13 The Interaction Between Cultivation and Livestock Production in Semi-Arid Africa

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13.1 Introduction

Although the majority of people in semi-arid Africa sustain themselves primarily by growing crops, this means of production is not practiced by all, nor is it the sole means practiced by the majority. Because of inadequate rainfall and high evaporation rates, average crop yields are low, and the risk of crop failure is high. Traditionally the inhabitants of these regions have relied on domestic grazing animals to supplement their food supply. The ultimate degree of this dependence is embodied in pure pastoralism; however, semi-arid Africa has a wide range of variation, both in the nature and the degree of economic dependency on livestock.

From the title of this chapter, the reader might reasonably expect a survey of the current importance of livestock in the agricultural regions of semi-arid Africa. But even if we had the African experience and relevant literature at our command to attempt such a survey, it is unlikely that this would be the most useful sort of contribution. Instead, an attempt is made to isolate the different types of relationship or linkage that characterize the interaction between cultivation and livestock production and to consider the conditions under which each linkage can be expected to occur. Eight cases from summer rainfall, semi-arid zones of Africa (Fig. 13.1) are described which demonstrate various configurations of linkages in existing production systems, together with the conditions under which they have developed. Finally, the trends in the forms of linkages from an evolutionary standpoint are considered. The aim here is not to provide a historical account, but rather to consider what forms are likely to emerge under different ecological, political, and economic conditions. This provides a basis for discussion pertaining to future livestock–cultivation interaction.

13.1.1 Basic Differences Between the Two Production Systems

In the semi-arid regions of Africa, crop production and animal production tend to take place in different management units, typically belonging to different ethnic groups. This dichotomy is, however, far from absolute: most pastoralists grow some crops, and most farmers keep some animals. Variation in the balance struck between the two activities and the nature and degree of interdependencies between the activities must be viewed as different forms of adaptation. Understanding the patterns of variation in these forms in space and time requires, in addition to

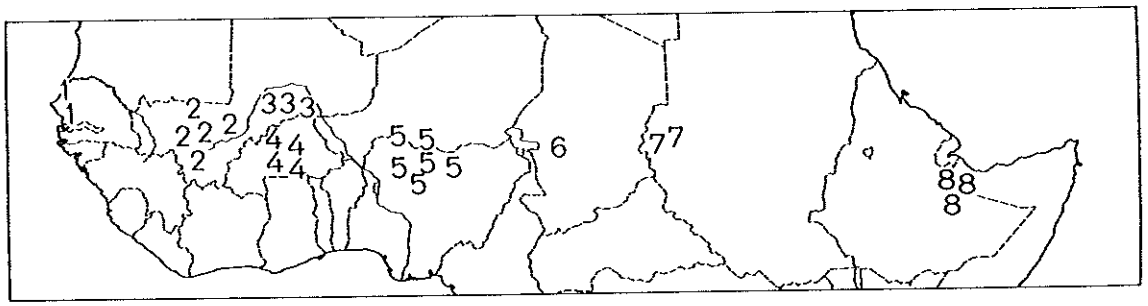

Fig. 13.1. Locations of selected cases of systems of production involving linkages between cultivation and livestock. *1*, Western Senegal; *2*, Bambara Lands; *3*, The Gourma Region; *4*, Mossi Lands; *5*, Hausaland; *6*, Bokoro Area; *7*, Western Darfur; *8*, Harar Province

information on environmental conditions, an appreciation of the major differences between the two production systems. A comprehensive comparison of the characteristics of these systems is given by Barth (1973). The following comparisons are pertinent for this geographic region.

1. Both systems require the same basic kinds of production factors: land (fields, pastures), capital (seed, herds), and labor.

2. In neither system does the right to use of land usually require capital expenditure. (In this geographical region, grazing rights are almost universally free. The situation with respect to cultivation rights is more variable, but purchase or rent of land is exceptional.

3. The amount of capital required for subsistence in pastoralism is high relative to that in agriculture. This is related to the difference in the annual rates of returns on seed (10–50 ×) and on animals (0.1–1 ×, in terms of reproduction).

4. In agriculture, labor is invested in the land, and the requirements are highly seasonal; in pastoralism, labor is invested in the herd, and the requirements are relatively constant.

5. Agriculture is labor-intensive, with increase in labor during the peak requirements periods providing the greatest marginal returns; pastoralism is capital-intensive, with increase in herd size providing greatest marginal returns.

There are three implications of these basic differences that are particularly important in the context of adaptive forms of inter-dependencies. First, the opportunity for investment of surplus income is greater under pastoralism. Here, investment and growth take place automatically through the process of production and are prevented only by a decision to slaughter, sell, or exchange the animals. In contrast, investment and growth in agriculture are possible only where institutions exist for converting surplus products to the critical factor of production, labor. Even when a labor market exists, the normal labor requirements are so seasonal in agriculture that the opportunity for increasing labor supply when the need is critical is usually very limited. A further implication resulting from differences in critical factors of production is that considerable growth in pastoralism can take place with only modest increase in labor. (It takes one herder, commonly a child, to tend one animal or to tend 20 or 30.) Clearly, there is ample stimulation for cultivators to invest in pastoralism if it is ecologically and politically feasible.

Second, economic viability in the two production systems is very different due to the difference in value of capital required for production. In a pastoral unit,

consumption needs can be satisfied not only by livestock products like milk and wool, but also by direct consumption of animals or by goods exchanged for livestock. A pastoral unit eventually falls below the viability level when loss due to satisfaction of consumption needs exceeds the reproduction rate. In an agricultural unit it is sometimes necessary to consume next year's seed. Although social institutions may exist that facilitate assistance in such situations, the high value of animals makes their availability (e.g., by loan) impractical. In contrast, replacement of seed is relatively easy. Since the supply of the critical factor of agricultural production, labor, is retained, full-scale production can be resumed as soon as weather conditions permit.

A third implication of the differences between the two production systems is that security in times of adversity is greater with pastoralism. In periods when capital must be consumed, the enterprise with large capital requirements is the one with large capital reserves. Not only is investment often difficult in agriculture, there are also serious constraints to saving capital (products). Traditional on-farm methods of storing grain in this region are unable to exclude grain insects, and grain preservation for periods of years has been impossible.

In the light of these differences between agricultural and pastoral production systems, it is to be expected that successful farmers in semi-arid regions might invest surplus in livestock, and that unsuccessful pastoralists might resort to farming. In the discussion of various types of interdependencies which follows the importance of both forms of adaptation can be seen.

13.2 Linkages Between Crop and Livestock Production

13.2.1 Interactions When Agricultural and Pastoral Production Take Place in Different Management Units

Historically, the interactions between pastoralists and agriculturalists involving agricultural economic consequences can be classified as nonexistent, positive, or negative. Examples are given here of each class, as well as some indication of recent trends in the nature and importance of each interaction, or linkage.

13.2.1.1 No Supporting Linkage

In this case, pastoralists and agriculturalists are self-sufficient units, i.e., the pastoralists rely on animal products and the agriculturalists have a consumption profile based on agricultural products. Traditional relations between Masai and Kikuyu might illustrate this situation, but because of pacification and expanded consumption profiles resulting from improved communication and education, it is unlikely that distinct examples could still be found today.

13.2.1.2 Ecological Linkage

In this case, the practice of one activity influences the other through its effects on the ecosystem. For example, during the dry season natural forage is in short supply, and the quality is normally very low. The residues of most crops, which are

of little or no value to the cultivator, provide a superior diet for the pastoralist's herds. At the same time, manure deposited on the fields as the cattle graze is beneficial for the subsequent crop.

The occurrence of this symbiotic relationship is widespread and varied in its ecological and economic complexity. In its simplest form, pastoralists camp near an agricultural area and herd their animals on the fields during the day. The benefits to the cultivator in terms of manure may be insignificant, but the trampling in of residues, breaking up of ridges, and stripping of stalks to be used later as building materials are considered beneficial (van Raaij, 1974:57). To deposit useful amounts of manure, animals must be corralled for several nights on a field and allowed to graze surrounding areas during the day. An empirical example with an additional feature is given in the Western Darfur case, discussed below, where *Acacia albida* trees are grown in the cultivated fields. Their pods, which are palatable and high in protein, fall in the dry season. Thus an additional source of feed is available that enables herds to be retained on fields for a longer period. The same example is reported for northern Nigeria (Morgan and Pugh, 1969). In recent years, this primarily ecological relationship has developed economic aspects. The value of crop residues is increasingly recognized by the cultivator, and the pastoralist has an increased appreciation of the value of manure to the cultivator. (Some of the types of transactions that take place are discussed below as exchange linkages.)

13.2.1.3 Exchange Linkage

This linkage is mediated by the transactions between agriculturalists and pastoralists involving goods, or both goods and services. Exchange of goods is the typical linkage when agriculturalists and pastoralists have similar consumption profiles, and the livelihood of one group is partially dependent on the products of the other. Examples are numerous. Traditionally, nomadic pastoralists such as Moors, Tuareg, Fulani (Peulh), and Baggara camp for at least part of the year in close proximity to agricultural areas, during which time they exchange products, e.g., milk, ghee (butterfat), meat, and hides, for millet and sorghum.

Although direct exchange still takes place, economic institutions increasingly play an intermediary role. Fulani pastoralists in northern Nigeria buy grain, salt, bran, natron (hydrated sodium carbonate and other salts), and household goods. There is usually a ready market for slaughter animals near centers of population. Usually farmers who wish to invest in livestock buy from pastoralists. In some cases, e.g., among the Hausa of northern Nigeria and the Fur of western Sudan, young cattle are purchased for fattening and resale; however, most cattle purchased by farmers are long-term investments. The cattle are usually tended by a pastoralist (frequently the former owner) who receives in return the milk produced, while the new owner gains interest on his investment in the form of progeny. Such arrangements are common between groups like the Fulani and the Bambara, or between the Fulani and the Hausa.

As noted above, a kind of symbiotic relationship has traditionally been associated with crop residue grazing. Although basically an ecological linkage, it has taken on economic aspects. When pressure on land is not great, and fertility is maintained by rotational fallow, manure is not highly valued by the farmer.

Residues are of little worth, and the modest benefits associated with trampling or the enhanced availability of fresh milk may seem sufficient return. If he has more business acumen, or if he himself possesses livestock, he may demand payment. If pressure on land increases, however, to a point where manure is highly valued as fertilizer, the demand for it may become so great as to reverse the direction of payment. Fur farmers pay Baggara pastoralists to camp for several days on their fields just prior to planting. An example of this is the Western Darfur case, described below. Among these cultivators and those of the densely populated areas of northern Nigeria, there is a ready market for manure gathered from pastoralist camps.

13.2.1.4 Competition Linkage

This occurs when the same resource (land) is ecologically suitable for both agricultural and pastoral production. Where this is the case, relative political power is likely to determine the land use pattern. During the centuries just prior to colonization, much control was exercised by belligerent pastoralist groups. With pacification and increased central authority, the balance of power has shifted decisively to the cultivators.

At present, two basic trends are profoundly altering the land use relationships between pastoralists and agriculturalists. To begin with, land is becoming increasingly scarce. The rapid growth of the rural population is expanding cultivation at the expense of the best grazing land. Increased cultivation of industrial crops has hastened this trend, as has government reservation of public lands (van Raaij, 1974).

