In African countries ridgers and multi-share hoeing implements were mentioned for weed control. In practice however these are only utilized under certain circumstances. The existence of a work peak and the cropping in rows tend to favour their use. Cropping without any particular order, broadcasting and mixed cropping tend to be a hindrance for their application. The application of the ridger for weed control purposes is associated with the regions where ridge cropping dominates. This is the case in some regions in Togo, Ghana, Cameroon, Malawi and Zambia. Cultivators are mainly used in Mali, Niger, Burkina Faso and Senegal, where shallow seedbed preparation is common.

In Brazil three-share cultivators having single-sided ridging shares are used (figure E 63). Single-share cultivators with broad swallowtail shares or a shovel-shaped tool, e.g. bico de pato (figure G 26) or the small fuçador (figure E 61), are utilized. On the other hand, ridgers are seldom employed for weed control.

Permanent cropping is almost always found in regions where mainly multi-share cultivators are used. Correspondingly few obstacles exist and the occurrence of stones is minimal. In the Andes countries and Ethiopia the ard is employed for weed control. In Ethiopia this work operation is seldom conducted since teff, the primary crop, is broadcasted.

Generally, difficulties were mentioned regarding the training condition of the animals and the too late weed control. Weeds are frequently not removed before they reach a height of 20 – 30 cm. If weeding is done by hand the weeds can more easily be gripped and can be completely pulled out. However this development stage of weeds has gone beyond the bounds of effectivity for the mobilization of implements.

F. Case studies: West Africa

1. Overview

1.1 The country and the population

According to the UN Economic Commission for Africa (ECA) West Africa is comprised of the countries south of the Sahara along the west coast of Africa up to the eastern borders of Niger and Nigeria, a total of 16 countries. (Nohlen and Nuscheler, 1982)

In an east-west direction West Africa shows up several parallel climatic and vegetation belts (see figure C 3). The Sahel and Sudan zones consisting of thornbush and dry savanna as well as dry forest are located below the Sahara. The Guinea zone begins towards the south where increasing precipitation occurs; here grass savanna and humid forest abound. Along the south coast of West Africa rainforest is found, which however is interrupted between Ghana and Benin. Some coastal areas still have mangrove forest.

The humid, hot climate in the coastal region has in the past given West Africa the reputation of being the most unhealthy climate in the world. Diseases such as malaria and river blindness are still prolific. The expansion of animal husbandry and therefore also animal traction has been severely limited by the widespread occurrence of the tsetse fly. (Nohlen and Nuschler, 1982) In contrast, the main limiting factor for agriculture and animal husbandry in the Sahel zone is the scarcity of water resources.

With 1/4 of the area and 1/3 of the population of Africa, the West African region holds a predominant position on the continent. In comparison to the average figures worldwide, West Africa is rather thinly populated with 24 inhabitants/km; very marked regional differences exist, however. Nigeria alone has over 90 million inhabitants, more than half of the total in West Africa. On the other hand, the desert areas in the north of West Africa are almost totally vacant. (Nohlen and Nuschler, 1982; Grubbe, 1987)

With regard to natural resources Nigeria is the richest country in the region with its oil reserves. In addition minerals are found, e.g. iron and uranium, in other West African countries such as Mauritania and Niger. Nevertheless, agriculture plays a significant role for the countries in this region, especially for subsistence production (share of per capita income in 1983 – Nigeria: 36%, Mautritania: 29%, Niger: 47%). Mali and Burkina Faso, on the other hand, are purely agricultural countries (share of agriculture for per capita income in 1983 – Burkina Faso: 45%, Mali: 50%). Of 23 LLDCs in Africa 10 are located in the western part of the continent (Nohlen, 1989; Haefs, 1988).

1.2 Agriculture and mechanization

The traditional economic forms of crop and animal production have always been adapted to the local soil and climatic conditions. In the colonial period however the farmers were forced to grow cash crops (depending upon the climatic zone: groundnuts, cotton, oil palm). Since even after the independence of the West African countries these cash crops often represent an important source of income for the annual government budget, the promotion of these crops was continued. Thus, the food production for own needs was reduced, whereby the countries became dependent on imported food supplies. (Nohlen and Nuschler, 1982) Furthermore, the EC countries increasingly placed their own subsidized food products on the world market at dumping prices, against which the farmers of the Third World could not compete.

The rapidly increasing population growth and the expanding cash cropping has led to an immense extension of the area for crop production, which has forced its way into the Sahel zone to the north; this was formerly reserved for animal husbandry. At the same time, the numbers of animals has increased due to the drilling of wells and improved veterinary services. Thereby, the ecological balance has been disrupted; increased catastrophes due to drought thus occurred in recent decades. Experts assume that the expansion of the Sahara is caused to 80% by the intervention of man (Grubbe, 1987).

The utilization of draft animals was first practised in the Sub-Saharan region during the colonial period by white settlers. They settled primarily in regions where they could continue to practise short fallow or permanent cropping based upon their former European system. Prior to this time the use of animals in arid areas was limited to the carrying of loads. Acceptance of animal traction by the local farmers as a rule did not occur, since they were often supplanted to regions where the introduction of the plow would have been less advantageous. Only in some marginal regions which were suited for draft-animal mechanization did the practice rapidly become widespread. Between 1925 and 1930 there was considerable acceptance in North Nigeria and Senegal. In both cases the incentive for using draft animals was given by the great demand for groundnuts, the cropping of which can easily be mechanized. During this time the combination of paddy rice cropping with the use of draft animals led to a limited expansion of the oxen-drawn plow. Attempts by the colonists to promote animal traction in other areas failed, primarily because of the fact that in these regions forest or bush-fallow systems were being practised. (Pingali et al., 1987) This connection remained unknown for a long time.

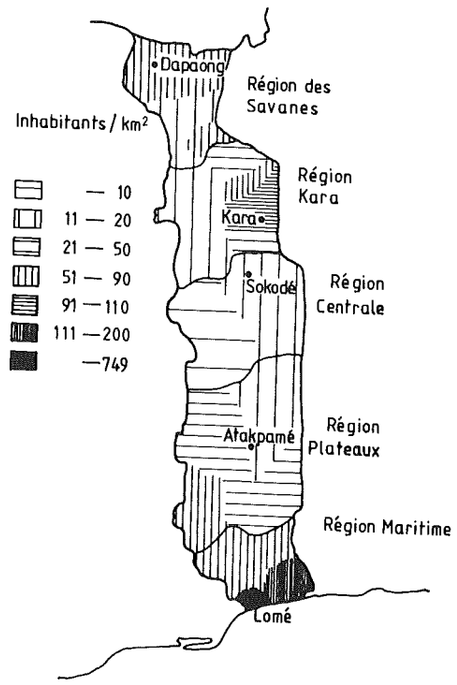
Due to the later reduction of natural vegetation caused by the increase of population density, did animal traction first become advantageous in further areas and was no longer connected with the cropping of rice (e.g. Mali, Guinea, Niger). Following the second world war the greatest hindrance for animal traction was tractorization, which received priority. These undertakings, however, also broke down. Today, tractors are only used in a few areas of West Africa (chiefly in paddy rice-growing areas) and their number per 1000 inhabitants is, with 0.12 (1987), much less than overall Africa (0.92), Asia (1.65) or South America (4.23) (FAO, 1988). Nevertheless, the preference for motor mechanization led to a stagnation of draft-animal use by the end of the 1970s, since it was difficult or impossible for the farmers to acquire the necessary implements. (Pingali et al., 1987)

2. Case study: Togo

2.1 The country and the population

Togo is divided into five larger regions from north to south – Savanes, Kara, Centrale, Plateaux and Maritime. Figure F 1 portrays the administrative divisions and the population density in 1975.

