

COMPETITION AND THE INTEGRATION OF AGRICULTURE
AND CATTLE RAISING IN SAHELIAN AND SOUDANO-SAHELIAN AFRICA¹

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INTRODUCTION

Situated between the Sahara, traditionally the domain of pastoral nomadism, and the Sudanian zone, the Sahel zone has long been a place of encounter, of competition -- even confrontation -- between herders and farmers. But is it not also a center for unique modes of production based on techniques specific to Africa and capable of explaining some of the most noteworthy aspects characteristic of Africa south of the Sahara?

Before trying to answer these questions we should give a short description of the area. Any attempt to fix the linear limits of an area defined by its climatic characteristics is arbitrary, especially in the Sahel where these characteristics evolve making imperceptible changes in space but which are greatly irregular in time. Even if one decided to use precise rainfall data one could not fix permanent boundaries because the same isohyets can have latitudinal changes of many kilometers, even more than 100 or 150 kilometers from one decade to another if the drought periods are taken into account. Strictly speaking, the African Sahel is an area of transition between the desert zone where the rains average less than 150 mm per year and the Sudanian zone where the annual rainfall regularly supplies agriculture with more than 600 mm. Since this is a discussion of rainfed agriculture, the whole area directly affected or threatened by the Sahelian semi-aridity must be considered. This semi-aridity comes not only from the deficiency in the total annual rainfall, but also from two other factors in the Sahelian climate: 1) the shortness of the humid season (and as a consequence, of the vegetation period) which is always less than 4 months per year, and 2) the inter-annual

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irregularity of the rainfall whose total commonly varies from single to double and too often from single to triple.³ This irregularity in rainfall, even more serious than its insufficiency and the length of the dry season, is the true source of the climatic insecurity weighing on the inhabitants of the Sahel. This insecurity was dramatically illustrated by the recent drought crisis which hit Africa from 1968-1973. We cannot forget, however, that it constitutes a permanent threat. All the information available, but especially all the Sahelian traditions, confirm that the periods of deficient rainfall, whose consequences are as serious as the aridity is intense, are due neither to accidents nor to circumstantial factors; they form an integral part of the definition of the Sahelian milieu.

Presented in this way the climatic characteristics of the Sahel (especially the irregularity of the rains which is the most difficult one for agriculture) spread over a large area and reduce the agricultural year to 3 or 4 months per year, severely limiting the range of plants which may be cultivated and threatening the harvests with unforeseeable rainfall deficiency. The semi-arid "regions" with summer rainfall in south-Saharan Africa extend at least up to the 800 mm annual isohyet while a figure twice as low determines the semi-arid zone in the regions with winter rainfall north of the Sahara.

This 800 mm southern boundary is also evident in the spontaneous vegetation since it defines the area of maximal extension of the Sahelian species, especially the thornbushes like the acacia, whose grouping with deciduous species defines the Sahelo-Soudanian associations.

Finally, the 800 mm line also has the advantage that it fairly often coincides with the southernmost limits of the ergs built up by the Saharan winds during the driest climatic phases of the quaternary age. As opposed to the Sudanian zone characterized by the presence of ferruginous crusts, the African Sahel is the area par excellence for light, permeable soils which are chemically poor but easy to work.

A final natural characteristic of the Sahel is that it is traversed by foreign rivers fed by Sudano-Guinean rains: The Senegal, Niger, Logone, Chari etc. cut across regions devastated by the dryness of the valleys. These swell impressively each year discharging thousands of m^3/sec while during the dry period there is not more than a few tens of m^3/sec . The slight slopes of a good portion of these valleys slow down the flooding to such a degree that in the dry season the waters reach their maximal size. It is in January and February, in the heart of the dry season that in Tombouctou, for example, the Niger reaches its highest level.