The second trend is that of increased individualization of land tenure. Although this rarely means that land is individually owned, the traditional "free range" philosophy whereby livestock has free access to water and fodder reserves of rangelands, fallow lands, and harvested fields is increasingly challenged by cultivators who want to control access to their holdings. Cultivators in northern Nigeria will admit that there long exsisted a system of tacit consent whereby Fulani pastoralists could graze their cattle on fields as soon as the harvest was completed, but there is a general feeling among cultivators that times have changed. Particularly in densely populated and commercialized cropping areas tensions and conflicts arise during the post-harvest period, and court records reveal an annual spate of cases against pastoralists for damage to late-maturing crops (van Raaij, 1974:36). Competition is minimal in the rainy season when supplies of feed and water are generally ample. Pastoralists normally go to drier areas unsuited for cultivation, in part because the feed value of range species in these areas is superior. It is in the dry season that competition is acute, with permanent water sources as the focal points.

The settling and farming of land near permanent water sources affects traditional pastoralists in several ways. First, the land that is cultivated is normally the best grazing land. In the *bourgoutières* of the Niger inland delta of Mali, the incursion of rice cultivation into the traditional rich, dry-season grazing lands of the Fulani has created competition in recent years. Second, in areas where dry-season crops are grown under irrigation, cultivators must keep pastoralist herds out

of the area to prevent crop damage. In Western Darfur, Sudan, Fur cultivators grow irrigated crops in continuous strips along the *wadis*. An unregulated continuation of this trend is likely to prevent Baggara herds from gaining access to water, with the consequence that the natural forage resources of the surrounding areas will not be utilized effectively. A similar problem occurs in northern Nigeria where Hausa cultivators increasingly irrigate crops in the *fadama* areas. These are depressions that flood in the wet season and retain residual water during the dry season. As a result, Fulani pastoralists are excluded from their traditional dry-season grazing resources (van Raaij, 1974:117).

There is a third, more subtle way in which the presence of cultivation deprives the pastoralist. Commonly the cultivators own livestock, which they herd on the rangeland around the agricultural community during the wet season. By the time the pastoralist herds arrive for dry-season grazing, local herds may have depleted the local range near water sources, destroying the viability of the traditional pastoral system. (The cultivators' stock is supported on crop residues during this time.)

In situations where rainfed cropping is spreading at the expense of grazing land, the loss of range forage is compensated to some extent by the fodder contributed by crop residues. The degree of compensation depends on the value of the crop residue, e.g., with sorghum, groundnut, and cowpea ranking high, and with millet ranking low (van Raaij, 1974:90). Because the quality of upland native pasture is so low in the dry season, the availability of the better crop residues greatly reduces mortality, especially among cattle (van Raaij, 1974:99).

13.2.2 Interactions When Agricultural and Pastoral Production Take Place Within the Same Management Unit

Livestock ownership benefits a cultivator either directly, or indirectly via benefits to crop production. This section discusses first investment and food linkages, which are directly beneficial, and then manure, draft, and fodder linkages.

13.2.2.1 Investment Linkage

The following features are characteristic of a substantial number of traditional African agricultural systems.

1. Agricultural and pastoral land is either free or communally owned.
2. Extensive land use is typically some form of shifting or rotational fallow cultivation.
3. Capital input is limited to seed and simple equipment.
4. Livestock are privately owned.
5. Institutions are present that facilitate conversion of agricultural products into livestock.

Given these features and the characteristics of agricultural and pastoral systems of production described earlier, one would expect that where returns from cropping cannot be invested in factors of agricultural production, and where they are mainly consumed by the producer, a balance will be struck between labor drudgery and the

satisfaction of returns to labor at a low level of production. If, however, livestock are present in the economy, this implies an opportunity for investment and consequently an incentive to increased agricultural production. One would thus expect that the cultivators would be stimulated to achieve a higher level of production in order to convert value from the agricultural to the pastoral sector. This strategy implies growth in the enterprise; it gives security both in terms of food (animals can be eaten or transacted), and in terms of mutual support (animal distribution can be used as a means for obtaining assistance from other people). The fact that livestock, especially cattle, are so highly valued as an investment all over Africa makes this the most typical form of integration of livestock into agricultural enterprises. A great many, perhaps most, of the cattle owned by cultivators serve little other purpose.

It is common practice among the Wolof (Ouolof) of Senegal, the Mossi of Upper Volta, the Bambara and other tribes of southern Mali, the Hausa of northern Nigeria, and the Fur of the Sudan to entrust their cattle to the care of neighboring pastoralists. Since the benefits of keeping the cattle close at hand are appreciable (regular milk supply, lower risk to the investor, and, in some cases, manure production), one would expect to find contractual herding only where local resources such as forage, labor for herding, and animal husbandry skills are traditionally inadequate. Nevertheless, this practice is found also in communities that possess enough grazing resources to maintain modest herds but which have invested in more cattle than these local resources can support.

A disastrous syndrome, the "cotton cycle" has developed in Sukumuland, Tanzania. Here cotton was introduced into traditional farming-grazing systems and crop production flourished. The newly prosperous farmers had only one outlet for investment: cattle. Soon, local herds were overgrazing the surrounding rangelands, and very ordinary drought conditions sufficed to cause huge losses of stock. In an attempt to recoup their investments, the farmers have put more land under cotton, thus reducing still further the available grazing area, and with it their ability to support their herds.

13.2.2.2 Food Linkage

Usually the investment linkage is supported by a food linkage, as in the case where the agricultural producers supplement their diet with meat and milk products from their herds and flocks. Some groups rely heavily on milk from large animals. The Songhai of Mali, for example, rely on cattle, and the Somalis rely on cattle and camels. Even in communities that lack a major cattle sector, the more successful farmers often keep cattle (Hill, 1972:217). More commonly, however, cultivators keep small stock, such as poultry, sheep, and goats, to supply themselves with animal products.

It should be emphasized that for most peasants and pastoralists alike, meat is a luxury food and cattle are slaughtered only on special occasions. Overall, there is less reluctance to kill smaller animals of less worth, but which species is killed depends largely on the wealth of the owner. There is a tendency for those who are predominantly cattle owners to consume goats and sheep and for those whose largest animals are the latter to consume chickens. A phenomenon that can reduce

this tendency is illustrated by a case in Sukumuland (Ruthenberg, 1964). Here, slaughter of sound cattle is rare, but considerable beef is made available for consumption as a result of a rather high mortality rate.

13.2.2.3 Manure Linkage

In traditional agriculture the manure linkage is associated with intensive cultivation. Intensive cultivation systems are usually associated with high population densities. This can be seen in refugee hill areas of Cameroon, Nigeria, Mali (Morgan and Pugh, 1969:104), and Wakara Island, Lake Victoria (Ruthenberg, 1971,118). Marginal returns of labor are frequently less under these intensive systems than under many extensive systems of cultivation.

With increasing political security, population pressures have been relieved through migration from the hill areas to the plains. Such migration is typically accompanied by a change in the cultivation system. Given the preferred balance between labor and consumption, easier access to land implies that a point will be reached sooner or later where optimization of returns on land and labor give way to extensive shifting cultivation with less need for manure. With increasing population pressure and better agricultural technology, this trend is being reversed again, and there is increasing reliance on manure to increase soil fertility.

The quantity of manure contributed by animals kept within the system is, however, rather low. For example, King (1939) reports that a pair of work oxen corralled overnight produce only about 5 tons of manure per year, enough for approximately 1–2 ha. Moreover, manure deposited on the land during the dry season declines greatly in value before it is plowed under. This inadequate supply explains the typical concentric distribution of cropland utilization around an African village. Near the houses, where labor input to manure supply is lowest, manure and household sweepings are applied, and the plots are permanently cultivated. At a greater distance, land is cropped with a rather brief fallow period and manured by the village livestock or by pastoralist herds. Where population density permits, there may be a third outer region comprised of bush land. Here the fallow period is generally long, and no manure is applied.

Various efforts have been made to increase the quantity and quality of manure through the introduction of manure pits, as in Senegal, Mali, and Upper Volta (Casse et al., 1965; Hamon, 1972), but the high investment and labor inputs required and the difficulty of finding enough water to maintain moisture in the pits during the dry season have acted as constraints.

13.2.2.4 Draft Linkage

This linkage was rarely found in traditional agriculture in semi-arid regions. There were, however, some interesting exceptions. Along the Nile, oxen provided the draft power both for plowing and for the Persian wheels used in irrigation. In the Kheiran depressions in Kordofan (Sudan), an unusual farming system evolved. The system involves a combination of intensive agriculture based on irrigation from groundwater with ox-drawn water wheels in the dry season, and extensive shifting hoe cultivation in higher-lying areas in the rainy season. With increasing

Table 13.1. Farm size in relation to presence and type of animal-powered farm implements in West Africa (from Casse et al., 1965)

Country	Type of equipment	Without equipment ha	With equipment ha
Senegal			
Thies region	Sowing machine	1.6	3.4
Sine Saloum	Sowing machine	3.8	8.6
Baol	Sowing machine	2.8	7.4
Mali			
Several regions	Plows	5.4	11.8

involvement in the market economy, the draft linkage has grown in importance, especially in West Africa.

The first draft implements were introduced to West Africa by the French government around 1850 (Boudet, 1969), but the practice remained in an experimental stage until the first decades of the twentieth century. Increasing use followed during World War II.

The type of animal traction used depends on environmental conditions. For example, in the sandy soil of Senegal, horses are used to pull light draft sowing machines while in the heavier soils of Mali, oxen are used for plowing.

Characteristic differences in size of farms with and without use of animal traction have been noted by several authors. Casse et al. (1965), for example, report statistics from various West African regions showing that farms using animal drawn implements tend to be two or three times the size of farms using hand labor only (Table 13.1).

There are two main reasons for these differences. First, because of the high cost, only large and successful farms can afford draft animals and equipment. Hill (1972) showed that in a Hausa community in northern Nigeria, only the rich own draft animals. Gallais (1967) found this to be true in Mali as well, and he showed that families with high social staus obtained credit from government agencies much more easily than others.

Second, increased labor productivity with draft animals is realized only on large farms. Surveys comparing the average area cultivated per active member of the family showed a 30%–50% increase in size with use of animal traction in Senegal and 40%–70% in Mali. Because labor is not usually limiting on small farms, this increase is only seen on farms larger than 4 ha (Casse et al., 1965).

Farmers who do not own ox-plows frequently hire them. In Chad, Dronne (1969) found an average of 2.4 ha plowed by oxen on the owner's farm and 2.0 ha plowed on the farms of others. Nicolas (1968) reported that 94% of total plowing hours might be spent on others' farms. In the latter case, farmers who owned the oxen preferred to hire out their animals and cultivate their own farmland with hired labor. A consequence of this hiring out is that statistics on animal traction, usually expressed in terms of degree of use per owner, do not reflect the real extent of use.

There is a close relationship between the adoption of animal traction and the cropping pattern: generally, more area is allocated to cash crops and less subsistence crops are grown. In Senegal, farmers using animal traction planted

10%–16% more groundnuts, and 3%–7% less millet than those not using animal traction. In Mali, farmers using animal traction planted more rice and less subsistence crops and groundnuts than traditional farmers (Casse et al., 1965).

The impact of animal traction on yields per unit area, especially at the farm level, is not easy to document, as it is often difficult to separate this effect from the effects of other improvements such as fertilizers, insecticides, better cultivating practices, etc. Where animal traction is the only variable, usually little or no increase in yield per unit area is apparent. The reason for this is that farmers using ox-plows without ox-drawn weeders tend not to be able to cope with the increased weeding requirement, and yields suffer (Ruthenberg, 1971,70).