Fig. F 1: Administrative divisions and population density of Togo, 1975. Source: Statistisches Bundesamt (1981)



The central area is sparsely settled; population concentrations are found in the north and the south.

There are approximately 3 million inhabitants and the annual population growth is 3%. The population is comprised of about 40 ethnic and linguistic groups having various languages, customs, economies and forms of settlement.

2.2 Local given conditions

2.2.1 Natural conditions

Climate

Togo is located in a subhumid zone in the south and a semihumid/semiarid zone in the north. The amount of precipitation varies from 800 to over 1400 mm per annum and occurs during one rainy season in the north and two in the south. The precipitation boundary line runs between latitude 7 and 8°N. (Faure and Djagni, 1988a). Figure F 2 shows the distribution of precipitation and the primary crops in Togo.

Soils and obstacles

The occurrence of stones is considerable in most regions. Gullies from erosion are found in the Centrale, Savanes and Kara regions; in the latter this is combined with flat ground.

In many areas having a marked dry period the uncovered ground is highly compacted prior to the beginning of the rains. The topography is flat in most cases; Kara region is hilly and the Centrale region is partially hilly.

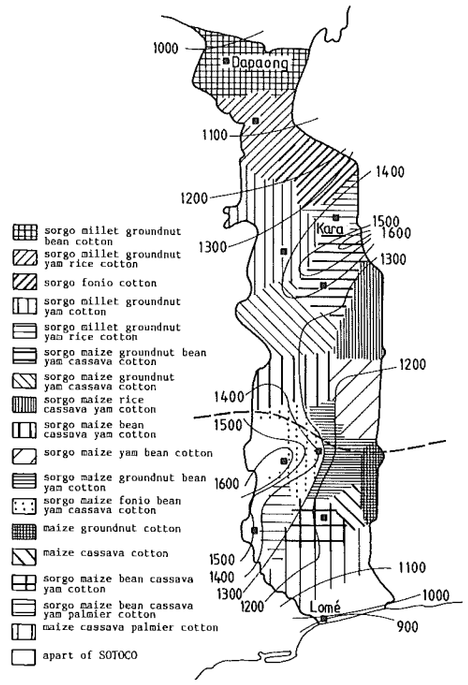


Fig. F 2: Distribution of precipitation and primary crops in Togo. Source: Strubenhoff (1988); Faure and Djagni (1988a)

2.2.2 Land use and farm systems

Crops

The production of crops has been stagnating during the past decade; however, varying growth and decline patterns are evident for the individual crops. The production of coffee and cocoa has dropped annually by 1.5 and 3%, respectively. The production of cotton increased threefold within 8 years following its promotion by the World Bank. Further high growth rates are recorded for karité, beans and maize. Staple foods such as sorghum and millet increased slightly; yams and cassava stagnated (Strubenhoff, 1988).

As can be observed from figure F 2 the perennials – oil palm, coconut, coffee and cocoa – predominate in the south. Cotton is found farther north. Maize and cassava are grown for food consumption. The cropping of yams and sorghum gains in importance where the transition from two rainy seasons to one is situated. Sorghum and millet increase progressively towards the north; these two crops take up nearly 70% of the total cropping area in the Savanes region. There, the climatic conditions are also appropriate for cotton and groundnuts. In the Centrale region sorghum is grown on 50% of the land area, but the proportion of 26.5% for tubers such as yams and cassava is still appreciable. Yams produce high yields per hectare and receive a good price due to consumer preferences (Strubenhoff, 1988).

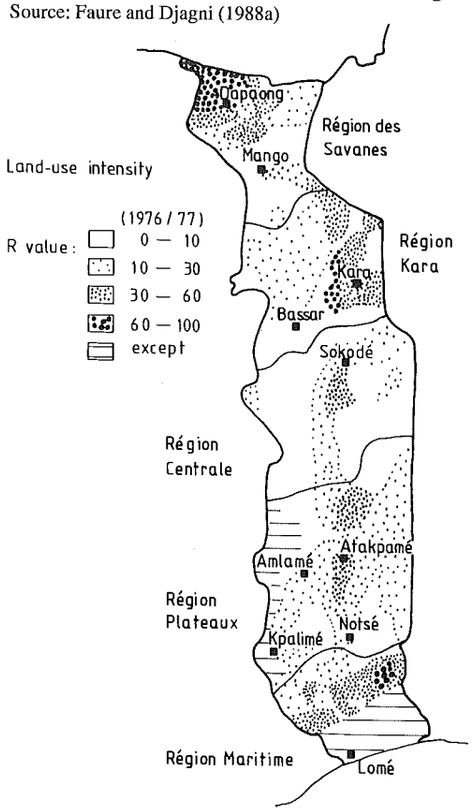
For animal traction it is important that the cropping of tuberous plants generates a work calender with less marked labour peaks than the cropping of grains in the north. This particularly applies for the soil preparation or for the planting at the start of the rainy season.

Farm and field size

An overview of land-use intensity in 1976/77 in Togo is provided in figure F 3.

In areas having higher population density the fallow periods are continually declining. In the northwestern part of the Savanes region, with over 100 inhabitants per km, an almost permanent rainfed cropping is observed, while in the Maritime region, also with a high land-use intensity, perennials are of great importance. In the main yam-cropping areas fallow periods of 5 – 10 years are common, however, with a declining tendency. As a crop yam places great demands on the soil and is planted as the first crop following fallow.

Fig. F 3: Land-use intensity in 1976/77 in Togo. Source: Faure and Djagni (1988a)



In contrast to the Maritime region, in the Savanes regions the widespread distribution of animal traction concurs with the highest land-use intensity. A combination of various land-use intensities within one farm was observed by Strubenhoff in the Centrale region, where fields near the farmyard were left fallow for short periods and tilled with oxen teams, while more distant fields were reserved for yams which require a longer fallow.

The sizes of the farms vary from region to region. In the Savanes region households having about 17 persons live from 4 ha of arable land. The average arable area per farm is 2.3 ha with approximately 11 family members in the Centrale region (Strubenhoff, 1988). These conditions were confirmed by our questionnaire, where the cropped areas for most of the farms in the Centrale and Kara regions were 1 – 3 ha and over 5 ha in the Savanes region.

In the Savanes region it was established that farms with draft animals hardly tilled more land than farms without animal traction. Due to high land-use intensity no more space is available for expansion (Faure and Djagni, 1988b). In order to exploit draft animals to the full extent they are often hired out (Lawson, 1988). Where sufficient space is available expansion does occur, according to our survey.

The plot size on smallholdings is between 0.2 and 0.4 ha. On farms having over 5 ha the individual plots range from 0.5 – 1 ha.

2.3 Status of animal traction

2.3.1 Historical development

The distribution of oxen teams in Togo from 1978 – 84 is shown in figure F 4.

