural work must be compressed into relatively few months (Cleave 1974:120 gives data on month-by-month inputs from 22 studies). Moreover, the productivity of labor will vary during the agricultural season (Upton 1973). The peak period of labor input tends to be at weeding, in the middle of the wet season (_ibid_:123). We have seen that weeding has seldom been successfully mechanized, and, indeed, that the use of ox-drawn plows for land clearing often increases the need for weeding later in the season. Where, as is common, several crops having different labor requirements, are grown, scheduling becomes complex, and opportunity costs (i.e., the product foregone by a particular allocation of labor) of decisions must also be reckoned (Upton 1973:144).

Traditional responses to labor constraints can run counter to "technically optimum" scheduling of tasks. For example, staggered planting spreads work requirements, but reduces overall yields (_ibid_:134). Crop substitution (e.g. cassava or plantain crops for grain crops) also reduces seasonal demands for labor. Manure application may make cultivation easier but necessitate an extra weeding with its demands for scarce labor. Suggestions for easing peak demand for labor have included: planting in rows (permitting ox-drawn cultivation) and the use of herbicides. Indeed, Norman (cited in Cleaves 1974:140) felt that the return to weeding in Zaria, Nigeria, was high enough that use of herbicides was economic even on small, traditional plots. In sum, suggestions for increased labor intensity in farming must try to avoid periods of peak labor demand and, where possible, should seek to equalize labor requirements over a long period. Efforts at technical innovation will also be most effective where they relieve a real stress in the system.

Data on labor needs are an obvious necessity for effective agricultural planning, but gathering such data can be costly in terms of time and of expense, if traditional ethnographic methods of participant observation are used in a small community. Standard procedures for getting farm management data include the cost-route method, where producers are interviewed regularly throughout the growing season (Spencer 1972), and single-visit farm business surveys (Collinson 1972). Comparing multiple-visit and single-visit surveys, Collinson (1972:229) noted that the latter method drew on the farmer's experience over a number of years, rather than on specific rates for a particular season. He felt that African farmers were likely to be used to estimating labor needs for various tasks -- since labor needs so often constrained production -- but that they were not likely to be able to express their estimates in terms of formal measures (e.g. man-hours) without help, and he furnishes detailed suggestions for survey procedures to make precise farmers' estimates of man-days needed for particular tasks, crop, field, and so on. Comparing costs of single-visit and multiple-visit survey coverage, per area covered, Collinson (1973:307) found that the former were far the less expensive. A possible strategy for preliminary agricultural planning might start with single-visit surveys, aimed at getting the broad outline of the local agricultural system and at asking farmers' opinions on how feasible specific innovations would be, and whether they, personally, would find specific techniques acceptable. Where necessary, cost-route methods could later supplement preliminary work, for example, in comparing labor inputs and yields for farmers participating in pilot extension programs, with those of farmers in the community as a whole.

Several general constraints for increasing labor inputs to agriculture have been discussed in the economic literature, and one of the most commonly mentioned is the "backward sloping supply curve of effort" -- the idea that farmers do not always respond to economic incentives, that they do not always work harder when marginal product for labor increases, or when wages rise, because of an inordinately strong preference for leisure. The implication has often been that peasant cultivators are economically irrational. Several authors summarize the available data on this problem, but none so succinctly as Upton (1973). "This, of course, is nonsense. In every society in the world people value their leisure and will not work all the hours that are physically possible in order to earn more." Clark and Haswell (1970:140), treating the backward sloping supply curve of labor noted:

> "This idea has aroused a great deal of interest, but facts in support of it are few. Both theory and empirical study indicate that such a state of affairs is not likely to be found in any community with reasonable contacts with the rest of the world, where men can seek alternative employment, and where a wide range of commodities is on sale."

They felt that the reasons African farmers produced relatively little were poor transport and problems in marketing organization. Dean (1965), investigating the supply respon to price change in Malawi, for tobacco growers, similarly found no evidence for a backbending supply curve for labor.

Discussing agricultural wages, Clark and Haswell (1976) noted that they were, of course, related to marginal product of labor. Worldwide, they found that agricultural wages (for local laborers) showed a minimum of 3 kg grain equivalent per day; that, at rates lower than that, workers seemed almost always to prefer leisure to work.