The ability of rich farmers to obtain animal traction, and thus to increase their labor productivity, coupled with the shift to cash crops, tends to widen the gap between the more and less fortunate cultivators. By hiring out ox-plows, owners can be assured of labor for weeding and harvesting. On the other hand, farmers who borrow to invest in oxen and implements cannot always meet their obligations. Raynaut (1975) describes a case in the Maradi Region of Niger, where, because of very small plot size, the tools distributed (which were heavy and expensive) could seldom be used to full capacity. This forced several farmers first to sell their equipment to reimburse the loan agency, and then to hire out their labor or to lease or sell their fields.

An important constraint on the further development of draft linkage, as can be seen in some of the cases (Bambara lands; Harar Province, Ethiopia), is the supply of animals for draft purposes. If a semi-arid country with a cultivable area of 10,000,000 ha is considered, and if it is assumed that an average pair of oxen will be able to cultivate between 5 and 10 ha per growing season, the total need will be about 2–4 million oxen. This means that a national herd of 8–10 million cattle is needed, which is likely to be many more than the grazing resources of the country can support. (This calculation assumes a weaning percentage of 50 and a working life for oxen of 5 years, beginning at 3 years of age.) Thus, any large-scale "revolution" in labor productivity would require considerable direct conversion from hoe cultivation to mechanized farming. The obstacles to mechanization of agriculture in many parts of Africa are, however, formidable (Orev, 1972).

13.2.2.5 Fodder Linkage

For livestock as well as for humans, the dry season is a nutritional bottleneck. Except in the permanently wet lowlands, no pasturage grows until the onset of the rainy season; meanwhile, herds consume the stores of standing hay. To make matters worse, the nutritive value of this forage steadily decreases as its tissues cure and weather. There is, therefore, a great need to produce forage crops superior in dry-season quality to range forage. Moreover, a sown leguminous fodder crop or ley would be more effective in restoring soil fertility than a bush or grass fallow. This practice, more than any other, is the key to mixed farming along the lines developed in Europe and North America. The main question is whether the value of livestock products and services and enhanced soil fertility outweigh the value realized from alternative uses of labor and land. In most of the dry tropics of

Table 13.2. The average yields and crude protein contents of residues of four crops in northern Nigeria (From Van Raaij, 1974,85)

Residues	Average yield (kg/ha)	Average crude protein (%)
Sorghum	1740	2.2
Cotton	280	8.0
Groundnut	515	9.2
Cowpea	260	10.0

Africa the pressure on land is not yet sufficient, nor is the price structure favorable, for a fodder linkage based on sown leys.

An important fodder linkage of a different sort does occur widely where a crop that provides either human or industrial products also provides dry-season feed as a by-product. Normally, of course, the primary products guarantee sufficient returns on land and labor to justify cultivation.

Although the quantity and quality of the residues from rainfed crops vary greatly (Table 13.2), they are recognized as a valuable supplement to range forage. From the standpoint of the economics of fodder linkage, it is instructive to consider the value of such crop residues in relation to the dry season value of specialized forage adapted to this climate. Crude protein of 3%–6% can be expected in standing hay or sown grasses and up to 10%–13% in legumes, such as *Stylosanthes humilis*. Clearly, this inherently low quality constitutes a more serious constraint to the successful establishment of a forage crop linkage than is commonly recognized.

13.3 Selected Cases of Cropping–Livestock Systems

In this section, we examine eight examples of production systems that exist in a strip of semi-arid land (250–800 mm mean annual rainfall) stretching from coast to coast across sub-Saharan Africa north of the equator (Fig. 13.1). In West Africa this region is generally classified as the Sahelian and Sudanian zones, characterized by a monomodal rainfall distribution. In the East, the rainfall is bimodal. We have not distinguished between these two areas in this chapter because the problem of adaptation and the types and degrees of interaction between cultivation and livestock do not appear to be related in any important way to the differences in rainfall patterns.

13.3.1 Western Senegal

The hinterlands of Dakar, especially the Cayor and Baol regions, form the heartland of groundnut cultivation in Senegal. The agricultural resources of the area are characterized by light, sandy soils ideal for groundnut culture, and a mean annual rainfall of 400 to 750 mm. The natural vegetation in the south is open woodland of *Acacia albida*, but the north is nearly treeless.

The principal ethnic groups are the Wolof of the north and the Serer of the south; others include sedentary Fulani and Bambara. During the recent drought there was an influx of Moors from Mauritania.

Although groundnuts have long been cultivated as a local food crop, the traditionally dominant crop of the region is bulrush millet, which is still cultivated widely. Since 1900, the improvement of transport and export facilities has permitted an enormous expansion of groundnut cultivation, and this crop now occupies two-thirds of the total cultivated area.

In a typical Serer farming unit there are three types of land use depending on the distance from the village: compound land, enclosed farmland, and open farmland. On the enclosed farmland, crop rotation occurs in the following sequence: (1) bulrush millet, (2) groundnuts, and (3) pasture or fallow (Pelisier, 1953). The degree of integration of livestock and cropping may be as high here as anywhere in the semi-arid zone of Africa. Livestock and cropping are reported to be of about equal importance, but there are indications that animal husbandry is declining as groundnut cultivation expands (Morgan and Pugh, 1969).

Fields are divided by hedges, and cattle graze on pasture and fallow lands during the wet season. In the dry months, they graze throughout the enclosed and open farmland areas on crop residues supplemented by the leaves of *Acacia albida*. No fodder crops are grown.

Except for animal traction, livestock are much less integrated with the rest of the agricultural system in Wolof country. Here the Fulani are contracted to herd Wolof cattle away from cropping areas, especially during the wet season, in return for the milk produced.

Manure deposited during dry-season grazing is plowed under, but no effort is made to produce and conserve better-quality manure (Hamon, 1970). This may be due in part to the smaller response of groundnuts to manuring than that of nonleguminous crops.

Introduced only three decades ago, animal traction is widely used, especially on the larger farms and plots. Use of animal traction has been stimulated by the commercialization of groundnut production. Casse et al. (1965) estimated that between 30% and 40% of the farms in the area owned both equipment and draft animals, and 10%–20% owned either one or the other. The percentages were highest in the Wolof region.

The most commonly used draft animals are horses and donkeys, rather than cattle. This is probably because the sandy soils are frequently not plowed, and low draft power is sufficient for sowing. The recent introduction of a groundnut lifter that reduces the labor needed during harvesting has significantly increased the use of oxen (Uzureau, 1974).

Among the sedentary Fulani, mixed farming, especially with the use of animal traction, was stimulated by the introduction of the plow (which replaced slave labor), and by the practical loan facilities provided by the French government. In the Serer region, some beef fattening is practiced by small landholders, and the resulting manure is used on the fields.

The indigenous system of mixed farming in this region provides the possibility of maintaining a high population density (40–75 inhabitants/km^2). With increasing population pressure, the following trends might be expected: (1) further increase in

the use of work oxen, especially when used with groundnut lifters, and (2) increased use of chemical fertilizers or development of more intensive mixed farming.

The maintenance of soil fertility will depend first of all on the economics of inorganic fertilizer: if its use is not economically feasible, an even higher degree of integration will be needed to provide manure. This would entail forage crop production plus manure production and conservation, which can only be profitable if a strong demand for high-quality animal products (dairy and meat) can be established. The proximity of the consumer market of Dakar may favor development in this direction, and plants for processing dairy products already exist in Dakar and St. Louis. On the other hand, if neither fertilizers nor more intensive mixed farming proves profitable, soil fertility will decrease, and greater areas will be required to maintain the same number of families. This can be expected to stimulate the migration of wage earners to the urban centers.

13.3.2 Bambara Lands

Information on Bambara lands is largely drawn from Morgan and Pugh (1969). The Bambara of Mali occupy three areas: to the south, the valleys of the upper Niger and Bani; in the center, the inland delta; and to the north the Soninke massif. There are about one million Bambara in all, living mainly in villages. Population densities are fairly low (5–15 persons/km^2).

In the upper Niger Valley, cultivation is mainly confined to the slopes and valley bottom. Vast areas are inhabited only by wild game and the tsetse fly. The rainy season lasts from 5–7 months, with an average annual precipitation of as much as 750 mm. Sorghum and millet are the primary crops. Rice is grown in the lower regions and in flooded areas. Maize and bananas are raised on the floodland fringe, and most vegetable and fruit crops are grown on compound plots near the houses.

Although the lands dependent upon rainfall comprise well over half the total croplands, they usually produce less than half the total crop yield. Cropping lasts for 2 to 6 years before fallowing. Bulrush millet and groundnuts are the chief crops. Rice, cotton, and onions are grown on the floodlands, and millet, maize, and tobacco are grown on manured compound lands. Cotton cultivation has increased considerably, primarily during the last two decades, and there has been an accompanying increase in animal traction.

In the inner delta, all cropping and livestock activities are governed by the annual flood. This is Mali's great rice-producing region, where floating varieties are grown to take advantage of flood areas. On the drier fringes, millet is cultivated. Animal traction is widely used, although almost exclusively in rice culture and under the ownership of large units or by cultivators with high economic or social status. Hiring out to smaller farmers is common, but Gallais (1967) points out that it is not plowing equipment, but available labor for weeding and harvesting, that determines the extent of the cultivated area.

Where possible, manure and compound sweepings are used to fertilize plots on the fringes of the dry-land areas. Preference is given to plots that have been cultivated for several years. For example, in one village, manure was applied to more than 50% of the plots that had been cropped for more than 10 years, whereas

the plots that had only been cropped for two years or less received no manure at all (Gallais, 1967).

The inland delta also provides a forage resource of particular importance in the dry season. As flood waters progressively recede, more and more pasture of the native grass *Echinochloa stagnina* becomes available at a time when the value and supply of upland pasture is declining rapidly. This is the region in which the transhumant Fulani graze their herds between December and June. The Fulani herdsmen who have settled in this area keep their milk cows near the villages all year long, and sell their products to the villagers and farmers. Although they may grow rice and sell the excess, their main source of income is the sale of animal products.

The Bambara, whose income is mainly derived from cropping, occupy also the southern portion of the Soninke massif, surrounded by completely pastoralist societies and close to the limits of rainfed agriculture. Millet is the chief crop, with substantial numbers of livestock owned as an investment and let out for herding by Fulani, Tuareg, or Moors. Cattle are usually obtained from pastoralists in exchange for grain. It should be noted that here, where cropping is risky, the farmers are more inclined to invest in livestock for security than are farmers of the inner delta, where cropping is less of a gamble and where the tendency is to invest in animals for draft purposes. Casse et al. (1965) cite a survey showing that in 1960, only about 20% of farm units possessed plows, and that the average size of these units was more than twice that of traditional farm holdings. In that year, the Compagnie Francaise pour le Dévelopement des Fibres Textiles (CFDT) began a program to expand cotton production outside the delta area through various means, including the use of ox-plows and the production and use of manure (de Wilde et al., 1967). The demand for plows generated by an improved extension service was so great that sufficient draft animals could not be found. To compound the problem, the livestock of many farmers was being herded by Fulani under such complex agreements that it was all but impossible to get the animals back.

The results of the efforts of the CFDT to increase manure production were rather disappointing. After four years, only 8%–10% of the area was being manured to any extent. De Wilde et al. (1967) concluded that only a complete transformation of the farm unit, with the introduction of fodder crops, construction of manure pits, etc., could bring about the widespread use of manure.

There is no doubt that in the future the delta farmers will increase their rice production in response to the demands of markets in the north and south. This increase will be accomplished at the expense of the forage in the delta from *le bourgou* and the dry season reserves of the pastoral Fulani. Competition for land could be avoided through the introduction of higher-yielding fodder varieties, or through decreasing herds, with resultant reduction of pressure on the pastoralist grazing areas. This latter development could be brought about through a further stratification of livestock production by the use of feedlots. The availability of rice and cotton by-products and the recent establishment of a sugar-cane plantation in the region are positive conditions for stratification. Outside the delta, further expansion of animal traction would allow for the production of cash crops, such as cotton, groundnuts, and rice, where plots of sufficient size exist.