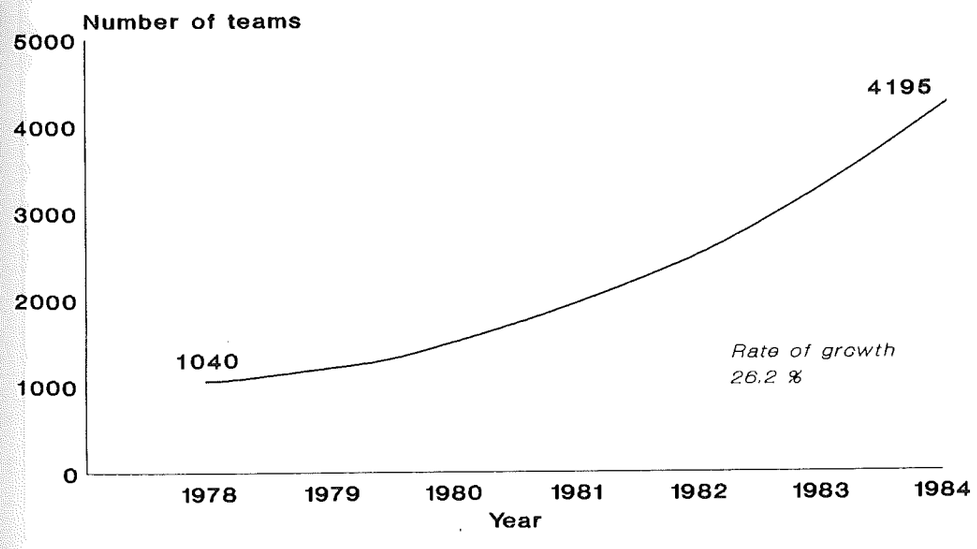
Since the beginning of the century attempts have been made to introduce draft animals to Togo, parallel with the colonialization measures. This however was not successful. In the 1950s and 1960s further efforts were again undertaken to disseminate animal traction in the north of Togo. Independent thereof, there were individual cases at this time where farmers in the Savanes region acquired animal teams from northern Ghana or southern Burkina Faso on their own initiative (Bordet et al., 1988). After the introduction of motorized mechanization generally failed in Togo the government assumed animal traction as a national goal in 1978. Thus, in 1985 alone 32 different development agencies were assisting Togolese farmers (Westneat et al., 1988).

In order to coordinate the individual projects PROPTA (Projet pour la Promotion de la Traction Animal) was initiated in 1982. PROPTA functions independently of the Ministry for Rural Development and has both administrative as well as extensive practical functions. It is particularly responsible for securing the supply of draft-animal materials. Furthermore, it is in charge of advisor training and veterinary supplies. As the sole authorized distributor in Togo it markets the implements manufactured by the agricultural machinery factory, UPROMA (Bordet et al., 1988).

2.3.2 Current distribution and use

Table F 1 illustrates the distribution of animal traction in 1985 in the particular regions of Togo.

Fig. F 4: Distribution of oxen teams in Togo, 1978 – 84. Source: Westneat et al. (1988)



Region	Savanes	Kara	Centrale	Plateaux	Maritime	Togo	
						Total	Mean
No. of oxen teams	3214	637	257	55	32	4195	
Share of teams in %	76.6	15.2	6.1	1.3	0.8	100	
Area (km^2)	8602	11630	13182	16975	6395	56784	
Population (1000)	368	448	319	724	1170	3029	
Inhabitants/km^2	43	39	24	43	183		53
No. of teams/100 km^2	37.4	5.5	1.9	0.3	0.5		9.1
No. of teams/1000 Pers.	8.7	1.4	0.8	0.1	0.0		2.2

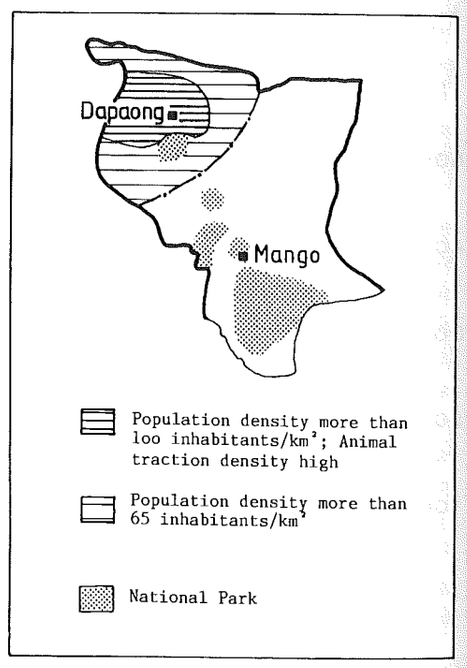
Table F 1: Distribution of animal traction in Togo in 1985. Source: Strubenhoff (1988), PROPTA (1985)

Accordingly, the largest proportion of draft animals is found in the Savanes region. In 1985 PROPTA estimated that the adaptation rate was approximately 9% among the farmers. Following the calculations of Strubenhoff (1988) each fifth farmer in the region possesses an oxen team. And, according to table F1 there are 9 oxen teams per 1000 inhabitants. Assuming that about half the population is occupied with agriculture and that a family consists of 10 people, then 9 draft-animal teams would be distributed on 50 farms. This results in an adaptation rate of close to 20%. However, they are not equally distributed in the Savanes region, but rather are concentrated in the northwest (figure F 5).

In the Kara and Centrale regions PROPTA estimates the adaptation rate to be about 1% and in the Plateaux/Maritime regions only 0.05%. This was confirmed by the survey.

As ascertained for the Savanes region Strubenhoff found a high distribution of draft animals in areas with a close population density (figure F 6) in the Centrale region.

Fig. F 5: Concentration of population and animal traction in the Savanes region in 1985 Source: Strubenhoff (1988)



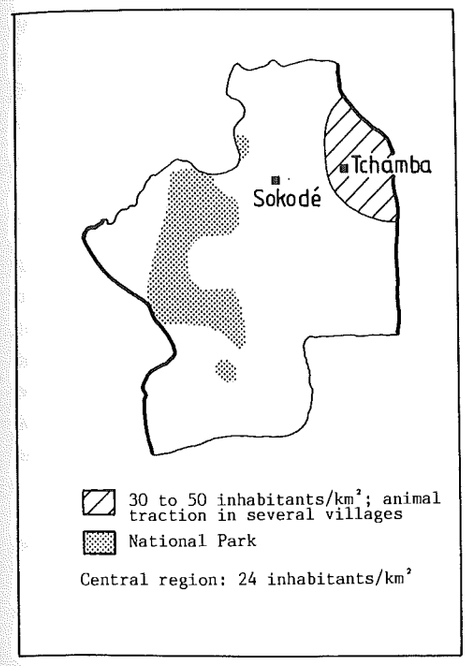


Fig. F 6: Distribution of animal traction in the Centrale region, 1985. Source: Strubenhoff (1988)

This relationship could not be derived for the Maritime region. Although the greatest population density exists here, few draft animals are found (table F 1). Limiting factors such as the high risk of disease due to the tsetse fly and the growing of perennials predominate here.

The survey yielded the following picture for division of work operations according to draft-animal use (table F 2).
The use of draft animals is limited essentially to soil preparation and transportation. It is worthy of mention that the latter activity is not done in the Savanes region. V.d. Decken (1989) reported that due to the extreme land-use intensity merely footpaths exist between the fields. In addition, the price for a cart is very high and there is no lack of a labour force. In contrast, 36% of the draft animals are mobilized for transportation in the Kara and Central regions.