The Traditional Forms of Land Use

a) A systematic, but sketchy view of the inhabitants of the semi-arid regions of black Africa gives a comparative view of the pastoral and farming peoples. The Maures, the Touareg, and the Peul are actually specialized herders profiting from the immensity of the Sahel grazing lands and effectively dealing with seasonal contrasts through their mobility. From the limits of the Sahara to the borders of the "Sudan" all forms of seasonal migration are found. The very mobile transhumant mode is the most common one, scattered in countless camps or climbing latitudinally whenever the rains revive the brush and strew the Sahel with multiple temporary ponds. In the dry season most of the herdsman group near permanent water sources -- valleys, lakes, wells -- or penetrate the domain of the farmers, settling after the harvest near sedentary villages. Although a growing part of the population no longer accompanies the herds in their migrations, this model of the pastoral life based on mobility remains the dominant one. It is found among the most typical Sahelian herders, the Peul, from Senegal to Chad. The Senegalese Peul, scattered across the Ferlo in the rainy season, regroup in this way in the north, in the peanut basin up to the Atlantic coast in the west, or on the fringes of the Saloum in the south. Likewise the interior delta of the Niger is a gravitation point for the transhumant migration which affects the whole Malian Sahel. The greatest concentrations of cattle in all of West Africa are located on its banks in the dry season.

At the beginning of the rainy season, on the other hand, it is the point of separation for vast movements which lead herds hundreds of kilometers from their bases, that is, from the permanent villages on the edges of the delta where the majority of the population lives. Likewise, in Niger, the Bororo Peul divide their lives between a relatively sedentary existence in the dry season spent in sedentary surroundings on the outskirts of Hausa villages and a migration season which takes herds and herdsman to the foot of the Air, hundreds of kilometers further north, where the salt cure always takes place.

The pastoral peoples' traditional mastery of the area seems to have been greatly reinforced in the 18th and 19th centuries by their political supremacy and their social organization, sometimes even by their religious proselytizing since they were often the initiators of and soldiers in the Islamic revival which happened in the African Sahel during the century preceding the colonial conquest. The Touareg are a case in point. Coming from the north they did not really penetrate into the heart of the Nigerien Sahel until the 19th century. It is also at this time that the Dina Peul established a political structure that assured their mastery of the interior delta of the Niger and simultaneously imposed Islam, the sedentary way of

life and a way of exploiting the bourgou pasture lands -- the valuable prairies of the flooding zone -- whose major features still dominate the lands and the human way of life in the Delta today (Gallais, 1967).

b) Confronted with these conquering peoples the peasant societies pushed rainfed agriculture to its absolute limits, limits which they sometimes dangerously compromised. But how does one set reasonable limits for agricultural production in an area where the rains show the annual variations discussed above? To say that the least demanding cereal varieties develop properly up to the 400 mm isohyet in no way gives a boundary line, since this figure is only an average between the actual rains, sometimes more generous, sometimes dramatically inadequate.

It is, then, more prudent to say one is generally gambling in pushing rainfed agriculture up to 400 mm. But the most incredible paradox of Sahelo-Sudanian agriculture lies in its exclusive choice of rainfed agriculture and in its corresponding ignorance of techniques of water mastery. Although the Sahelian peasants traditionally know how to use the alluvial plains through subsidence agriculture, and how to multiply fields and gardens in the dry season on the edge of lakes and ponds to the extent that they have dried, they have never been able to master runoff, store seasonal waters or dam the floodwaters, and as a result irrigation is totally unknown to them.

Inversely, African civilizations have shown a remarkable aptitude for permanent rainfed cultivation and have planted lands into the heart of the Sahelian zone (4). Can there be any more impressive demonstration? North of Mopti, in the Kounari and the dry lands overlooking the eastern bank of the inner delta of the Niger, or even on the dunes of the Niafounke ergs which dam the Debo lake below the same delta and receive scarcely 400 mm rainfall in 3 months, rainfed crops feed 30-60 persons per square kilometer. These people live in large sedentary villages while the flooded plains of the living delta that they overlook sustain less than 10 persons/km². Likewise, at lower latitudes, it is always rainfed agriculture which maintains the greatest number of people, whether it be in the lands surrounding Kano and Sokoto in northern Nigeria or the remarkably managed agrarian lands in the mountains of north Cameroon. Here and there densities greater than 100 and sometimes 200 persons/km² live exclusively from rainfed crops with rainfall averaging 600-800 mm at latitudes still threatened by the Sahel's irregular rainfall (Diarra, 1975).