13.3.3 The Gourma Region

The Gourma region of Mali (Fig. 13.1) provides an example of differing degrees of integration between livestock and cropping (see Morgan and Pugh, 1969; Gallais, 1975). This region contains three basic habitats: (1) the Bandiagara Plateau (9,000 km²), a traditional refugee area of the Dogon tribe, with population densities of 10 to 50 inhabitants/km², varying in relation to availability of arable land, and rainfall of 400 to 600 mm per annum, (2) the plains (30,000 km²) bordering this plateau to the east with about the same population density and rainfall, and (3) the Gourma itself (90,000 km²), the area inhabited mainly by pastoralists, bordered by the inner Niger Delta to the west and the Niger River on the north and east, with low population density (1.5 inhabitants/km²), and a typical Sahelian climate of 250–400 mm annual rainfall concentrated in a three- to four-month period.

The Tuaregs in this region are almost completely dependent on livestock. However some pastoralists at the beginning of the rainy season when animals are being moved to the grazing lands of the inner Gourma remain behind to plant crops in traditional enclosed areas, albeit with a minimum of cost and effort. As soon as fences are repaired and crops weeded, they rejoin their camps. Later, they return briefly to harvest the grain and store it in the fields as a reserve. At the beginning of the dry season they migrate to the river banks and wait for the flood to subside. Calves and milk cows are kept near the camp, and milk is sold or traded to the cultivators for grain. The main herd will graze in an area up to 20–25 km from the riverbank, returning every two days to drink. As the dry season advances, the Niger flood subsides and *le bourgou* becomes accessible. At this time serious competition between the settled Fulani and Bambara cultivators and pastoralists may occur, especially in densely settled regions. Along the river, where cultivators also keep animals, various conventions have been established to regulate competition, protect cultivation, provide corridors to watering places for the pastoralists, and delimit grazing areas.

Plowing is done for the settled Fulani by the Bambara or by the Bozo; the Fulani provide the oxen, and the latter contribute the plows.

Farther south, on the escarpments of the Bandiagara Plateau, the Dogon have traditionally occupied the cliffs, where they were safe from attack by the Fulani and Tuareg. While these pastoralists are nonegalitarian military societies in decline, the Dogon cultivators are an egalitarian village-oriented society in a state of expansion. Although average rainfall is only 400 to 600 mm annually, intensive cultivation has developed due to high population pressures. Population density is as much as 600 inhabitants/km² of cultivatable land in some areas. Crops are watered either by gravity irrigation or by hand. The Dogon traditionally grew their millet and other food crops on the cliffs, venturing only occasionally onto the plains, which were frequently under the control of the Delta Fulani. During the last two decades, however, the cropping pattern has changed toward horticulture, and the region now produces onions, tomatoes, and other vegetables. The livestock kept on the cliffs consist mainly of small ruminants, with some cattle. Their manure and compound sweepings are used to fertilize the poor soil between the rocks (Gallais, 1975).

Increased political security and the disintegration of the Fulani empire has allowed the Dogon to emigrate to the plains in response to drought. Although population density is high here also (10–50 inhabitants/km²), much more arable land is available. Accompanying this change in location and farming conditions has been a change in farming practices: the old cropping patterns which supplied nearly all the needs of the Dogon have largely been abandoned and replaced, especially by shifting cultivation with millet. The region also provides wet season grazing for the Fulani of the interior Niger Delta. All over the region, and especially in the more densely populated areas, the Dogon and Fulani interact profitably: the Fulani cattle manure Dogon fields, and grain is exchanged for milk and other animal products. Nevertheless, a certain amount of friction exists as the Dogon are not accustomed to fencing their land, and the Fulani regard all unfenced areas as free for grazing. A much higher total production of grain is achieved than was possible on the cliffs, and this has enabled the Dogon to invest in cattle. Their herds are kept locally most of the year, although they may migrate short distances under the care of the Fulani from time to time. Thus, livestock is seen primarily as a means of investment, because, as Gallais (1975) notes, the man whose money is tied up in livestock is able to evade continual demands for cash by friends and relatives, and can as well supply them with milk and butter. For this reason, the ownership of herds has become desirable to cultivators at all levels of the economy.

Future trends will probably include increasing pressure on *le bourgou* and on wet-season grazing areas in the Gourma. The Dogon will probably emigrate in ever larger numbers to the plains, where there will be an increased investment in livestock, a reduction in the fallowing period, and more demand for manure, and, possibly, animal traction.

13.3.4 Mossi Lands

Morgan and Pugh (1969) provide a concise overview of agriculture and pastoralism in Mossi Lands. The two Upper Volta states of Ouagadougou and Yatenga occupy the watershed between the Volta headwaters and the Niger. This area consists of a remarkably level plateau 250–300 m above sea level, the agricultural environment of which is characterized by high year-to-year variability in rainfall, a wide range of soils, and poor surface drainage. Mean annual rainfall varies from 500 mm in the north to 800 mm in the south. Upland soils form mosaics of varying texture and fertility. In general, the plateau is so flat that drainage is not well developed, and marshes develop in the rainy season. Upland vegetation is sparsely wooded savanna.

On this plateau, an island of ordered Mossi government has existed for 500 years with no incursion other than that of the French. The society is characterized by a lack of ethnic diversity and a relatively high rural population density (25–40 inhabitants/km²).

Average farm size is rather small (4 ha/family, or 0.5–1 ha/person) because of high population pressure. Farms usually consist of three types of fields: (1) a household field adjoining the hut, kept under permanent cultivation, with some manuring from household wastes, (2) fields in or around the village, also under

permanent cultivation but receiving less manure and being therefore much less fertile, and (3) the outfields, unmanured, and cultivated after long periods of fallow. The farming system is almost totally geared to food production, with a preponderance of bulrush millet and sorghum. Cotton and groundnuts are also grown to some extent, but rice is restricted to the limited bottom lands of the region.

In addition to earnings from crops, the Mossi have an income from handicrafts, fishing, and hunting. Because of demographic pressures, labor migration to Ghana and Ivory Coast is important, particularly among persons in the 15- to 30-year age-group. Length of stay ranges from one crop season to several years. Workers bring cash and goods back to their villages (Lallemand, 1975), thereby supplementing local agricultural incomes.

Many Mossi families own some cattle, sheep, and goats. Few families own more than a dozen sheep, however, and most of these animals are held for slaughter on Muslim holidays or in traditional ceremonies. Almost all Mossi cattle are herded by Fulani, who receive milk in payment for their services. Much manure is deposited away from the area because the cattle migrate seasonally; the main role of cattle ownership is investment and security.

In 1961, the Société d'Aide Technique et de Coopération (SATEC) organized an extension program to introduce animal (donkey) traction, mechanical cultivators, and mineral fertilizer (de Wilde et al., 1967). Results have been variable, depending on yields and farm size per active member of the family. Major problems affecting the success of the program are the low level of education among the farmers, the absence of a major cash crop, and the extreme degree of subdivision of fields. The mineral fertilization program seems to have suffered especially from the first two factors.

Lallemand (1975), in describing the effects of the drought during 1972–74 on a small Mossi village in the densely populated north, illustrates the limitation of cattle for drought security. A disastrously low yield of millet in 1972 and 1973 caused a rapid seven-fold increase in the price of food grains. The first response to the growing crisis was that farmers reduced their daily consumption of grain. Next, products such as handicrafts, began to be sold at prices far below normal. As the situation became desperate, farmers were forced to sell their cattle, which by then were in very poor condition. As these cattle flooded the market, prices dropped correspondingly. Whereas in normal times an ox might bring 1000–2000 kg of bulrush millet in trade, this figure dropped to 200–300 kg during the drought.

Increased pressure on land due to increased population or unfavorable weather is usually reflected in two trends. One is increased migration of the active labor force to industrial areas, which causes a further reduction in the region's agricultural production. Second, driven by the desire for self-sufficiency in food supply, farmers expand the area of food crops at the expense of commercial crops, with a corresponding return to traditional lower-input methods. Both trends tend to reduce cash income, thereby reducing the desire and opportunity to adopt a mixed farming system. In view of the limited agricultural resources of the area and the small size of farms, mixed farming may have a future only if a complete transformation of the farming system takes place and intensive livestock production is introduced.

13.3.5 Hausaland

The semi-arid part of Hausaland lies between 12° and 14° north latitude, mainly within northern Nigeria, but in southern Niger as well. It includes the Sokoto River and its tributaries to the west, and the great plateau to the east. The Hausa Plateau is fairly level, at an elevation of about 600–700 m, sloping down to 450 m in the north. It consists mainly of basement complex rocks overlain in the north by sand and deposits of a former southerly extension of the Sahara. The predominantly light soils are partly responsible for the success of groundnut cropping in this area. The length of the rainy season varies from 5 months in the region south of Kano with 850 mm of rainfall, to 3 months in the most northerly part of Niger. North of Sokoto and Katsina, rainfall becomes marginal for cultivation except on flood land.

The rural population is made up of traditional cultivators, mainly Hausa, Fulani pastoralists, and settled Fulani, who, though relying heavily on cultivation and speaking Hausa, retain the animal husbandry skills of their forefathers (Morgan and Pugh, 1969).

Except in the heavily populated area around Kano, the cultivation system is principally rotational bush fallow. Bulrush millet occupies the greatest area, but groundnut, cowpeas, and sorghum are combined in rotation. Cereals are alternated with groundnuts for periods of up to 4–6 years and are followed by 5 to 10 years of fallow (Morgan and Pugh, 1969). Fields are communally owned and individually cultivated, but without manuring. In the area immediately surrounding a village, fields that are individually owned are well manured. In the densely populated region around Kano, manuring is practiced over the most important croplands.

Within Hausaland, groups of pastoral Fulani have established certain rights in seasonal pastures and in cropland, and migrate regularly between the areas as the need arises. These regions are also occupied by other groups, mainly Hausa cultivators, and close interdependencies have developed between the two communities. The pastoral Fulani do not depend on their livestock alone, but cultivate bulrush millet, sorghum, rice, groundnuts, and beans. Only a few of them have no arable holdings, for to subsist without cultivating requires large herds. In Sokoto, the average family of six has 30 cattle [van Raaij (1974) cites 10 per person among nomadic Fulani], which is insufficient to provide a living without grain (Morgan and Pugh, 1969). If a large herd is re-established, they may return to pure pastoralism; but the fact that most Fulani are now settled indicates the prevailing trend. In no region do pastoral Fulani account for more than 6% of the total population (Morgan and Pugh, 1969).

The Fulani who are settled rely at least as heavily on cropping as on livestock. Some migrate with their herds and flocks in the dry season, but most own only a few cattle and reside throughout the year at their homesteads.

Van Raaij (1974) reports that in the vicinity of Zaria, all ethnic groups value livestock highly. At least 85% of all rural households own livestock. In the Kano area (Hill, 1972), most households keep sheep, goats, and poultry, which are allowed to feed unattended around the settlement. Successful Hausa farmers may own cattle but nearly all animals are tended by the settled Fulani.

There is a widespread tendency in Hausaland to invest in livestock, particularly cattle. Hill (1972) found that in one Hausa community most cattle were owned by a few of the wealthiest farmers. Fulani aristocrats, well-paid government and company employees, and businessmen also invest in cattle (van Raaij, 1974). In general, such animals are entrusted to a Fulani within the owner's social sphere and often to the former owner himself. The owner realizes interest on his investment in the form of progeny, and the Fulani gets the milk.