In most regions draft animals are hired out for both soil preparation as well as for transportation (v.d. Decken, 1989). According to Lawson (1988) a team is used by 6 farmers each year in the Savanes region. Considering that each fifth farm has draft animals available, it can be assumed that almost the total cropping area in the heavily populated northwestern part of the Savanes region is tilled by draft animals.

Table F 2: Application of draft animals for various work operations, 1989

Region	Soil preparation	Seeding	Weed control	Harvesting	Transport
Savanes	94 %	–	5 %	1 %	–
	76 %	5 %	19 %	–	–
Kara	70 %	5 %	5 %	–	20 %
	70 %	–	–	–	30 %
	50 %	–	38 %	–	12 %
Centrale	50 %	–	–	–	50 %
	30 %	–	–	–	70 %

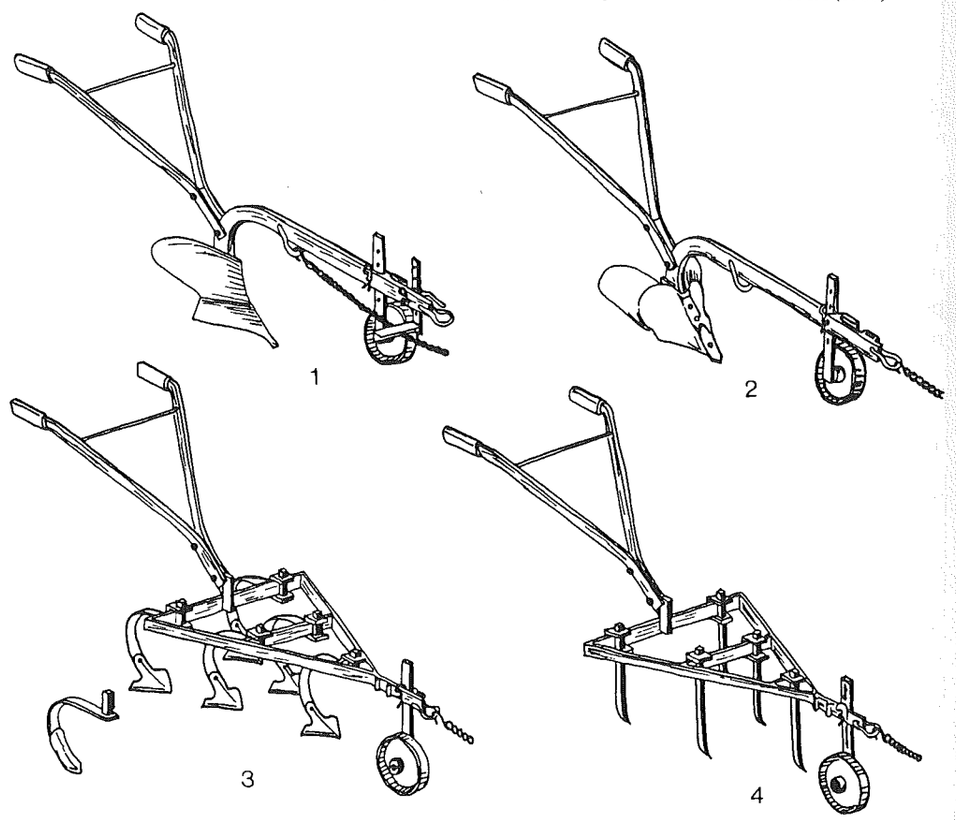
2.4 Implement types

All of the implements used in Togo (figure F 7) are manufactured by the agricultural machinery factory UPROMA in Kara, which has been in production since 1981. The steel is imported from Europe. A multifunctional tool is fabricated, called the multiculteur or omniculteur. It can be converted to perform different functions such as ridging, tilling and cultivating. The whole frame must be exchanged in order to convert the tool from a ridger to a cultivator or tiller; merely the handle and support wheel are universally useable. This operation must be carried out by the farmers several times per season if they wish to exploit the various possibilities of using the tool.

Conventional plow and ridger

The working depth of this device can be adjusted between 5 and 20 cm with the support wheel. The regulation of the working width of the conventional plow is done with the aid of a chain which is fastened to the plow frame and runs through a perforated rail at the point of attachment. The holes permit

Fig. F 7: 1 Bourguignon CH9" and CH6" conventional plow, 2 BHV ridger, 3 Houe Triangle H5S cultivator with duckfeet or with bar-point shares, 4 Houe Triangle H5R chisel plow with rigid tines. Source: UPROMA (1986)



adjustment of the working width between 10 and 25 cm. The body of the plow and its individual parts are offered in two different sizes.The working width of the ridger is varied by a spreading of its wings. The pulling chain is fastened on a connecting link. Both implements weigh 30kg.

Chisel plow and cultivator

Equipped with five rigid, straight tines (pics fouilleurs) the omniculteur is employed as a chisel plow. Three semi-spring tines are attached to the frame for weed removal; duckfoot shares or reversible bar-point shares may also be mounted on the tines. The working depth is adjusted by means of the support wheel. The rated weight of the chisel plow/cultivator is 60 kg.

Harrow

Two types of zigzag harrows are on offer – the single-section Herse 25 Dents weighing 50 kg and the double-section Herse 30 Dents weighing 75 kg.

Row marker

A row marker can be attached to the frame of the omniculteur, which draws five rows with adjustable spacings. It weighs 38 kg.

Groundnut lifter

This device consisting of a wide sweep share can be mounted on the plow frame.

Seeder

Two types of seeders employing the dibbling method are offered – a single-row hand seeder, Semoir Rotativ SR 1, and a two-row animal-drawn implement, the Semoir Rotativ SR 2. According to the catalogue the machines are suitable for planting sorghum, millet, maize, rice, beans and groundnuts. The seed is transported to the seed tube by means of a vertically rotating hole disk. There are various sizes of disks available for the different seed types.

2.5 Cropping methods and mechanization

The introduction of animal traction is predominantly facilitated on the basis of credit. In order to make repayments for loans the farmers must plant cash crops such as cotton and groundnuts. For example, SOTOCO, a monopoly for the promotion of cotton in Togo, provides loans which must be repaid in 2 – 5 years with an interest rate of 8%. The maintenance of a cropping calender is required and to assure repayment the farmers are obligated to grow at least 1 ha of cotton (Lawson, 1988).

The farmers are offered advice by the concerned organization when they purchase their equipment. If they have no experience they frequently buy a greater variety of implements on the basis of recommendation. These include the conventional plow, ridger, tiller, cultivator and often also the harrow. Primarily the farmers in the Centrale region take advantage of this wide array of implements; based upon their experience, on the other hand, in the Savanes region the farmers chiefly demand only the ridger.

Various mechanization methods using animal-drawn implements are found in the Savanes and the Centrale regions.

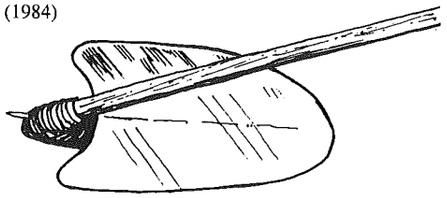
2.5.1 Savanes region

Soil preparation

The ridger is the most frequently used implement for soil preparation in the Savanes region. This reflects the findings from our survey as well as a study by the Société Togolaise d'Étude et de Développement (STED) in May 1988. Accordingly, only 5 of the 100 respondents in the Savanes region did not use the ridger. Also Strubenhoff (1988) reported of the exceptional importance of the implement in this region. Contrary to the recommendation of the extension services only 5% of the cropping area was tilled by the conventional plow, 74% directly by the ridger and the remainder by hand or directly planted without prior soil preparation.