This rainfed agriculture consists mainly of cereal crops. Sorghum is predominant south of the 800 mm isohyet but can hold its own on the clayey humid soil of the interdunal depressions or on the banks of ponds at 600 mm or possibly 500 mm. Between 400 and 700 mm it is basically the small millet (Pennisetum) which prevail, especially on the sandy soil. The varieties needing less water have growth cycles near 100 days.

There is only one addition to the range of crop plants cultivated by these cereal based societies. This is the peanut, a profit crop adapted to the soils and climate of the Sahel (rainfed cotton is not cultivated until after 800 mm). The least well known innovation, and one which we consider essential is the spread of manioc. This equatorial root puts up the best defense against dryness and grasshoppers, since it increases the length of its growth cycle in response to reduced rainfall, and in this way has penetrated into the heart of the Sahel where it is now found up to the 400 mm isohyet.

The apparent simplicity of the agricultural techniques of the Sahel farmers disguises the fact that they are remarkably well adapted to the unstable environment in which they are used. For example, from Senegal to Niger, the sandy soils are neither plowed nor hoed but are worked with light instruments. The most characteristic is the "iler," a triangular kind of scraper which facilitates loosening of the soil with little disturbance and is used in seeding, weeding, and as a kind of sub-soiling instrument after the first rains. This is a genuine dry farming technique which decreases evaporation and facilitates soil water storage. The particular aptitude of the Sahel peasant for farming expanses of sand, as soon as they are sure of controlling it, must be emphasized. For example, J. Gallais (1967) has shown that in northern Kounari with 450-500 mm rainfall, Bambara farmers produced the highest yields in the central Niger delta. They systematically occupied the sandy banks and cones which best suit their techniques as millet producers. However, they derived no benefit from the delta flood plains or the heavy clayey soils of that region. Moreover, in Senegal the highest rural densities are neither on the periodically flooded banks of the river nor in the splendid rice fields of Lower Casamance, which are generously supplied with water by a sub-Guinean climate, but rather on the sandy soils of the Sine where the annual rainfall varies between 550 and 750 mm and is distributed over no more than 4 months.

When population density stays at a moderate level, the abundant space permits long fallows which give the soil a chance to build up fertility following several years of cultivations; the fields are, then, only temporary clearings in the midst of thornbush. The problem of the relation between cultivated land and pasture land is then only a defensive one. It arises from power relationships which have developed over the centuries. Certain overlapping indices lead to the conclusion that the herdsmen had the upper hand during the two centuries immediately preceding the colonial period. Their military and political preeminence in certain circumstances provided them with a genuine monopoly on cattle raising. The peasants were compelled to retreat, either grouping in defensive sites or in high densities propitious for defense.

c) The presence of large rural populations which depend on rainfed agriculture in parts of Africa with a long dry season poses a fundamental problem. It is not clear whether these large populations are a result of choosing civilization or the desire to oppose unfavorable political circumstances. How have Sahelo-Sudanian peasants been able to go from

agriculture with long fallows to forms of permanent agriculture where the permanence of the fields and the perenniality of their production must find its source in the density of the population and in the need to capitalize on the increase in numbers on the spot? An examination of agrarian lands from the Cape Verde Islands to Chad and even to Kordofan yields a precise answer. Wherever there is a high population density—on the order of 10-100 inhabitants per km² living in the 400-800 mm rainfall area, rainfed agriculture has met its needs by fertilizing the soils and assuring their permanent exploitation with the systematic coupling of cattle raising and a forest cover in the cultivated area. Trees and cattle then form part of a genuinely integrated production system which spreads over thousands of kilometers and contradicts the usual conception of the separation of agriculture and cattle raising. This schema is as debatable as it is classic.