All ethnic groups value meat, milk, and eggs as food (although donkey meat is taboo in Islam). In the relatively highly monetized economy of Hausaland (see Hill, 1972), there exists a lively trade in animal products through the local markets, with most milk and slaughter animals contributed by settled Fulani and, in certain seasons, by their pastoral fellow-tribesmen.

The manure linkage is possibly more important in Hausaland than anywhere in semi-arid Africa. Particularly in the densely populated Kano area, where widespread permanent cultivation is practiced, the use of manure (as well as household refuse) makes sustained crop yields possible. Compound sweepings (mainly goat, sheep, and donkey droppings) have a significant commercial value, and are commonly sold by poorer farmers to the more successful ones (Hill, 1972). Cattle herds are corralled on dormant fields whenever possible. Settled Fulani are obviously in an advantageous position in this regard. One aspect of the cattle investor-Fulani herder arrangement is that the owner has the right to recall cattle for manuring his fields (Hill, 1972).

In the case of manuring by corralling the cattle in the fields, an associated fodder linkage occurs. Manuring is done in the dry season, between crops, and this coincides with a serious deficit of fodder for cattle. Crop residues constitute a most important contribution to cattle nutrition, and the quantity of residues largely determines the quantity of manure for a farm.

In the case of the pastoral Fulani herds grazing the crop residues in the predominantly bush fallow areas, the opportunity to acquire animal products is considered much more important than the manure contribution (de St. Croix, 1972).

In areas of rotational bush fallow agriculture, tillage is by hoe; but in the permanently cultivated fields, plowing with oxen has become important. In Hill's study of 171 farmers, 13 owned oxen and about 80 more hired animals for plowing. The purchase of oxen and plows for contract work was found to be an increasingly common enterprise (Hill, 1972).

Although major population centers have existed in Hausaland since ancient times, there has been a recent growth stimulated by the commercial groundnut industry, which came into being with the establishment of the rail link between Kano and the coast in 1911. Commercialization of the rural economy, including land transaction, is probably more complete than in any other part of semi-arid Africa. One can expect that checks on continued growth of commercial cropping will occur due to failure to maintain soil fertility. As fallow periods shorten and more land becomes permanently cultivated, there will be an increasing shortage of manure as well as of fodder to support animals to supply manure. One obvious solution, recognized by colonial administrators 50 years ago, is ley farming. In 1929 a scheme to encourage mixed farming was initiated [for a history of the progress

and problems, see King (1939)]. Van Raaij (1974) has argued that adoption of mixed farming would be hastened if attention were redirected to those with the skills and values necessary for successful animal husbandry, such as the Fulani.

13.3.6 Bokoro Area

Bokoro is an administrative area in the center of the Département de Chari-Baguirmi, Chad. The Baguirmi area is part of a vast peneplain that stretches eastward from Lake Chad for several hundred kilometers. Bokoro sits astride the 500 mm isohyet and has a Sahelian climate to the north (mean annual rainfall down to 400 mm) and a Sudanian climate in the south (mean annual rainfall up to 600 mm). In the rainy season from May or June to September, there are on the average no more than 35 days of rain.

Agriculture in the Bokoro area is treated by de Wilde et al. (1967). The high variability in amount and distribution of rainfall makes cropping a hazardous enterprise. In the north the soils are mainly sandy, carrying bushed grassland of rather low grazing value. In the south the sandy soils, poor in organic matter but with modest fertility, are suitable for the cultivation of millet and groundnuts. In certain seasonally flooded alluvial areas, heavy black soils are used for cultivation of the bottom-land sorghum known as *berbéré*.

About 15% of the population of Bokoro is made up of nomadic Bororo Fulani pastoralists. Of the sedentary population (about 1.2 inhabitants/km^2), about 60% are Arabicized; among these, the Ouled Mouson predominate. Another 20% belong to the composite "black" population, mainly members of the Bilala and Louka tribes. The groups of Arab descent are traditional pastoralists, and today are the main stock owners. Stock rearing has been adopted relatively recently by the Negroid groups and among them is still second in importance to cropping.

Most of Bokoro lies in the Sahelian zone, and livestock rearing is the principal productive activity. In the Bokoro area there is an average of three cattle and three sheep or goats per capita. Most of the cattle are owned by the Bororo. They are commonly sold for slaughter, often in exchange for millet.

Cropping is mainly done on a shifting system. The principal crops are bulrush millet and groundnuts; secondary crops are beans, maize, sesame, potatoes, peas, and okra. The groundnut crop is the main cash earner. Depending on the inherent soil fertility, a field is cultivated from two to six years and fallowed for a minimum of two to three years.

Sedentary pastoralist-farmers invest in cattle, and their livestock are generally kept near the village, except in the dry season. Farmers often buy lean, three-year-old cattle for resale within a few years, using these transactions to compensate for fluctuations in agricultural output. Some cattle are kept to manure arable land, usually by corralling on fields for a considerable time. Where trypanosomiasis is a serious problem, farmers entrust their livestock to nomadic pastoralists.

In 1962 the Bureau pour le Développement de la Production Agricole (BDPA) contracted with the government of Chad to develop the Bokoro area agriculturally. Its main effort has been in promoting groundnut production and marketing. One means has been the introduction of implements and animal traction in the hope of expanding the area under cultivation and the yield per unit area. The use of

cultivators seems to have resulted in larger areas being planted. Seed-drills have improved yields by increasing the density of planting.

Ecologically, the Bokoro area is better suited to animal production than to cropping. Even after 15 years of promotion, it is questionable whether groundnuts exceed livestock and livestock products in commercial importance. In view of the inherently low productivity of the land and the low population density, it is likely that livestock production will continue to be of considerable importance in the future.

13.3.7 Western Darfur

The Western Darfur region includes the Jebel Marra and stretches as far as the Chad border with Darfur Province, Sudan. Apart from the volcanic Jebel Marra, the land is a gently undulating plain at about 900 m elevation, dissected by streams, or *wadis*. The average annual rainfall in the south—the area of a case study conducted by Barth (1967)—is 500–700 mm. The interfluves carry a woodland savanna vegetation. Permanent water is supplied by the sandy streambeds of the *wadis*, which are bordered by valuable alluvial soils.

The majority of the rural population of the southern zone of Western Darfur are village-dwelling hoe cultivators, most of whom are rural Fur. The second largest group is that of the nomadic Baggara. Other minor groups include the Fulani cattle-nomads who have moved in recently from the west, and camel-nomads who appear in the dry season.

Fur cultivators traditionally grow rainfed subsistence crops of sorghum and bulrush millet on a shifting system. Rainy season cash crops include chilies, tomatoes, sesame, and okra. In the dry season, onions, wheat, potatoes, garlic, and native tobacco are grown under irrigation in the lower *wadis*, along with irrigated orchard crops. Most buying and selling is done at the weekly village markets. Traditionally, livestock are of little importance in Fur production. Although goats and, in some areas, cattle are owned in relatively large numbers, they are mainly objects of investment and saving, realizable in cash through sale (Barth, 1967).

Most Baggara pastoralists cultivate bulrush millet in the rainy season, but others are essentially nonagricultural. Millet and butterfat are bought and sold at the weekly markets; and some cattle are sold locally, although most are exported from the area.

Within the Fur community, the primary crop–livestock linkage is that of investment. It is possible for the successful Fur cultivator to build up a herd, but with paradoxical consequences (Barth, 1967). As the herd grows, the farmer becomes more concerned with its welfare than with that of his farmland. When the herd size exceeds about 10 head, the owner tends to shift his emphasis from the *wadi* bottom to the upland grazing areas. If the herd continues to grow and becomes larger than 20–30 head, the former successful farmer becomes a full-time nomad. A rate of about 1% per annum disappearance from the lower *wadis* is reported. The paradoxical quality of this phenomenon is enhanced by the fact that Fur cultivators scarcely utilize milk products at all.

A more recently encountered form of investment by upland cultivators is that of purchasing, tending, fattening, and reselling Baggara cattle. Usually they buy two-

year-old bulls, keep them for three or four years, and sell them at twice the purchase price.

Manure is highly valued by Fur cultivators, but is used mainly on horticultural crops.

In addition to the exchange linkage between cultivators and pastoralists, there is a rather remarkable ecological linkage. Although the alluvial lands along the *wadis* are the main agricultural production lands, they are also traditionally important dry-season grazing areas for Baggara cattle. Following the crop harvest in November, cattle are brought from the upland wet-season grazing areas into the alluvial areas where they feed on sorghum crop residues. A critical fodder shortage is encountered late in the dry season, when pastures and residues are depleted. At this time the herders camp on the fields and the cattle feed on the residues of surrounding fields by day and on the pods of *Acacia albida* in the camps at night. Since they spend the night under the *Acacia* trees, much manure accumulates there. The effect of this is seen in better sorghum yields. Studies have indicated that the organic matter falling from the trees also improves the soil fertility (Giffard, 1971). *Acacia albida* has the important characteristic that it loses its leaves during the cropping season; consequently, it does not shade crops during grain filling. This tree appears to have value to both cultivators and herders, and occurs widely in cultivated areas of the northern Sudanian zone.

It is not surprising that an important competition linkage has developed between Baggara pastoralists and Fur cultivators in the dry season on certain alluvial areas. The crucial dry-season value of the water, grazing resources, and *Acacia* trees in these areas is obvious. Although the pastoralists have traditionally used this land, they have no legal right to do so. Irrigated cropping spreads at the expense of the best grazing resources, and it is accepted that irrigated land is virtually privately owned. Traditionally, Baggara camps were welcomed by the cultivators for the manure contribution, and the herds departed before wet-season crop damage became a problem. But because Baggara cattle are not carefully herded, they are a menace to dry-season irrigated crops. Irrigation commonly develops in a strip along the *wadi* which, if properly guarded, effectively excludes the Baggara herds from water.

In favorable locations a limited form of mixed farming exists among agricultural Furs. Large herds are sent to graze elsewhere in the rainy season, and in the dry season are kept on the fields at night. Under this system of manuring, millet can be grown continuously for 15 to 20 years, rather than the usual 3 to 5 years.

As a result of an increasing desire for consumption goods, the trend in Western Darfur is toward cash cropping. Implementation includes rapidly expanding the cultivated area, thus increasing the possibility of a growing conflict of interest between cultivators and pastoralists who in the past have enjoyed a symbiotic coexistence.

13.3.8 Harar Province, Ethiopia

A very interesting spectrum of combinations of pastoralism and cultivation is found in an area in Harar Province, Ethiopia, south of the Chercher Highlands, extending south into the Ogaden, and from the 42nd Meridian eastward into

Somalia. East of the Jijigga to Degahabur road, the land consists of rolling plains of virtually treeless grasslands in the north and gently undulating plains of *Acacia* woodlands and bushlands further south. Land to the west of this road consists primarily of deeply dissected limestone plateaus and the associated river valleys. Elevation and mean annual rainfall decline from 2000 m and 500 mm in the north to less than 1000 m and 200 mm in the south. Soils of the wetter areas are predominantly fine-textured and relatively fertile.

Although the entire area was formerly occupied by sedentary Kotu Gallas, most of these people have been forced westward or assimilated by Somali clans from the east. Today the areal pattern of land use conforms closely to clan holdings. For example, in the northern part of the area, virtually all arable land is cultivated and livestock are of secondary importance. The Geri and Jarso clans have cultivated here for perhaps 80 or more years and population pressure is high. The Abaskul, further south, are relatively recent farmers and only about 50% cultivate. Among all clans seasonally migratory husbandry of cattle, sheep, goats, and camels is important. The Awal have strongly resisted cultivation and rely entirely on nomadic pastoral activities. Our discussion of agriculture in Harar Province is based largely on unpublished information of the Ethiopian Livestock and Meat Board and the International Livestock Centre for Africa, Addis Ababa.