The ridger is preferred because it meets the demands of the short cropping season and the traditional cropping methods on ridges in this region. Generally, the vegetation period is about two months shorter in northern Togo than for example in the Centrale region; thus, the farmers are forced to complete their food production in a shorter period. The soils, which are usually light and flat and show up few obstacles, meet the conditions for quick cultivation. With the exception of rice all grain types (sorghum, millet and maize) as well as groundnuts and cotton are grown on the ridges in the Savanes region. The peoples in the north practice cropping on ridges by means of the hand hoe, called the dabba (figure F 8).

Fig. F 8: The "dabba" hand hoe. Source: ORSTOM (1984)



The ridger applies a method similar to the dabba; thus, it is often referred to as the "oxen dabba". The soil under the ridges remains untilled and is driven along during the subsequent cropping period. This facilitates a significant increase in area performance as opposed to the conventional plow, since only half of the field is actually tilled.

The farmers begin soil preparation with the first rainfall. The implements cannot be used earlier as the ground is too hard. Within a few weeks the preparation must be completed so that the crops have a sufficient growing and maturing period. With an area performance of approximately 16 h/ha (survey) and a daily work time of 2 – 4 hours for plowing (Faure and Djagni, 1988b) a farmer requires 3 – 4 days per hectare. With an average field area of 4 ha per farm in the Savanes region it takes up to 3 weeks to prepare the ridges.

The most important crops in the Savanes region – sorghum, millet, cotton, maize and groundnuts – are easy to mechanize and represent a clear work peak during the soil preparation; thus, the farmers are interested in accomplishing this task quickly. An added work operation with the harrow is not possible with ridging.

Seeding and weed control

An overview of the proportion of individual crops in terms of total cropping area is given in figure F 9.

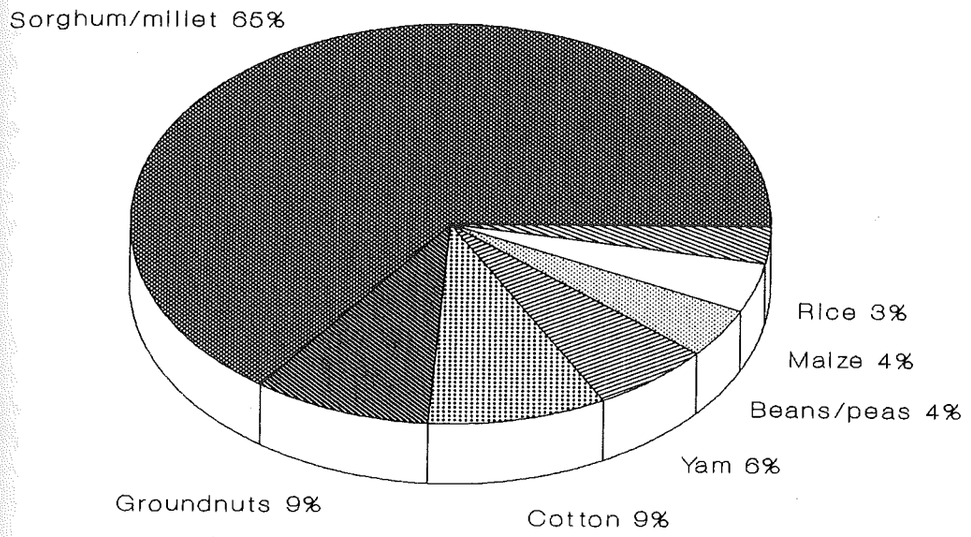


Fig. F 9: Proportion of agricultural crops in the Savanes region, 1985. Source: Strubenhoff (1988)

The seeding procedure corresponds to the climate and the type of soil preparation conducted by the ridger. The aim is to plant the seed as quickly as possible since climatic conditions only allow a short growing period.

Sowing is done exclusively by hand in the Savanes region. This is begun when precipitation continually occurs, about 1 – 3 weeks following the start of soil preparation. In part, sowing is done immediately following the ridging preparations without moving the soil again. The seed is sown into the ridges, often with a planting stick. The job is chiefly conducted by the women and children. By means of pocket drilling (dibbling) 3 – 4 seeds are planted. The large number of seeds per hole insures that with low germination or bird and weed invasion sufficient grains will sprout. In addition, this compensates for the relatively large plant spacings per row occurring due to the rapid sowing (step size). The ridge spacing is approximately 60 – 80 cm.

Midhoe and Hecht (1982) criticize the low plant density/area in this procedure. However, it could certainly correspond to the output capacity of the soil. Weed control is chiefly conducted manually in the Savanes region. A small hoe, simply called houe, is used in the furrows, and afterwards the larger hoe, the dabba, is used to build up the ridges. For the latter work operation the ridger is occasionally employed. If no complications set in, a work time saving of approximately one-third can be achieved by substituting the dabba with a ridger (v.d. Decken, 1989).

For the application of the ridger as a weed controlling device, the precondition of even, parallel rows must be established. This is not always carried out in the Savanes region according to v.d. Decken (1989), although

there draft animals are the most widespread of all of Togo. It must be assured that weed control is a relatively minute problem. Due to the climatic conditions the risk of weed invasion is less in this region than farther south. This operation is not as tied to deadlines, as for example soil preparation, and no lack of labour exists.

Furthermore, there is another reason why weeding is not carried out by animal-drawn implements. In the survey the problem was frequently mentioned that this "precision work" cannot be done by the animals because they are not sufficiently trained. The farmers are afraid that plants will be damaged.

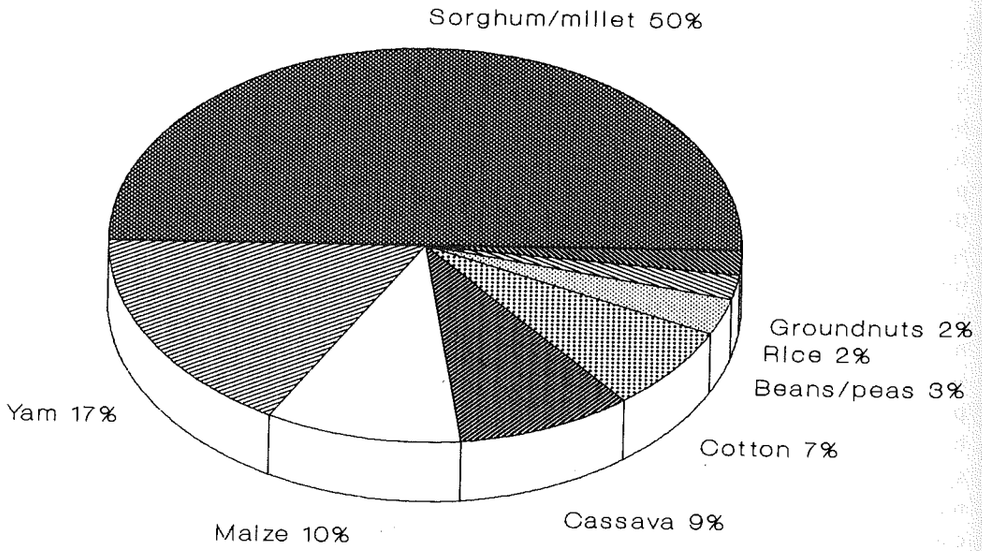
2.5.2 Centrale region

Soil preparation

With an adaptation rate of only approximately 1% in the Centrale region animal traction is only marginally represented and virtually little experience has been registered by the farmers. The recommendations of the extension services have been better accepted and it is simpler to introduce a certain array of implements for animal traction from the very beginning (v.d. Decken, 1989).