One of the most unique qualities of dry tropical Africa is the juxtaposition of societies specialized in agriculture or cattle raising with agro-pastoral societies where the cattle no longer compete in the field but rather are the agents of its fertilization. The trees are no longer an obstacle to cultivation but play a choice role in establishing the agricultural area and maintaining the herds.

The area of Sahelo-Sudanian Africa most affected by man is not vast cleared fields but the parks in whose shelter there is sometimes very intense agriculture. Some of these parks (more extensive in the Sudanian zone itself) are the result of systematically selecting a limited number of volunteer species whose products play a useful role in the daily life of the peasant, especially in his nutrition. The locust bean tree (Parkia biglobosa), the shea-nut tree (Butyrospermum Parkii) and the tamarind tree (Tamarindus indica) can be found in parks up to the 500 mm isohyet common in Mali and Upper Volta. These are intentionally created by farmers who, while clearing, protect these species and facilitate their propagation by eliminating competing vegetation. Other more typically Sahelian species interest both herders and farmers and are diffused by the cattle which eat their fruit and spread their seeds, thus facilitating germination. This is the case from Soump (Balanites aegyptiaca) to precious fruit which are often found densely grouped around cattle watering sites, or the jujube tree (Ziziphus mauritiaca) which provides fruit and foliage and whose supple and thorny branches are used to surround cattle pens and fence in the fields. But, coincident with the highest rural densities and, consequently, with the most intensive production systems, the most noteworthy Sahelo-Sudanian parks are those which are created rather than selected. The former are made up of species absent from volunteer vegetation but introduced by man or, more specifically, by agro-pastoral civilizations. The Acacia albida (Pelissier, 1966) is both the indicator and the cornerstone. This mimosa (Senegal's kad, Mali and Upper Volta's balanzan, Niger's gao) has the unique characteristic of having an inverse growth cycle. It loses its leaves with the first rains, and is totally bare throughout the rainy season, turning green once again at the beginning of the dry season when it is covered with verdant boughs. The unique

physiology of the Acacia endows it with three basic virtues. Losing its foliage with the first rains it provides the soil with an abundant supply of organic matter valuable both for its effect on soil structure and its chemical richness which is added to the soil. Modern agronomy is convinced of the fundamental role Kad plays in fertilizing soils under permanent cultivation and especially its action on high cereal yields (Charreau and Vidal, 1965). This soil amending process at the beginning of the crop cycle requires no work since the burial of the green matter is automatically provided by cultivation.

The Acacia albida also provides forage which is as rich as it is precious in the dry season. When the soil is covered with no more than dry straw, the herdsmen prune the trees for animal food since the foliage and pods have considerable nutritive value. In this way the Acacia albida becomes an essential agent in the integration of cattle raising and agriculture by contributing to nutrition of the herds in the dry season, thus sustaining them in agricultural areas. In addition to its pedological role, the park assures animal fertilization that is as intense as the density permits. Another virtue of the Acacia albida is that its uniform populations do not hinder crop development. Their barren branches neither screen the sun nor the rains. On the contrary it is at the base of the trees, where the animal and plant fertilizer combine, that the seedlings are the hardiest and the yields are the highest. Inversely, in the dry season the dense foliage of the park provides the soil with very effective protection from the harsh sun and its bacteriological and organic effects as well as from the wind and particularly the formidable harmattan. Finally, the removal of soil water and soil chemicals by the surprisingly deep taproots of the Acacia albida, although poorly understood but undeniably important, should be mentioned as an unforeseen advantage of these populations because the absence of lateral roots in the upper soil horizons facilitates mechanization and will eventually open the way to the use of traction equipment up to the trunks of the trees.