Although the relative importance of farming and pastoralism varies greatly, the characteristics of agriculture are remarkably uniform. Land rights are vested in the clan and thereby in the village. Individual farmers have plots permanently allocated to them, but these cannot be sold. Except for the northern areas, land is plentiful and only a portion of a man's plot is cultivated. Fields are permanently cultivated in the north because of the scarcity of land, and in other areas because the soils are sufficiently fertile. Principal crops are sorghum and maize; wheat and barley are often sown late, following failure of sorghum or maize. Maize is grown in woodland areas where birds are a major problem. Cropping is a high risk endeavor due to unreliable rainfall and, to a lesser extent, late season frost. Water-harvesting techniques are widely used to augment incident rainfall. Yield in normal years is sufficient for subsistence; in good years, surpluses are sold.

Livestock are herded locally on uncultivated areas during the wet season. In the dry season they are fed on crop residues in their corrals and herded on stubble fields. When either feed or water run out the livestock are moved into distant river valleys until the next wet season. The primary investment opportunity is in livestock, mainly cattle as oxen. In densely populated areas where grazing resources are scarce, herding of cattle is commonly contracted to pastoralists.

The food linkage is very important. Both Galla and Somali are fond of milk, ghee, and meat; the Somalis prefer camel's milk.

Manuring of fields is practiced in the densely settled northern areas, but manure is always in short supply. In other areas farmers contend that they get an uneconomic response to manuring.

Throughout the area the draft linkage is universal, the Somali presumably having adopted the practices from the Galla. The fields are plowed with a furrow-opener-type plow and the seed is broadcast. When plants are 30 to 40 cm high, the plow is used again in a process that creates rows by cultivating out "inter-row" plants. In addition to hand weeding, subsequent inter-row weeding is done with the

plows. Many farmers consider that disturbing the surface soil crust allows higher infiltration and is of even greater importance than the weeding effects of plowing. Although teams of oxen are preferred for traction, camels and donkeys are used in emergencies, e.g., following the recent drought, during which most oxen were sold from the area.

Among the Galla, fattening oxen for sale is an old tradition. Forage includes crop thinnings, weeds, and lower leaves stripped from crops.

Although no forage crops are grown, the fodder linkage is very strong. The price of stover per camel load (enough to feed a camel for 30 days), increased six- to sevenfold in the drought of the early 1970's. Sorghum stover is more highly valued than that of maize because of its greater digestibility. The mixture of bran and germ from threshing is a highly valued supplement.

Most trade is conducted on a cash basis in centers such as Jijigga and Babile. The locally grown grains, milk, ghee, and livestock are sold, and rice, dates, spaghetti, tea, sugar, and clothing are imported.

The history of relations between Somali and Galla, and between individual Somali clans, features conflict over the resources of production. In recent years, the Ethiopian government has resumed control of tracts of land that were being disputed by neighboring clans. Such conflicts inevitably involve cultivation rights, since grazing rights are communal across clan distinctions. A serious form of competition has developed after the drought. For example, the Fafan River valley has traditionally been the dry-season grazing area for a number of clans, e.g., the Abaskul. Recently a number of Abaskul have settled and are cultivating in the Fafan. They are, however, simultaneously building up their depleted herds. As yet, the area of land actually removed from the pastoral system is still very small, but the effect of having sizeable herds grazing throughout the wet season on the amount of forage available for nomadic herds in the dry season appears serious.

It is generally recognized that producers with both crops and livestock fared best in the drought. Grain crops that failed still provided forage for livestock. Cattle were sold off to buy grain. If a man had sufficiently large herds and fields he came through with only moderate losses. Most producers, however, lost a large proportion of their stock, and cultivation has increased markedly. Many new farmers plan to return to nomadism when their stock numbers increase, but others have no plans to return.

As population grows, it is to be expected that cultivation will increase. Even the strictly pastoral Awal are considering cultivation. The problem of declining soil fertility in the old, densely settled, farming areas of the north is alarming. Programs that increase the amount of livestock kept within the area, e.g., the current IBRD Small-Holder Fattening Project, hold the prospect of retarding the decline in soil fertility and providing alternative income.

13.4 Trends in Organization of Linkages

The purpose of this section is to provide an evolutionary account of linkage development by considering what kinds of linkage can be expected to develop under various conditions: it is historical only in the recognition that some sets of

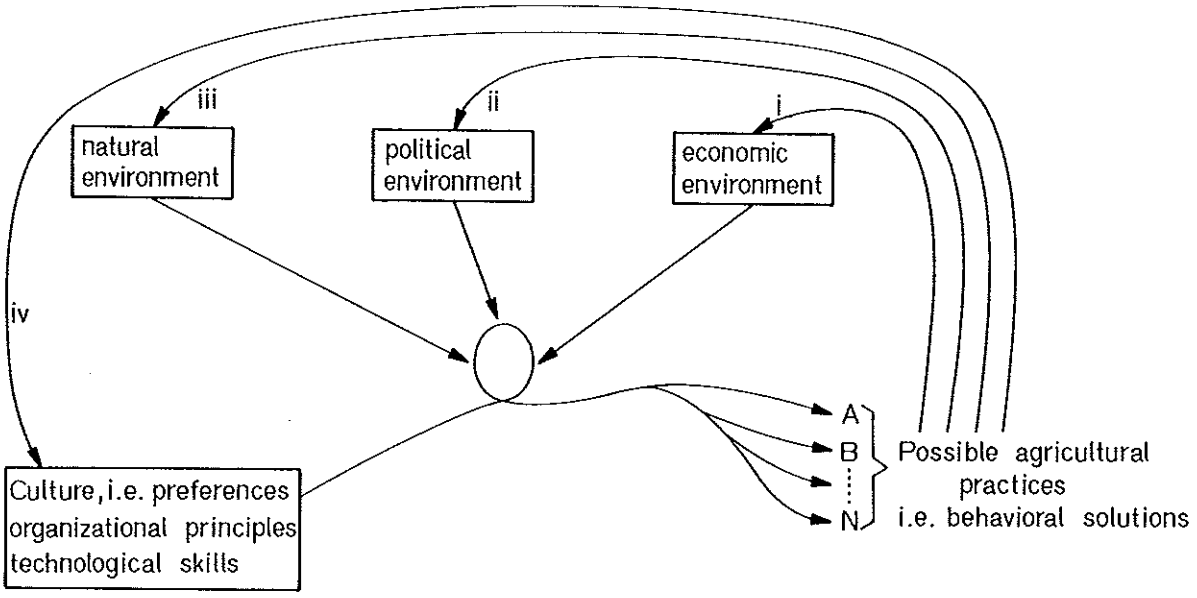

Fig. 13.2. The scheme of evolution of agricultural practices. From the starting point of culture, practices are selected for by factors in various environments, all of which are influenced by feedbacks from current practices

conditions are specific to certain periods of time. Different linkage organizations are viewed as techniques of adaptation to prevailing conditions rather than steps in a unidirectional and irreversible sequence, e.g., from shifting cultivation to mixed farming.

13.4.1 The Process of Adaptation

An established agricultural practice or management strategy is the result of a complex evolutionary process. In order to understand a change, the lack of change, or the likelihood of a change, it is necessary to understand the nature of the process of adaptation. A general perspective can be gained from Figure 13.2.

The starting point is the pool of technological skills, organizational principles, and preferences held in common by a given group. These aspects of culture form the basis for behavioral solutions to problems of adaptation. What concerns us here are practices related to cultivation and animal husbandry, particularly forms of integration and how these are selected with reference to the economic, political, and ecological contexts, respectively.

13.4.1.1 Economic Viability

Absolute viability is that production threshold where costs are equal to returns. Obviously, achievement of this threshold is a necessary condition for the maintenance of any specific practice. However, practices that are viable in this sense are subject to further selection of a relative nature according to which are most satisfactory to the management units as strategies of value maximization. This is primarily a matter of weighing the disutility of labor drudgery against the utility of return to labor (consumption satisfaction and investment opportunity).

13.4.1.2 Political Viability

The maintenance of any cultivation system requires that management units be able to rely on political support for right to the resources they have invested in the process of production. Today such support is to a large extent mobilized and exercised through the political and administrative framework of the state. Political pressure is applied by special interest groups, mainly on the central governments, on matters such as land and labor legislation, taxation, subsidies, and foreign trade policy. In the past, however, support had to be mobilized at a local level, and the effort required for this mobilization detracted from production activities.

It is important to note in this context that there is no direct relationship between the efficiency of a cultivation system (in terms of returns on land and labor) and the efficiency of the corresponding political system (in terms of mobilizing support for defense or expansion). Thus, selection pressures operating on political viability do not necessarily lead to a succession of economically more efficient forms. An example of such incongruence between the economical and political organizations is found in southern Ethiopia.

The cattle-herding Boran Gallas in Sidamo Province depend on a number of deep wells for water. These wells are quite complex structures which require continuous maintenance and a large input of coordinated labor to operate. Each well is managed by a "well council" and a number of elected officials. The physical labor is supplied by the actual users of the well, in proportion to the number of stock they water. Boran wells are nominally owned by clans, but as members of any clan are widely dispersed, recruitment to the well council follows a number of different principles. The composition of the well council is a reflection of the complex Boran kinship system, and the operation of the wells reflects the high degree of inter-tribal solidarity in Boran culture.

Over the past century, the Boran have been pushed westward by the militarily superior Somali, whose ability for mobilizing personnel rapidly for military purposes has enabled them to expand gradually. However, the Somali clans which have taken over exclusive rights to the Boran wells do not seem to have the organizational capacity for cooperation and coordination of the labor inputs needed for their maintenance. Consequently, their production system is less efficient than that of the Boran in terms of what they are able to extract from the environment, since they cannot utilize the grazing lands as completely.