Soil preparation is almost exclusively carried out with the conventional plow. 45% of the crops are heaped up (buttage) at a later time (PES, 1988). The ridger is employed by 2% of the farmers for soil preparation (billonage). This is practised particularly by the farmers from the Savanes region who have migrated into the Centrale region. Although the climatic conditions in the Centrale region do not require it, with an approximately 2-month longer vegetation period, they maintain their customary work practices. The cropping calender in the Centrale region varies considerably from that used in the Savanes region. The proportion of grain planted

Fig. F 10: Proportion of agricultural crops in the Centrale region, 1985. Source: Strubenhoff (1988)



consists of 50% of the total arable area, to the advantage of the tubers (figure F 10).

Since the soil preparation for yams is done at the end of the rainy season, there is no marked work peak at the beginning of the rains. Moreover, cropping tubers can not easily be mechanized.

In comparison to the Savanes region the farmers have a more balanced working calender. A second work operation with the harrow, as propagated by the extension services and according to a study by PROPTA (PES, 1988) as being quite frequently carried out, was not confirmed by our survey. V.d. Decken (1989) mentions that instead the animals are hired out. After tilling their own fields the farmers plow for others who have no animals. Since they receive cash for this activity they prefer it to harrowing their own fields.

A severe problem for soil preparation is the occurrence of many obstacles in the form of roots and organic residues. This leads to implement clogging and time loss and can invoke an undesirable behaviour of the animals. If roots get tangled in the implements during weeding the farmer must halt the operation and remove them, which takes a great deal of time and energy. This leads to the habit that oxen develop to stop and reverse when any resistance is perceived during tilling (Gutsche, 1989).

The reason for the numerous obstacles lies in the low land-use intensity in the Centrale region. Because a short period of cultivation and long fallow periods are usual here a thorough clearance and removal of roots does not appear to be of any use to the farmers.

Seeding and weed control

On the flat, level fields in the Centrale region sowing and planting is primarily done manually. According to estimates by Bordet et al. (1988) and v.d. Decken (1989) 300 – 400 implements have been delivered, of which some 150 are actually put into use, concentrated in the Kara and Centrale regions. When seeders are employed they can only operate efficiently about two days after a fall of rain, since they become plugged when the soil is too wet (v.d. Decken, 1989). This represents a contradiction as opposed to sowing by hand, which can begin immediately following a fall of rain. The farmers find it difficult to attach any importance to later sowing, and this work operation does not represent a work peak. In part, training measures are lacking. These expediencies plus the high price fail to convince the farmers of the advantages a mechanical seeder can bring and does not promote purchase.

Normally the plowed fields are sowed directly without further soil tillage. This results in the growth of weeds prior to germination of the crops. Weed invasion is a more serious problem in the Centrale region due to the somewhat wetter climate. Since sowing is done on flat, level land the rows of crops are often difficult to identify during weeding. The occasional use of the cultivator then becomes less effective. If weeding is done with the hand hoe the weeds that have reached a height of 20 – 30 cm are first pulled out by hand. The earth is shaken off the roots and the weeds are left to dry on the ground. Often the implements are mobilized at the same time as hand weeding; this leads to less success in weed control and frequently causes plugging. In contrast to the ridger the efficiency of the cultivator is lower.

Work operation	Hectares	Percentage
Plowing	664.15	97.61
Ridging	71.75	10.55
Harrowing	234.27	34.43
Seeding	36.50	5.36
Heaping up	305.82	44.95
Weed control	168.75	24.80
Investigated area in total: 680.40 ha		

Table F 3: Work operations with animal-drawn implements in the Centrale region. Source: PES (1988)

Thus, the former tool is preferred for weed control (table F 3).

On the whole the oxen farmers in the Centrale region employ animal-drawn implements to a greater extent than in the Savanes region. According to v.d. Decken (1989) the plants are sown in more exact rows. However, as in the Savanes region they complain about the poor training for the animals with regard to weed control operations. In addition, the farmers in the Centrale region have not become accustomed to dealing with animals and are frequently afraid of them.

2.5.3 Discussion

In summary, it has been determined that the situations under which the farmers conduct agricultural production vary from region to region. In the northern areas the farmers encounter more adverse conditions due to a 2-month shorter vegetation period and a higher population density. This has led to the development of a system for employing draft animals that is more adapted to their own conditions. Therefore, the farmers only select implements and cropping recommendations that fit into their methods. In this case it means that the availability of a ridger suffices and would save them from higher loan repayments for unnecessary implements.

In the Centrale region the necessity to use animal traction is less relevant on the basis of the already mentioned factors. The hand-hoe system of cultivation predominates in this lesser land-use intensive approach, adapted to local conditions. Animal traction is not widespread. Where it has been introduced, the recommendations of the extension services are simply followed due to a lack of own experience. A large array of implements is then purchased, of which only one or two are actually being used. It would be desirable if the extension services would pay closer attention to this problem and make a more decided attempt to correlate the purchase of implements with the actual requirements and conditions, since the financial load is considerable.

Animal traction is primarily applied to soil preparation. It is common to hire out the animals for this work operation in both regions. This conflicts with application by way of a second tillage operation with the harrow, which according to v.d. Decken (1989) should be carried out in the Centrale region because of the greater amount of weed invasion. Nevertheless, it should be discussed whether the use of the harrow makes any sense, considering the number of roots and the risk of removal of organic matter. The farmers are tempted to burn the piles of decomposed plant material occurring from continuous cleaning of the harrow. Gutsche (1989) is of the opinion that the harrow could be replaced by an object (e.g. a wooden beam for breaking clods) that could simply be dragged through the fields and need not be transported to fields farther away. If

weed control is conducted by animal-drawn implements the time of application must be earlier than that with the hand hoe, since larger weeds cannot effectively be eliminated with implements.

Finally, it must be mentioned again that the introduction of animal traction can only be financed by cultivation of cash crops. As an alternative the animals in the Centrale region are readily used for purposes of transportation, since it represents good earnings for the farmers. The credit grantors do not appreciate this, as direct influence on the income of the farmers is no longer possible.

2.6 Training

Most farmers first come into contact with draft animals in a 2-week training period, if they have not already had the opportunity to acquaint themselves through neighbours. Following the training period they receive the animals and implements on credit.

Numerous difficulties and shortcomings become apparent during the training. In part there are language problems; interpreters are used in an attempt to overcome these deficiencies. There is a great danger that insufficient or incorrect translations will lead to the conveyance of erroneous information, which can hardly be corrected later, since accompanying extension services are not ensured due to a lack of expertise.