Not only are the Acacia albida parks important, but also their random geographical distribution. For example, they are found in the Sérèr country in Senegal, on the Niafouké ergs, at the foot of the Malian mountains in Bondiagara, in Yatenga, Upper Volta, on the sands of the Zinder sultanate in Niger, and on the massa banks of the Logone in Cameroon and Chad. This wide distribution causes one to wonder about the origins and geneses of populations associated with the parks. Numerous observations and cross checks indicate that these lands developed by genuine peasant societies who seek the fertility of their millet fields and the fecundity of their herds. They are compelled to live in crowded situations because of the inadequacy of their organizational skills or historical reverses which forced them into places of refuge. Finally, in certain cases organized cohabitation of the same lands by both pastoral and agricultural peoples has led to the creation of lands made by juxtaposing (on the scale

of village grounds) Acacia albida parks under permanent cultivation with brush barely selected by the passage of temporary clearing and having a basically pastoral role. The creation of these parks thus responds to the double need to sustain the people raised in limited spaces and to accomplish, by intensive techniques which are themselves made possible the action of an abundant herd, the maintenance of which the park claims as its primary merit. Combining the permanent field, the trees and the cattle is not only functional it is also genetic. Animals, and especially cattle, are indispensable to the Acacia albida whose seeds are enclosed in a waxy casing and do not germinate until after they have been digested by ruminants.

Planned human intervention is nonetheless necessary in establishing a park. The Acacia albida does not take on a tree-like development until after it has been pruned, trimmed and protected. Analysis of peasant strategies leads to the conclusion that the creation of a park is the last phase in intensification. It is required by rural densities which are as low as the natural conditions are mediocre and, specifically, as the climate is dry and the feeding of the livestock is difficult in subsistence economy. Agriculture with long fallows where additional animal fertilization is unnecessary can satisfy modest needs. Higher densities require the temporary addition of cattle to keep up the fields. Finally, with demographic levels that are even higher but which vary as a function of soil quality and climatic severity, the creation of a park is a necessity. This is imposed by the obligation to guarantee the perenniality of agricultural production by enriching the soil through the permanent presence of livestock maintained by the Acacia albida in the dry season and through this tree's unique role in general. The dynamics of the relations between human densities, amount of cattle and Acacia albida defined in this way are illustrated in the following example: a close analysis of the population and the land in the Sérér country of Senegal shows growth parallels between human density, cattle density and the density of the park. This same dynamic relationship explains why one finds across Africa that either demographic evolution or economic circumstances have sometimes led to abandonment or expansion of these parks.

Of course the coexistence of cattle and fields is the object of systematic organization in the heart of integrated agro-pastoral systems. Common pasture land throughout the dry season, the cultivated land must be protected in the rainy season from browsing by cattle. Two kinds of areas can be discussed here: 1) areas where cattle are daily sent to outside pasture lands and cross the fields using fenced animal trails, and 2) those where a genuine field rotation reserves part of the agricultural area for livestock. These are sectioned off and enclosed by a system of seasonal fences which are moved and reconstructed each year. This is naturally done under the auspices of appropriate institutions which regulate the life of the village communities, imposing on each the necessary collective disciplines.

Recent transformations

Profound transformations were initiated to varying degrees during the colonial period and generally accelerated since these countries received their independence. These transformations have affected the situation in which people of dry tropical Africa live and the relationships between cattle raising and agriculture. The following will outline the most general tendencies of this evolution.