13.4.1.3 Ecological Viability

Adaptation in the long term must be judged by the degree to which the land use practices can be maintained without a decline in the productive capacity of the land. The productivity of land under any form of use is maintained as long as the intensity of exploitation is below the productive capacity. Ecological viability is thus threatened when demands on the production system exceed the supply capacity of the system. In the case of overcropping this is manifested by degradation of soil chemical and/or physical properties. Overgrazing reduces the productivity of valuable forage species directly; it reduces productivity indirectly by adversely affecting soil surface properties which are linked to infiltration and erosion. The

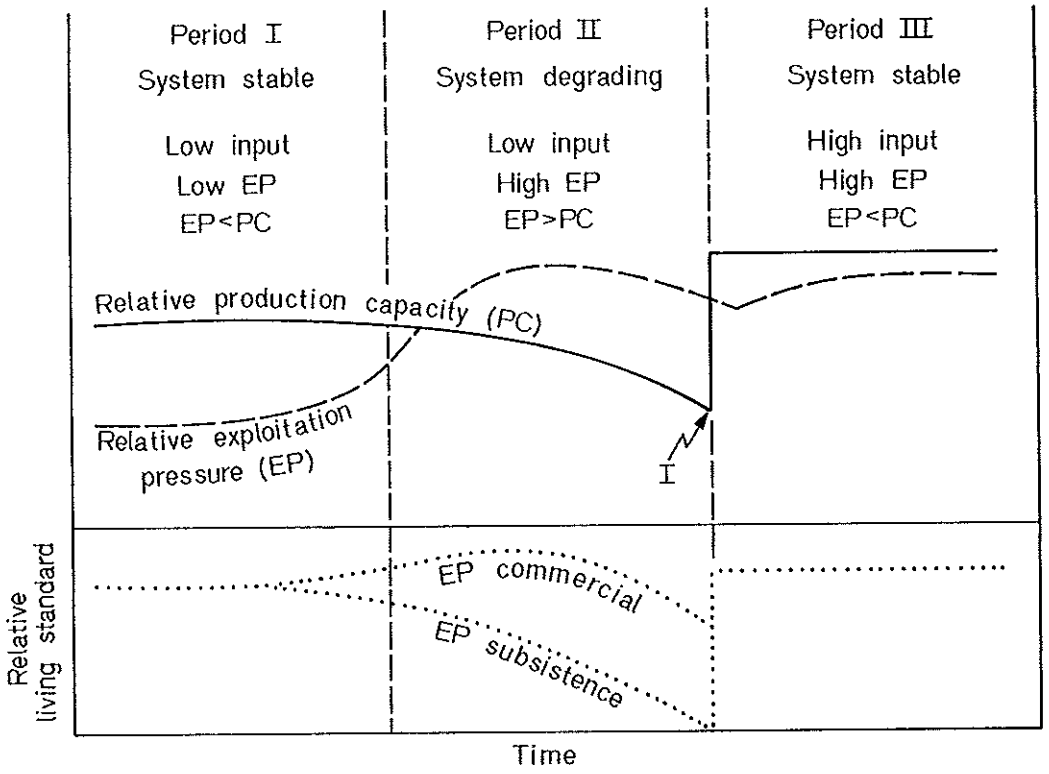

Fig. 13.3. Generalized relationships between the production capacity of land, exploitation pressure on the land and the living standard of the exploiters. *I* indicates introduction of a major technological innovation

occurrence of over-utilization is determined by technological, economic, demographic, and political factors through their individual effects on the intensity of exploitation of the land resources and on the production capacity of the land. In Figure 13.3, a hypothetical sequence of three production situations is presented. Period I represents a situation of a human population of low density, practicing subsistence agriculture or pastoralism. There is a substantial margin between the average production capacity (PS) and the exploitation pressure (EP). (The figure depicts smoothed long-term changes; in reality there would be important short-term fluctuations due to drought, dissease, war, etc.) Inputs to production are modest, but as long as the population is low and production is primarily for subsistence, the system is ecologically stable, as is the standard of living of the producers.

Entering period II, the pressure of exploitation is increasing rapidly and eventually exceeds the production capacity, resulting in degradation of the latter. If the main cause of increased exploitation pressure is increased population, then one would expect the average standard of living to decline. If, however, the stimulus to increased exploitation is economic (e.g., an attractive new market), then the expansion of commercial production should increase the standard of living initially, but it would fall off with declining productivity. With sufficient decline in production capacity, exploitation pressure declines in response to (1) decline in population, as individual households fall below the minimum subsistence level, or (2) return of the most marginal commercial fields to fallow.

A major production innovation initiates period III, e.g., a shift to ley farming with fertilizers, introduction of chemical pest and disease control, an irrigation scheme, etc. In the main, the technology required to provide the major increase in the production capacity is available. The major constraints to implementation are economic ones related to cost-price relationships. In Figure 13.3, population stabilizes in period III. This could occur only as a result of deliberate political and administrative policies. Without such effort the technological gains in production capacity would soon be negated by increased exploitation pressure.

The dominating importance of population growth rates on ecological viability is clear. The central question is, given a certain land area with its inherent production limitations and a certain type of technology, how many people can be supported without reverting to land-use practices that are ecologically harmful? One of the main regulators of human pressure on land is the existing system of land rights, which is both variable and complex. The most important distinction is between landright systems based on inheritance and systems based on descent.

Inheritance systems are usually associated with individual tenure and imply a mechanism for transfer of rights in specific plots. The central problem in this context is whether the inheritance rules allocate rights to a multitude of inheritors (a situation which stimulates land fragmentation) or whether the rules designate a single inheritor to the plot (a situation which stimulates consolidation of land holdings and reduction of population pressure by exclusion).

Descent systems are associated with communal tenure where land constitutes an estate of a descent group. Rights to exploit this estate follow automatically from group membership, which is typically allocated on the basis of kinship in one line, either male or female. Such a situation stimulates neither fragmentation nor consolidation, but accumulation of people on the land. This system was well-adapted to a context of shifting subsistence agriculture and low population density. With increasing population pressure, more efficient technology, and greater involvement in the cash economy, it is coming under increasing strain. In the long run, it is the least adaptive of all. Since the cultivating units are not permanently associated with specific plots of land, they lack the opportunity to excercise land management individually.

Since ultimately all types of landright systems are politically sanctioned, an evaluation of ecological viability requires an analysis of the political forces maintaining specific landright systems.

In discussing trends of integration of agriculture and livestock, it is important not to confuse the different types of adaptation. The fact that some forms are adaptive in the economic and political sense, i.e., that they are accepted and expand rapidly, does not imply that they will have long-term viability. Forms are selected primarily with reference to their competitiveness in an economic and political context. The problem is that the ecological implications work in a long-term perspective. When these implications are eventually manifested in decreasing returns to land and labor, the organizational practices may be tied up in forms of an involute character. For example, the population's response to the ecological situations may serve to reinforce the deteriorating trend without leading to organizational changes.

In terms of Figure 13.2, the argument can be formulated in the following way: behavioral solutions are selected with reference to how satisfactory they are as strategies of value maximization, given the preferences and skills of the producers and the limitations imposed by the conditions under which they operate. The economic and political environments are of dominating importance in determining the viability of the chosen solutions (A, B, N). These solutions have feedback effects on the economic environment, in the sense that they affect the scarcity of goods and services, and on the political environment, in the sense that they affect the distribution of power. The effects of the natural environment are long-term, and are manifested in decreasing returns to land and labor. The structure of the cultivating system is of vital consequence for the kind of behavioral feedback this ecological change stimulates. The feedback may be positive, e.g., a response that reinforces the trend, or negative, e.g., a response that tends to reverse it. Feedback can be mediated by supply and demand mechanisms, by political mechanisms such as warfare or restrictions on the people's access to resources, or by the mechanisms of learning, i.e., the cognitive re-evaluation of the underlying cultural premises as their behavioral consequences are experienced. Such understanding of the strains on adaptation is a stimulus to change, but it is not effective unless people have the organizational opportunity to take action on the basis of their knowledge.

13.4.2 Conditions and Adaptations in the Semi-Arid Zone

In this zone, the linkages between agriculture and livestock have been organized in various ways at various times and places. Some organizational trends that have emerged in relation to the environmental, economic, political, and demographic conditions that prevail in this geographic region are outlined here.

The extreme seasonality of rainfall, pasture growth, and drinking water supply tends to enforce (1) extensive animal husbandry based on migration between different ecological zones (toward the desert in the wet season and toward the forest in the dry season), and (2) agricultural settlements in areas where rainfall is sufficient for cultivation and where water is available for domestic purposes throughout the year. Environmental conditions thus produce a tendency toward a dichotomization of production, namely between pastoral nomads and sedentary cultivators.

In the prevailing situation, where the factors of production are not monetized and where the external markets for agricultural and pastoral products are limited, there is little opportunity for the growth of the cultivating enterprise, and consequently investment strategies are directed toward the pastoral sector. Thus, the typical pattern shows a flow of capital from the agricultural to the pastoral sector, which may be accompanied by a flow of personnel in the same direction (nomadization) if the natural conditions are unfavorable to a combination of agricultural and pastoral acitivities. This is exemplified by the Western Darfur case, discussed above.

The reverse process, that of sedentarization of pastoralists, is also controlled by economic circumstances and occurs through loss of economic viability when there are insufficient livestock to support the household unit. Although households may borrow animals to maintain viability, they usually resort to cultivation for

subsistence. This alternative is usually feasible because of the small capital required (essentially the cost of seed), the high rate of return, and the fact that the land is free.

Until recently, political conditions were characterized by dependence on local support for security and control over the processes of production. In some areas this is still the case. One form of organization was the formation of the large-scale state with specialized administrative and military apparatus, exemplified by the Mossi state. A second form was the more fluid organization typically based on kinship loyalties and clientship and involving little specialization of administrative and military functions. It featured great flexibility in rapid ad hoc mobilization of personnel for raiding and defense, and so suited most pastoral groups. A third response was the localization of population in areas easily defended because of their relative inaccessibility, as among the Dogon of the Bandiagara Plateau, Mali.

When population density is low, the optimal behavioral response with regard to the balance of labor drudgery and income satisfaction is mainly extensive shifting cultivation or pastoralism. Integration is usually limited to investment and food linkages, the latter mainly via milk. Such a form of integration is more accurately described as an agro-pastoral combine than as mixed farming. Where low population pressure occurs, the linkages between specialized pastoral nomads and cultivators are primarily those of exchange. A greater number of linkages can be expected under conditions of high population density, as in restricted refugee areas, where shifting cultivation is not able to provide for subsistence needs. In these areas, more intensive forms of cultivation develop, with livestock as an integral part of the farming system and with most of the elements of mixed farming, except for draft plowing and the sowing of forage crops.

Urban areas, which usually begin as centers for trade or administration, present another picture. The food requirements in these areas completely utilize the land resources nearby. To supply these requirements with a system of shifting cultivation, it is necessary to utilize farmland at greater and greater distances from the population center, thus increasing transportation costs and reducing the reliability of supplies. One alternative is to adopt a more intensive system with livestock linkages, as described in the Hausaland case from Kano, northern Nigeria. Here the change from shifting to more intensive cultivation has stimulated a change in organizing principles from communal control of land to more private control. In contrast, failure to modify tenure principles can result in environmental deterioration such as that which occurred around Nyala, Sudan. Here unregulated charcoal production and stocking have resulted in deforestation and overgrazing. In addition, under conditions of intense pressure on land, the legal tenure system, which stipulates that landrights lapse if plots are left uncultivated for more than two years, has encouraged overcropping.

13.4.3 New Trends and Their Implications

Several of the conditions discussed above have changed significantly in this century, and new trends in land use and the organization of linkages between livestock and cultivation have developed. This section deals with three changes and the trends they stimulate, and concludes with a discussion of the overall implications of the changes.

13.4.3.1 National Pacification

The most important change is that security and guarantees for rights to production resources are now maintained by the administrative apparatus of national governments. In general terms, this has resulted in wider access to land formerly retained by pastoralists for the exclusive use of their own particular groups. One development has been expansion of the areas of cultivation. With rare exceptions, the land is considered to be communally owned, and rights of exclusive use are held only as long as the land is actually cultivated. Part of the pressure for expansion of cultivation has come from groups formerly living under conditions of high population density for reasons of defense. As seen from the results of population movements from the refugee hill areas of West Africa, and from Wakara Island in Lake Victoria, there is a tendency to change from systems of intensive cultivation with a high degree of livestock integration to shifting cultivation with a low level of integration. The expansion of cropping has been partly due to the attitude of local pastoralists that if grazing land is to be sacrified to cropping, they themselves might as well be the beneficiaries. Widespread cropping by Somali pastoralists in Harar Province, Ethiopia, illustrates this attitude.

A second manifestation of intensified use is the increasing density of grazing animals in certain areas. Formerly, control over grazing lands was maintained by the continual conflict of pastoral groups with their neighbors. This acted as a check on stocking rates. With the elimination of group controls, all grazing land became equally available to any and all stock, regardless of ownership. One important result of this trend has been to make it easier for sedentary cultivators to invest in livestock and to keep them under a migratory system.