Another factor which was shown to limit farmers' willingness to intensify was their uncertainty about environmental conditions like rainfall and flood levels as well as about prices for agricultural products. Because the odds on different environmental conditions cannot be quantified, because farmers cannot estimate these probabilities, some say that farmers' inability to predict is better called "uncertainty" than "risk" (Cancian 1972:6, Calavan 1974:229). Others, however, (e.g. Upton 1973:91) feel that the distinction becomes blurred in practice.

The case studies discussed some of the responses of traditional farming to these risks, including: diversification (engaging in non-farming activities as well as crop diversification), staggered planting, use of drought and insect-resistant crop varieties, and planting fields in different micro-environmental conditions. Many of these adaptations, of course, are achieved at the cost of less than maximal yields during some years. Examples from Mali showed that planners did not always realize the full possible range of variation in environmental conditions, and quantitative data gathered over only a short period cannot fully apprise them of it. The classic examples of failure to see the range of possible changes come from the literature on the recent drought years.

Where technical innovations are being introduced into traditional farming areas, producers are faced with new uncertainties. Several recent ethnographic studies from outside Africa have tried to elucidate how farmers make decisions under these circumstances: a study of cultivators of irrigated rice in a village (where external environmental variation is less than in the Sahel) in Thailand found (Calavan 1974:128) that:

> "Sansai decision makers operate under the constant constraint of incomplete information. They must choose crops, varieties, and techniques without a full inventory of possible payoffs. Long-established strategies may provide nearly complete information, but promise lower payoffs than newer strategies for which less information exists... Farmers clearly regard each crop, each year's planting pattern as an experiment, to be altered without compunction if some other appears to be superior."

Calavan examined the pattern of acceptance of one innovation -- a higher yielding rice variety introduced by agricultural extension agents -- in detail, and derived a model for the decision making underlying the observed pattern of crop choice by these farmers. He felt that the farmers observed the experiences of a random sample of their acquaintances with both old and new rice varieties on their own lands, and chose the higher value. The model correctly predicted a major shift in crop choice: while only a small minority (10%) used the new variety in the first year after introduction, a substantial majority (66% to 90%) of households planned to adopt it during the second season (ibid:258). The model can be generalized to cover a longer time span. Calavan's model of decision-making has implications for government policy: if farmers indeed made choices more or less as statisticians do, then the principal effort of agricultural extension services should be to educate them to assess the range of available technical options. In addition, it is important that government agents attain a "critical density in the dissemination of new techniques and varieties. If only a few cases are available from which farmers can sample, then their judgments cannot be as reliable as when a larger sample size is available."

Experience in the Sahel has shown that farmers are more willing to increase inputs to agricultural production, in cases where risk of crop failure can be reduced. Thus, farmers in the inland delta (Mali) were more willing to use fertilizer on irrigated fields within the Office du Niger, than on fields with only partial water control. Similarly, Hausa farmers in Niger (Raynaut 1975:27) showed themselves unwilling to use chemical fertilizer on rainfall-dependent fields, but use it regularly on fadama (low-lying fields) and in well-irrigated gardens.

Another sort of risk, of course, is that of fluctuations in world commodity prices. Haswell (1975:79f) describes one instance of the dislocation caused by such price changes: in the Gambia, producer prices for groundnuts had been raised substantially in 1951 - 1952 (to bring them into line with world market prices), but world prices fell sharply the next year, and producer prices had to be reduced accordingly. Farmers, who had been granted advances based on 1951 - 1952 prices found themselves unable to pay debts; and purchasing firms found themselves unable to extend further credit. Impact on purchasing power in farming villages was great, and one result was to encourage stock-raising by farmers, as a buffer against risk of dramatic price declines (ibid:174).

Where a failure to balance food and money income with subsistence needs in any one year may mean hunger, farmers are understandably more concerned with limiting the standard deviation of their yields than in maximizing production. In trying to assess the effect of risk of farmers' willingness to intensify and to innovate, planners should try to combine long-term data on fluctuations in product prices, in rainfall, insect damage, and so on, with interviews of producers in target regions. These interviews could productively be combined with farm-business management surveys, and should try to ascertain what have been causes for crop failure and financial loss in the farmer's experience, which are the risks he takes into consideration when making production decisions, and also how these risks might be lessened.