a) Relations have always existed between herders and farmers, and these agro-pastoral societies have been able to create lasting isolates. The current period, however, is marked by increased exchanges, the interpenetration of the populations and a more generalized expansion of the occupation of the Sahel lands. The motivations basic to these transformations have as their source political, economic and demographic factors. It is not the intention in this paper, however, to delve into this in detail, but it is significant that they all converge toward an increased exploitation of the Sahel environment and an ever increasing interdependence of populations that live there. Sometimes the Sahelian-Sudanian zone is represented as a marginal region, but on the contrary it is a place of encounter and settlement. The climatic insecurity, the austere living conditions and the low monetary income have not inhibited population growth. It should be first emphasized that the coexistence of strictly specialized and antagonistic ways of life will henceforth belong to the past. There is no doubt that herdsman as such still exist, especially among the nomads on the edges of the Sahara. They would, however, no longer know how to do without agricultural products they acquire at Sahel markets. The majority of Sahelian herdsman, especially the Peul, devote themselves to agricultural activities. There are practically no farmers left who do not own cattle or who do not intend to build up a herd. We then have simultaneous expansion of the cultivated areas and increased size of herds which is independent of the general increase in population, but which is aggravated by it. This evolution has increased the competition between the fields and the cattle, but paradoxically has brought out their complementary nature. More than ever farmers solicit the help of herders in fertilizing their fields by having the cattle stay on village land during the dry season. Their specific agreements guarantee remuneration for this annual fertilizer which is particularly beneficial for cereal production. Likewise the farmers always need the services of the herdsman to watch over and care for their cattle. Formerly nomadic and dreaded, the herdsman are fast becoming hired shepherds. Likewise the pastoral societies find in the farmers a market for their milk and meat, and it is no longer true that the Peul, for example, refrain from selling their cattle. In this way the Sahel seems more and more like the theater of a genuine economic symbiosis between modes of production that were previously much more specialized. At the same time competition for living space has become more intense and the cropping area has increased in size around water sources. The development has taken pastoral land and limited the movement of cattle. At the same time the farmers

complain about damage caused by the herds in trying to check their movements and control access to the valleys and wells while fearing an early return of transhumance in which the herders hurry to have access to markets to sell their products including milk. Thus we have a conflict of interest and social tensions which sometimes result in strife.

b) Overall, crop expansion has increased land use by the farmer and reduced pastoral lands. This has caused general deterioration in the situation of specialized herdsmen. This deterioration can first of all be explained by the minority status of pastoral peoples and the loss of their former political preeminence. It is also a result of the vulnerability of any pastoral land as opposed to the solid control the peasant exercises over the land he occupies, but the loss of the balance of power formerly favorable to the herdsmen is aggravated by the unequal demographic dynamics of these two groups. Sedentary farmers have increased their number much more rapidly than have the pastoral peoples. From Senegal to Niger every census taken of the Maure, the Peul, the Touareg and the Bororo showed an annual rate of increase of about 10-20% while the same census of sedentary farmers, whether they are the Toucouleur, the Bambara, the Sonrhail or the Hausa showed a 25% or greater population increase. This is shown in all the observations made, especially those of the Touareg in Mali and Niger (Gallais, 1972; Bernus, 1963).

The deterioration in the conditions of the pastoral way of life is also the result of social evolution. Not only do the nomads no longer have captives to herd and water their livestock, but in the whole of the Sahel the former serfs, now emancipated, are the most active pioneers of a very extensive agriculture which uses a great deal of space. This is how Bernus (1974) brought to light the role of the Iklan in the extension of agricultural space across the whole west of the Niger Sahel, where the dynamism, the dedication, the frugality of these "black Touareg" made them the principal millet producers and have given them a virtual monopoly on its marketing. In the same way Barral (1970 and 1974) and Gallais (1975) showed the spatial dynamic and the decisive role in agricultural organization played by the Iklan scattered from the Malian Gourma to the Voltaic Sahel. The double (demographic and economic) preeminence of their former serfs brings the breakdown of purely pastoral societies and a cutting back in nomadic herding while bringing about the emergence of a mixed, typically Sahelian way of life, which combines extensive agriculture, semi-nomadic herding, migration and commerce. Likewise, the deterioration of nomadism and the traditional pastoral life has not reduced the numbers of livestock or the importance of herding, nevertheless within a technically unchanged framework, herders find increasingly difficult conditions.

Finally the situation of the herder has continued to deteriorate economically since the colonization; on the eve of the recent period of dryness Bonte (1968) determined, for example, that in Ader-Doutchi a cow was worth 4-5 sacks of millet while thirty years before it would have been exchanged for ten sacks. The years of catastrophic rainfall, 1968-1973,

induced herders to get rid of their cattle at very low prices. The return of more regular rainfall, and the reconstitution of pasture lands brought higher prices without bringing about any reversal. All long term studies show that since the beginning of the century the Sahel has experienced a continual deterioration in exchange terms to the detriment of the herds. This is a paradoxical situation at a time when urban explosion offers more open markets for their products.