Another development is the apparently universal tendency of governments to favor cropping pursuits over nomadic pastoralism. This is reinforced by the fact that pastoralist interests are seldom strongly represented in government, while considerable pressure is exerted toward increased settlement. Although some ranching schemes have been initiated, as, for example, in Kenya and Nigeria, it can be expected that most settlement will result in small landholder combination of animal husbandry and cropping.

13.4.3.2 Urbanization

The overall population growth is not equally distributed in rural and urban settlements. Urban growth rates of about 7%/year seem to be typical for the savanna belt. These rates reflect the net effect of a substantial rural-to-urban migration, usually caused by the promise of employment opportunities in the town and the result of limited income opportunities in the rural areas. The growth of urban centers has significant implications for the structure of farming systems. Other potential developments relate to the demand structure of the urban populations.

13.4.3.3 External Demand for Crops and Livestock, and External Supply of Consumer Goods

The major shift in demand for crop and livestock products from the areas of production in the Sahelo-Sudanian zone of West Africa took place as a result of the shift in trading from the traditional northern centers to coastal locations (Morgan

and Pugh, 1969). The development of coastal ports has made possible the large-scale export of products, most notably groundnuts, and the ports themselves have become major markets for food crops, meat, and milk. The growth of these ports has also enhanced the availability of imported goods, thus increasing the consumption demand of subsistence producers. This in turn has resulted in a readjustment of the balance between labor drudgery and consumption satisfaction to a higher level of productivity that provides a surplus for sale. Frequently this readjustment is expressed as a change in agricultural production from subsistence toward cash crops, such as groundnuts or cotton, and a redirection of livestock production from local consumption toward export.

The result of this shift is an increased cultivation of land. Initially this takes the form of clearing previously uncultivated bush, thus increasing the scale of the bush fallow systems, as in the groundnut area of Cayor District, Senegal (Morgan and Pugh, 1969). Eventually land becomes scarce, fallows shorten, and low soil fertility becomes a serious problem.

In the Baol District, Senegal, the Serer have had a traditional rotation system that includes a pasture fallow and other manure concentrating practices. In some of the areas experiencing greatly increased exploitation pressures, however, pastures in rotation have disappeared, along with permanent grazing areas (Morgan and Pugh, 1969). Ruthenberg (1971) points out, with particular reference to the groundnut areas of Senegal and Nigeria, that the more rapidly the commercialization of production has been achieved, the less farmers worry about conserving the soil at least until sources of new land are exhausted.

Two or three forms of integration of livestock become important under these conditions. One is the use of draft animals to increase labor productivity and thus facilitate the expansion of cropping, as in Senegal. The very linkages that are reported as being abandoned in Baol, Senegal, are the ones that contribute toward long-term stability, specifically manuring and leys. An alternative would be commercial fertilizers, but this would require substantial changes in current cost–benefit relationships.

There is a growing demand for meat and milk in the population centers of sub-Saharan Africa, and for meat in the Arabian Gulf states. Nigeria, the most populous country in Africa, is experiencing a meat shortage and is importing large quantities of beef. This situation has stimulated a great deal of interest in ways to utilize the nation's cattle better, a resource found almost exclusively in the Sahelo-Sudanian zone. One approach is to increase the commercial output of cattle from pastoral areas by increasing the rate of slaughter of mature males. Another is to develop new areas for more intensive animal husbandry, mainly "grass fattening", which would also serve to increase output from range areas by providing a market for young male animals. This stratification is being attempted in Nigeria by the utilization of natural pastures in high potential areas previously under-utilized because of tsetse infestation, and which are now usable because of tsetse eradication or of trypanosomiasis prophylaxis.

In most areas where stratification of livestock production is contemplated, fodder crop cultivation will be necessary. This is a serious constraint because of the generally more favorable short-term returns from alternative uses of land and labor. It means that market prices must be very high, with good prospects of remaining that way, before fattening can compete economically with cash crops for

returns. (As noted in the discussion of the Western Darfur and Harar Province, limited smallholder fattening is taking place without fodder crops). In addition, it is unlikely that stratification would become economical without a substantial premium being placed on fat beef. Without this, pastoralist breeders can be expected to hold males until mature, rather than to sell young animals, since the opportunity cost of retention is so low (grazing is free).

A substantial increase in milk production is unlikely without fodder crops. The constraints on profitability of such crops for milk production are somewhat less than for fattening, since there is a growing high price market among the higher-income urban populations. An implication is that increased commercial milk supply cannot be viewed as a future source of protein for the undernourished poor.

13.4.3.4 Population Growth

Better health facilities in recent decades have led to a dramatic decrease in human mortality without a concurrent decrease in birth rate. There is an annual rural population growth rate of between 2% and 3%. At this rate the number of cultivating units will double every 20 years or so. The limited amount of land suitable for cultivation points up the inevitable increased intensity of land use, i.e., a higher R value. (Ruthenberg (1971,3) defines R as the number of years of cultivation $\times$ 100/number of years of cultivation and fallow.)

Among pastoralists, the number of animals that can be maintained varies widely according to the availability of forage and water resources. Given (1) a growing human population, (2) a minimum number of animals required for subsistence, and (3) an upper limit to the number of aniamals that can be kept on a given area, the system is far from stable. It is inevitable that a certain number of households will fall below the viability level and either consume their capital and be eliminated from the pastoral sector, or they will supplement their incomes in alternative ways, primarily by cultivation. Although this transition is entirely rational from the standpoint of the individual household, the aggregate effect is to increase the pressure on pastures even further.

13.4.3.5 Overall Implications

The overall effect of the various changes described above is that sooner or later, following the increase in the number of cultivating units and the amount of land under cultivation, the exploitation pressure will exceed the production capacity of the land.

The implications for traditional pastoralism are various. Where agricultural expansion takes place within seasonally critical pasture areas, it is likely to stimulate a snowball effect, i.e., a decrease in pasture resources, forcing more pastoralists to cultivate, and thus reducing pasture resources even further. Conflicts may develop between pastoral and agricultural interests, depending on whether pressure on pastures leads to an elimination of marginal pastoral households or to an increase of pastoral households with agricultural interests.

If natural conditions confine agricultural expansion to areas where the cultivating season corresponds to the season when the pastoralists are exploiting other ecological zones, there may be a positive linkage between agricultural and pastoral enterprises. The value of most crop residues is higher than that of native

pastures, which permits larger numbers of animals to be carried through the dry season.

The implications for the cultivation system mainly concern the process that leads to the deterioration of soil resources. What solutions do people find to this problem? Do they adopt mixed farming, which has a retarding effect on the deterioration process, or do they find alternatives that actually reinforce the downward trend?

We know that in earlier times the populations of the semi-arid area found solutions that enabled them to maintain soil fertility. However, the following sets of circumstances, to which a substantial number of the inhabitants of this zone are exposed, mitigate against this: (1) a management system that requires long fallow periods to maintain fertility, (2) a communal land tenure system under which a cultivator's rights to his fields lapse if the fields are left uncultivated, (3) increased intensity of land use by cultivation (R), (4) rapid population growth, and (5) demand for labor from modern sector units.

Since the land tenure system implies that the units of production have no certainty of appropriating the benefits of improved soil management, we are faced with a situation that invites exploitation of soil fertility and consequently environmental destruction. It is thus likely that initial economic expansion in the traditional agricultural sector will lose its momentum as pressure on land increases. The probable result is the emergence of national economic structures characterized by duality. The population increase is absorbed in the traditional sector, but decreasing returns to land and labor stimulate an increase in the supply of labor migrants to cities. Low wages motivate the migrant to maintain ties with the home area, where he keeps his wife and children and to which he will return in his old age. In its extreme form, a dual economy is characterized by a wage level lower than that required to totally support families in the city. Through the mechanism of labor migration, however, the supply of labor is maintained because it consists of units that derive a significant fraction of their income from subsistence agriculture. If such a trend develops, the growth of modern sector enterprises whose economic viability is based on a continuing supply of cheap labor can be envisaged. In particular, if most of the modern enterprises produce goods for the export market, their profit is thus not dependent on buying power within the country, and it is likely that strong political interests will be involved in maintaining the conditions that guarantee a cheap labor supply, i.e., a continuation of the traditional cultivation system.

13.5 Conclusions

The general picture that emerges from the above discussion is not encouraging. Adaptations to former conditions are proving nonadaptive to new conditions, and new adaptations are slow in developing. It seems appropriate to conclude this chapter by focusing on the most important problems of agricultural production in this zone and to consider the prospects of solutions involving increased integration of livestock.

Perhaps the most obvious general problem is that of declining production capacity of land as a result of over-utilization. This is due primarily to an expanding

population of subsistance cultivators. However, in localized situations this over-exploitation can be attributed to commercial motives. A second major problem is the constraint on growth of commercial enterprises due to low labor productivity. This is closely related to the problem of over-utilization, in that recovery and maintenance of production capacity requires increased inputs which are possible only with higher commercial returns resulting from increased labor efficiency.

Solutions to the problems of increasing and maintaining production capacity are largely technological in nature. In general, appropriate use of commercial fertilizers, herbicides and pesticides, and tractor implements would go a long way toward solving both problems. But due to the generally unfavorable cost–return relationships, resulting, in part, from the inherently low production ceiling and the high risks imposed by the climate in this zone, implementation of such solutions is likely to be rare. It is natural to look alternatively to more intensive farming systems with integration of livestock for solutions to these problems.

Use of sown legume-based leys in place of bush fallow could probably regenerate soil fertility, allow plow cultivation, and provide increased amounts and quality of forage to support greater numbers of livestock. However, the obstacles to development in this direction should not be underestimated. Ruthenberg (1971,80-82) raises the following problems: (1) the economics of ley farming in these areas are not proven, (2) short-term leys are unlikely to maintain fertility without addition of manure or other fertilizers, and yields are inherently low and risks are high, (3) the costs are high (clearing of timber and stumps, constructing roads and buildings, and purchasing oxen and implements, (4) the increased investment requires a commercial livestock enterprise with high prices for animal products, (5) in most cases, land tenure systems must be changed to ensure exclusive use of leys by the investors, and (6) the system must be initiated in a coordinated manner.

What factors are likely to influence development toward the more ecologically viable, intensive mixed farming system? First, the deterioration trend itself is evidence of the inadequacy of the cultivation system and may act as a stimulus to change. But as Ruthenberg (1971,82) points out, although yields are declining in many areas due to over-cropping, they may have to decline much further before there is sufficient incentive to change.

An increasingly important trend, which encourages the higher input required for intensification, is the growing demand for consumer goods and investment objects. As land for cultivation becomes scarce, the importance of maximizing return on land increases. This can be effected only by increasing inputs.

Political-administrative inputs in various forms (land tenure, taxation policy, subsidies, etc.) constitute a most important mechanism in providing new opportunities for farmers, and thereby stimulating the desired behavioral solutions.

Increased knowledge of alternative technology may speed up innovation. Although it is difficult to envision this as being of great importance in the absence of other stimuli, there are undoubtedly contributions to be made in research, and perhaps more importantly, in extension. However, a substantial effort on the part of those concerned with facilitating change through biotechnical research and education must be directed toward understanding the political, socio-economic, and cultural aspects of the existing situation if realistic expectations and relevant programs are to result.

Finally, solutions to the problems of over-utilization via control of exploitation pressure on rural land must not be ignored. Although these solutions are beyond the scope of agricultural science, it is clear that without effective action by enlightened politicians and administrators the future is bleak, irrespective of the accomplishments of agricultural technology. It is especially important in semi-arid regions, where the production potential is modest and the risks high, that policy makers have realistic expectations of agricultural development, and thus be required to consider the politically unattractive alternatives that are necessary to control exploitation pressure on land.

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