A third factor which limits intensification of agriculture is transport -- both transport from producing areas to market, and the daily back-and-forth transport of the workforce to the fields. One of the first efforts to model the interrelationships of transport and the intensity of agriculture was Von Thunen (1966). Clark and Haswell (1970:191f) give a more recent summary of transport costs as they affect agriculture:

> "It cannot be emphasized too strongly that the first requisite for the improvement of the production of a subsistence economy is the provision of transport. Fertilizers, improved strains of seed, education and other objects are all of the greatest importance. But the need for transport is prior to all these. It follows from the nature of the case. If there is to be any improvement in an agriculture which at present only provides for subsistence, crops must be grown which can be sold. Selling implies transport to market. The methods of transport available to subsistence agricultural populations, as will be seen below, are so costly that produce only has to be carried a limited distance before most of its value, from the point of net returns from the sale, has gone."

Although some areas have adequate primary road networks, feeder roads are often nonexistent, or usable during only part of the year (e.g. Steedman et al. 1976:53). Where the feeder system is inadequate, villages more than 5 km away from all-weather highways find themselves isolated (Haswell 1975:217). Costs of transport have been shown to affect the possibility of seasonal labor migration as a source of supplemental income (Beals et al. 1967).

Transport costs also underlie the sort of gradation of cultivation intensity around settlements. Cleave (1974:3! summarizes available data on time spent by farmers walking back and forth to the fields as a percentage of total annual labor input which ranged from 10 to 12% (in Genieri, Gambia, 1953) to 34 to 46% (Nupe villages of northern Nigeria, 1954). Improvements in transport between village and field can profoundly alter the pattern of agricultural production (e.g. Cancian 1972). A classic African example is the village of Genieri, in the Gambia, where a causeway had been constructed in the 1950s, which made river flats more accessible for wet-rice cultivation (Haswell 1975:115f)

Swamp rice cultivation, using transplanting, was traditionally carried out by women, and, relative to less labor-intensive upland cultivation of millet and sorghum, it increased greatly in importance with construction of the causeway. During the time after the construction of the causeway, the sexual division of labor began to alter, with men helping women at production bottlenecks. Construction of the causeway permitted cultivation nearer to the edge of the mangrove swamps, where yields were higher, without change in production techniques. Thus per capita subsistence crop production, expressed in paddy equivalents, rose by 30% after construction of the causeway.

The case studies noted that intensification of agricultural production was only one of a number of options for increasing communities' food supply -- labor migration, commerce, crafts, are among the possible alternatives to agriculture. Smith (1975) presented a scheme which related population density, location with respect to markets, and transport for western Guatemala. The relative productivity of labor in various rural, non-agricultural occupations has been debated. In very high-risk agriculture, like that of the Hausa of Niger (Reynaut 1975:30), commerce may often be a more productive use of labor than subsistence agriculture.

The effects of colonialism, explosive urban growth, and government fostered unequal development may mean that even menial jobs in the modern economy may pay better than farming. Certainly the Kusasi who migrate from northeastern

Ghana see no material advantage to remaining in agriculture. More productive intensive systems in more highly integrated economies may alter this balance. Recent data from rural Java showed that rural owner-cultivators had substantially higher returns than agricultural and other wage laborers, craftsmen, small traders, and herders in that order (Nag, White, Peet 1978). As long as farmers have adequate land and can market their surpluses profitably, they find this occupation more financially advantageous than the other employments open to them.

Impressive local examples have shown that agricultural intensification has taken place with indigenous crops and tools in the West African savannahs, that it is continuing, and that intermediate technology is being adopted in this process. It is equally plain that the lack of water and the presence of certain soils may restrict intensification to certain areas with better rainfall, seasonal flooding, or the potential for irrigation. Whether this possibility is achieved will depend on the factors of population push and economic pull. The competition for land that makes permanent cultivation necessary and the attraction of marketing surplus production combine to make more intensive farming a logical, indeed almost inevitable, development. The cost to the African smallholder is usually increased labor input, and he is likely to make this investment only if he finds it profitable as compared to other uses of his time. The best indicator of where and in what agricultural sectors intensification is feasible are the trends already visible in local land use, cash cropping, land tenure, road traffic, marketing, and personal income. The variety and vitality of such efforts suggests a flexible, localized strategy for cultivating intensification where it is already growing instead of transplanting a standardized Western model to an alien ecosystem.

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