Confronted with this general evolution only one country has, to our knowledge, tried to establish a concerted policy of protecting pastoral land. In Niger specific legislation fixed the northern limit of crop production or, more exactly, of the settling of sedentary farmers (Bernus, 1974) but enforcing this legislation has been extremely difficult. It is possible that only the 1968-1973 drought has temporarily put an end to the farmers' push northward and stopped their progression. Counterpointing the crop pressure on pastoral lands the only spontaneous reaction of the herders that could be registered was flight, in some cases combined with a return to the itinerant life. The crossing of the Senegal River eastward toward Mauritania by the Peul of the Senegalese Ferlo was observed after the war in 1960. Another example is the recent arrival of Voltaic and Malian Peul in northern Ivory Coast, in the Malinke zone, and on the edges of Senoufo country. This was especially brought on by the drought. It is doubtful, however, that such transitory events substantially compensate for the effects of the general expansion of agricultural space.

c) The third characteristic of recent developments in human habitation of dry tropical Africa lies in the spatial expansion of agricultural life. This is not only linked to the new activities of more or less settled herders and the development of a new way of life which combines agricultural production and herding, but basically results from the extension of territories inhabited by the farmers. It is affected in three ways: 1) by the population expansion, 2) the development of profit crops, and 3) a frequent return to extensive production techniques. As important as it may be, the first factor, population expansion, is too well known for us to stress further. It has already been mentioned that it specifically concerns peasant peoples who are by far the most prolific. Let us just mention that the population doubled in 25-30 years, and that migration to the cities or even abroad has far from absorbed this growth.

The pursuit of monetary revenue by peanut production and, in certain cases (centered basically in Niger for the zone that interests us), cotton, and even by the marketing of surplus cereal, is behind the substantial increase in area farmed per person. Compared to the areas cultivated in subsistence economy this increase can fluctuate between 50 and 100% if the techniques remain unchanged. It can be two or three times higher if innovations like hitched cultivation are adopted. Less well known but no less important is the third expansion factor, the return to extensive production techniques. It basically involves the peasantry where, historically, living conditions caused them to unite in self defense and sometimes to band together in places of refuge, but it also involves

all the areas of recent colonization. Actually, within the framework of agriculture which relies entirely on human energy, extensive techniques repay human effort at a higher rate than intensive techniques. These techniques, developed in high density areas where space is restricted, often produce high yields but they require repeated soil cultivation and, consequently a great deal of time. All things considered, they do provide subsistence but bring little per hour invested. On the other hand, when space is available and land belongs to whoever clears it, extensive techniques display their superior economic value; even if they only secure modest yields more land is cultivated and thus higher yields result for a given amount of labor. In this way labor productivity during a very short agricultural season uses less costly means than the increase in yields. It is a legitimate pursuit for farmers since land is no longer limited and they have free access to it. Also, all forms of agricultural colonization are accompanied (in the Sahel as in the rest of Africa) by a cutting back in the use of intensive techniques in favor of more extensive modes of production which, besides their immediate financial value, allow farmers to extend to the maximum the lands over which they exercise basic control. It is unquestionable that for rain-fed agriculture with the current population and technical conditions existing in tropical dry Africa, economic and agronomic progress are not only hard to reconcile but are naturally contradictory.