The training period is too short and takes place during an inappropriate point in time, the dry season. Therefore, no possibility is given to try out the work in the crops in practice. The implements and the training can generally not be made to correspond with the requirements of the various soils (types, structure) found on the farms. The knowledge of the trainers is minimal in terms of the various regional conditions. The farmers learn to apply the right implements and the adjustments on their own by trial and error. They often complain that there is a lack of willingness to attempt innovative action (v.d. Decken, 1989). Their respect of the new technology is so great that they do not take any risks.

There could be other reasons for the behaviour of the farmers. When the soil is ready for tillage they probably hardly have time to conduct experiments with their implements. Furthermore, each time an alteration of the implement is undertaken a tool (a spanner etc) is required. Since necessary parts easily become lost or are not available due to inadequate delivery services, for many the time investment may appear to be too great for the knowledge and experience gained thereby.

Frequently, complaints are uttered regarding the poor training of the animals as a reason for not employing animal-drawn implements in weed control. Usually the farmers receive relatively young oxen that possess little experience and a restless working manner (Gutsche, 1989). The farmer fears a loss of his crops if the oxen do not walk precisely in the furrows. This starts a vicious circle. If they are only used for soil preparation the animals are not challenged enough and lose their trained abilities by the next cropping season. Farmers not accustomed to using animals are often afraid of the oxen and lack the appropriate sensitivity.

The training programme normally terminates with one schooling session. Field advi-

sors should be on hand to serve as contact partners. However, they can hardly master the task, since they are also responsible for all areas of agriculture – plant and animal production as well as infrastructure. Per extension officer there are 300 – 400 farmers (v.d. Decken, 1989).

Thus, the introduction to animal traction cannot be accompanied by trained personnel.

2.7 Repair and procurement of spare parts

All spare parts and abrasive components are manufactured and distributed by UPROMA. Procurement of spare parts and the possibility of repair is generally difficult. The purchase of required parts should be conducted by way of orders given through the field extension officer, who is overloaded with work. Another problem is the names of the parts. Not only is a translation problematic, but often there is no terminology for the parts in the local language. This is particularly the case for specific small parts.

In many cases proper maintenance cannot be carried out due to the poor spare part supply situation. The cropping period has often already passed between ordering and delivery. Because of the high abrasion – a plowshare lasts one season – severe problems are encountered. It is not surprising that the farmers allow their implements to deteriorate to the point of wearing out of the critical components, e. g. the mouldboard.

The exchanging of plowshares is completed by the farmers. Blacksmithing of the shares is only partially done by artisans since their function is limited to the fabrication of hand hoes. Attempts by the artisans to manufacture the implements themselves are set back in preference to the main production line. V.d.Decken (1989) is of the opinion that the village artisans are basically in a position to do the welding if they have access to training courses. Thus in the Savanes region a programme is being offered. Nevertheless, spare parts must still be procured from the neighbouring country. Ridging tools from Ghana are employed, but these do not fit on the omniculteur very well. A consequence of the poor situation is also that the farmers do not want to use their implements for less effective work operations in order to preserve them.

On the whole, repair work for artisans is economically more attractive in the regions where animal traction is more prevalent; thus, procurement of spare parts and possibilities of repair are better than in the regions having a lesser distribution.

2.8 Experience with equipment

2.8.1 Soil preparation

Experience with equipment has primarily been made with the conventional plow and the ridger, as other implements have not been mobilized.

If they have been properly adjusted the results with the conventional plow and ridger are good (Gutsche, 1989). With a weight of 30 kg they are well adapted to the draft power of the animals, the work operation and the handling. Difficulties arise during use mainly due to faulty adjustment and technical defects. The latter is not due to design errors

but rather to inadequate material quality and a poor infrastructure for maintenance and repair. Thus, a timely exchange of worn out parts is hampered. The individual aspects are now dealt with in detail.

Adjustment

Since the farmers only receive a brief training, in which the adjustment of the plows is not conveyed to be remembered for any length of time, this constraint frequently shows up. This has consequences for the point of gravity, hinders an optimal efficiency of forces and increases therefore the specific resistance. The imbalance makes it more difficult to keep the implement in the furrow and provokes a counter-reaction by the person guiding it. Thereby, bending is caused on the width adjustment and the handle. The adjustment mechanism can also break off. The farmer then simply uses a hole at the hinge.

Incorrect adjustment leads to a more rapid abrasion of components and damage to the bearing of the support wheel. Finally, a faulty adjustment demands a greater energy input for both man and animal.

Abrasion and breakdown

Material quality has been a problem since the beginning of production at UPROMA; to date this deficiency could not be removed. In a study by STED (1988) on the abrasion occurring on the conventional plow and ridger the wear on various parts (shares, ridging tools, slade, plow heel and axle) was measured.

The wear on the most critical parts is generally less for the ridger than for the conventional plow, according to the study. The plowshare is more rapidly worn out than the tip of the ridger (table F 4). This tendency was also confirmed by our survey. According to v.d. Decken (1989) a plowshare lasts for the plowing of 5 ha, which is the equivalent of operation for one season in the Savanes region. A further problem occurs with the bolts on the implements which undergo

Table F 4: Abrasion of various components on the conventional plow and the ridger. Source: STED (1988)

Parts: / Region	Beak-type share cm/ha	Landside mm/ha	Plow heel mm/ha	Wheel axle mm/ha	Ridger share cm/ha	Ridger heel mm/ha
Savanes	0.98	0.16	0.46	0.25	0.38	0.35
Kara	1.40	0.11	0.66	0.25	0.68	0.44
Centrale	1.31	0.11	0.55	0.20	0.34	0.47
Plateaux	1.20	0.11	0.31	0.15	0.15	0.12
Maritime	1.31	0.13	0.70	0.39	0.25	–

severe wear at the shares. In the Kara and Centrale regions the abrasion due to the very stony ground is greatest.

In the Savanes and Centrale regions near Tchamba many worn out and unusable mouldboards and ridger bodies can be found that are only 2 – 4 years old; obviously worn out shares, slades, and plow heel had not been replaced in time. Mouldboards and plow frog were not taken into account in the data collected by STED, as they are not normally exposed to abrasion. It has been shown however that they can become severely damaged if the adjacent parts are not exchanged regularly.

A further cause of damage is the unsuitable time of using the implement. The farmers in the Savanes region for example are forced to begin seedbed preparation and planting as early as possible because of the brief vegetation period. Soil preparation takes place when the soil moisture is insufficient or even prior to the rainy season. A dry, hard soil can hardly be loosened or crumbled without harming the implements. Implements can also undergo damage during transport by dragging to the fields and the handle can become bent.

Design

In relation to the work results fault cannot be found with the design of the plow and the layout could hardly be simpler. Nevertheless, the technique places new demands on the farmers that does not correspond with their knowledge and customs. If one compares the conventional plow and ridger with the traditional implement, the hand hoe, several new characteristics can be distinguished. The dabba has no bolted connections. This is therefore unknown to the farmer and often he does not possess suited tools. Moreover bolts undergo a high abrasion particularly on the shares.

Every alteration includes rebolting, if the potential of the omniculteur is to be fully exploited. Mastering this job depends on the technical understanding of the farmers. This is also a reason for poor adjustment and improper exchange of worn-out parts.

The occurrence of abrasion on the bearing of the support wheel is partially due to the design (material application of steel on steel). In order to prevent damage to the bearing it is sometimes suggested to use an adjustable skid that does not jam or plug as easily. In practice, however, this has not been accepted because the plow cannot be transported to the field. V.d. Decken (1989) suggests the attachment of the wheel to a fork-type support, which could also fulfil its purpose when worn out.