Numerous examples illustrate the crop spatial expansion and the simultaneous diffusion of extensive techniques. In Niger the Hausa peasants, coming from the border regions of Nigeria, have developed their cotton and sorghum fields in the Ader valley and pushed millet and peanut crops beyond the 400 mm isohyet. This has sent herders, whether they be Touareg or Bororo, and their herds into the dunal hills and the areas with the least water. In Mali, a very recent study (Gallais, 1975) analyzed the colonization of the Séno plains by the Dogon. The Dogon are now coming down out of their refuge in the Bandiagara mountainous area where they retreated under pressure from the Yatenga Mossi, and later by the Peul (even into the 19th century) whose horsemen and herds created insecure conditions for men and cultivation outside the protection afforded by the mountainous relief. Within their refuge the Dogon developed an admirable intensive survival agriculture. The population explosion and the increased demands of the monetary economy, however, make any overpopulation impossible under these conditions which is not compensated by technical progress. Emigration or, actually, a return to the Séno plain gives the Dogon the chance to escape famine and provides access to an open economy. Gallais (1975) estimates that in the eastern, most densely populated part of the Dogon lands, the "new country" on the plain has twice the number of inhabitants as the "old country" in the mountain areas, even though inhabitants of the Séno plain have been there for less than half a century. This colonization is accompanied by a remarkable extension of the cultivation system and has produced an incredibly ingenious intensive polyculture in the mountainous region. The Dogon, since inhabiting the relatively open spaces of the Séno, have developed a typically extensive cultivation. They have devoted their efforts mainly to cereal production and have

invested the remaining resources to building up herds which could then become a source of monetary revenue without presenting any technical competition to agricultural life. With respect to the Peul, former masters of the Séno, they again helplessly watch the invasion of their territories by farmers who leave them no choice but to retreat.

This situation is in many respects comparable to Senegal (Pelissier, 1966) (although chronologically earlier) which can be brought up as a third example. The area that is today covered by the peanut basin in north Saloum (between the 400 and 800 mm isohyets) is at least twice as extensive as that where the Wolof and Sérér peasants lived at the beginning of the century. A genuine pioneer front has developed and its continued progress eastward has brought with it the colonization of large areas taken from the Ferlo, the traditional Peul domain. However, the progression of farmers in this area is largely dependent on a network of deep wells originally set up for herders. Far from helping the Peul master their territory and improve the upkeep of their cattle, these set-ups greatly encourage settling by farmers and decrease the pastoral land of the Ferlo. Here also extensification of cultivation systems accompanied agricultural colonization. The "new lands" farmed by extensive exploitation are areas of expeditious clearings with separate farming and herding, while on the old lands of their native habitats farmers, and especially the Sérér, practiced scrupulous cultivation techniques which provided continuous production by systematically pairing trees and animals to maintain basic capital.

d) The forms of evolution that we have just outlined naturally lead to a genuine deterioration of lands in high density regions made up of agro-pastoral civilizations; deterioration came after the working force left to colonize new lands. The deterioration was caused by the abandonment of unprofitable intensive techniques. Sometimes deterioration was even brought on by innovation when, for example, the diffusion of modern production methods saturates the area to the point of requiring evacuation of livestock and thus loss, at least for part of the year, of animal fertilizers (Lericollais, 1970; Pelissier, 1972).

This short review of the complex relationships between agriculture and cattle raising in dry tropical Africa may lead to the following considerations. In the first place the Sahelo-Sudanian zone, for a long time a land of a vigorous antagonism between herders and farmers, is probably experiencing a spontaneous technical and cultural blending that will lead to the practice of commercial agriculture while economically and socially benefiting the Sahel's pastoral vocation. Secondly, the cereal and the cattle, more than industrial crops, are the bases of the agricultural development in these regions. The coastal cities and the cultivation lands guarantee regional outlets for these products which are much less risky than overseas markets. Finally, no matter what the promises of irrigation are in the long term, Sahelian and Sahelo-Sudanian Africa will remain a land of rainfed agriculture par excellence. In this area it has acquired an irreplaceable heritage of experience and techniques. Any development project, or any attempt at innovation, must take seriously into account the existing knowledge base and profit from it.

Notes

3. It is a well known fact that the interannual irregularity of the rains is as high as their average is slight. This is the case in the African Sahel and may be demonstrated by the following example: in Niger with an average of 491 mm over 50 years, Tillabéry recorded values ranging from 746 mm to 250 mm. But with an average of 164 mm, Agadès had a minimum of 54 mm and a maximum of 388 mm that is five times higher.

4. Here we are not talking about subsidence cultivation as is found in the Senegal Valley since it is no longer a question of rainfed crops but of dry season crops exclusively developed with water stored in the soil during the river's swelling.

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