2.8.2 Seeding

Experience in this area is hardly available, since these implements are seldom used in practice, although they are pulled by hand or by animal. The few experiences with UPROMA implements show that the technique has not reached any level of perfection. The planting jaws become plugged easily and at a higher speed the seeds become damaged. Depth of depositing seed is not adjustable and sowing occurs by pocket drilling. V.d. Decken (1989) found in one experiment that the hand-operated seeder can in principle also be used on ridges.

2.9 Summary and conclusions

Since the colonial period many national and international organizations have attempted to introduce draft animals to Togo. For over 10 years the government of Togo has promoted the concept of animal traction. Despite widespread application the efforts to date have led to little success. With an average adaptation rate of 2.5% work operations with draft animals still represent a small share of the total agricultural activity in Togo.

The accent lies in the north of Togo, especially the Savanes region where animal traction finds a distribution rate of over 10% among the farmers. In the Kara and Centrale regions, which border on the Savanes region, an adaptation of only 1% reflects low acceptance by the farmers. It is hardly present in the southern Plateaux and Maritime regions.

In summary, the most important reasons for the distribution as well as the problems of draft-animal application are elucidated.

– A high land-use intensity exists in the Savanes region. The semihumid/semiarid climate and the associated vegetation period of approximately 5 – 7 months call for a rapid planting of the fields at the beginning of the rainy season. The use of animal-drawn implements is favoured because of the easy-to-mechanize crops – sorghum, millet, cotton and groundnuts – as well as the fact that the fields are largely free of obstacles and roots.
– In the Centrale region low land-use intensity and a rapid planting is not urgently required since the vegetation period in comparison to the Savanes region is 2 months longer. The work is more evenly spaced due to the higher proportion of tubers, yam and cassava, whose soil preparation already occur at the end of the rainy season. These crops are also difficult to mechanize. In addition, the use of animal-drawn implements is hindered by the occurrence of roots, because of the longer fallow period.
– The subhumid southern Plateaux and Maritime regions have a high population density as does the Savanes region, and a high land-use intensity. However there is also a longer vegetation period and a different constellation of crops, primarily perennials. The more moist climate also presents a greater risk of disease for the animals.
– Animal traction is predominantly introduced by larger farms (4 ha arable land, 10 – 15 family members). The investment is mainly financed by the cultivation of cash crops such as cotton and groundnuts, which correspond with the suitable climatic conditions in northern Togo. The Société Togolaise de Coton (SOTOCO) is one of the agencies that promotes animal traction and provides loans for this purpose. At the same time, this organization purchases the cotton from the farmers, thus having direct control over their income and ensuring repayment of credits. Therefore, the farmers are obligated to maintain a cropping calendar that includes the growing of at least 1 ha of cotton.

– Animal traction is primarily employed for soil preparation; farmers in the Savanes region purchase and use the ridger for their traditional cropping on the ridges. The ridger, as a high area-performance implement is well adapted to the short vegetation period and corresponds to the hand hoe, the dabba, in terms of the type of work accomplished.

In contrast, the farmers in the Centrale region purchase a larger assortment of implements (omniculteur with components for conversion to conventional plow, ridger, tiller, cultivator and harrow) since they lack

necessary experience in procurement; the actual use is limited to a few implements. The conventional plow is primarily used for soil preparation, in accordance with the recommendations offered by extension officers. About half of the crops are heaped up at a later point in time by the ridger. Harrows and cultivators are used to a lesser extent percentagewise. Essentially, only the work operation for soil preparation with animal-drawn implements is mechanized; all others are conducted manually.

– The only implements available to the farmers are purchased from UPROMA, the only farm machinery factory in Togo; imports from neighbouring countries or local manufacturing by local artisans have been suspended to the benefit of a central, national production. The main implement is the omniculteur, which can be converted for different functions, but is chiefly used as a conventional plow or ridger. The marketing of a smaller variety of implements or components, differentiated according to regional requirements, would suffice and also, lower the cost of the loans.

– The introduction of animal traction in comparison to work with the hand hoe represents a complex, entirely new technique in many fields; the single period of training of usually 2 weeks is too brief. Parallel courses are necessary to provide practical experience for the farmers in the new working methods.

– Due to a lack of technical knowledge and difficulties encountered (roots, stones, hard soil) the implements are subject to severe abrasion and frequent damage. The possibilities for repair are inadequate since there is a poor supply of spare parts and a lack of training for the artisans. These infrastructural measures appear to have been neglected by the promotion agencies. Subsequently, the implements become more rapidly unusable and cause a greater load for both man and animal. It then often happens that the farmer returns to his accustomed methods of carrying out the work with the hand hoe.

Finally, it has been determined that animal traction is only found and can be effectively introduced where it is adapted to the local conditions and respective farming systems. Attempts to establish it in less suitable locations such as the Centrale, Plateaux and Maritime regions only have proved a minimal success. It would be more beneficial to promote the expansion of spare parts distribution and possibilities to have repairs made as well as training opportunities for the farmers and artisans where animal traction is adaptable.

3. Case study: Senegal

3.1 The country and the population

Senegal (figure F 11) has a total surface area of ca. 197,000 km^2 and thus is somewhat smaller than the Federal Republic of Germany (250,000 km^2). In 1988 there was a population of approximately 7.1 million inhabitants with a growth rate of 2.9%. On the average the population density is about 35 inhabitants per km^2, but this varies considerably from 6 per km^2 in East Senegal to 2500 per km^2 in the Cap Vert region. 70% of the Senegalese people live in rural areas. The rapid rural exodus is creating a population explosion in Dakar, the capital, as well as the Cap Vert region. (Statistisches Bundesamt, 1987; Nohlen, 1989)

The country has relatively few natural resources, phosphate being the most important. The main share of the gross national product is covered by agricultural products, representing 20 – 30% of the total, whereby great fluctuations occur depending on the climate. Since Senegal is the world's largest exporter of groundnuts, the record harvest in 1987/88 of 950,000 tons severely depressed the world market price. Approximately 1/4 of the turnover of the industry in Senegal is generated by oil mills. About half of the industrial products are exported, mainly groundnut products, tinned fish, phosphate, shoes and textiles. Transportation routes have been built up relatively well for African conditions. (Statistisches Bundesamt, 1987; Nohlen, 1989)

Senegal, along with six other West African countries, belongs to the Communauté Financière Africaine, which issues the franc CFA currency unit. It has a fixed exchange rate of 50 CFA to the French franc. Therefore, currency exchange problems do not exist to the extent known in other countries of the Third World. The importation of goods is thus easier within certain limits. In 1987 the expenditures for imports were covered by exports to 58% (Nohlen, 1989).

3.2 Natural endowment

Climate

The south of Senegal has a wet and try tropical climate with a rainy season from June to October. In the north there is a semiarid climate with only a 3-month rainy season and an uncertain amount of rainfall. The precipitation ranges from 1200 mm per annum in the southwest to 300 mm in the north of the country. (Statistisches Bundesamt, 1987) It is being observed that from the northeast to the southwest aridity is on the increase, thus changing the overall agricultural production systems.

Soils and topography

Senegal is predominantly flat; the existing slight rolling hills are seldom higher than 200 m. The soils are mostly sandy (Sols Fer-

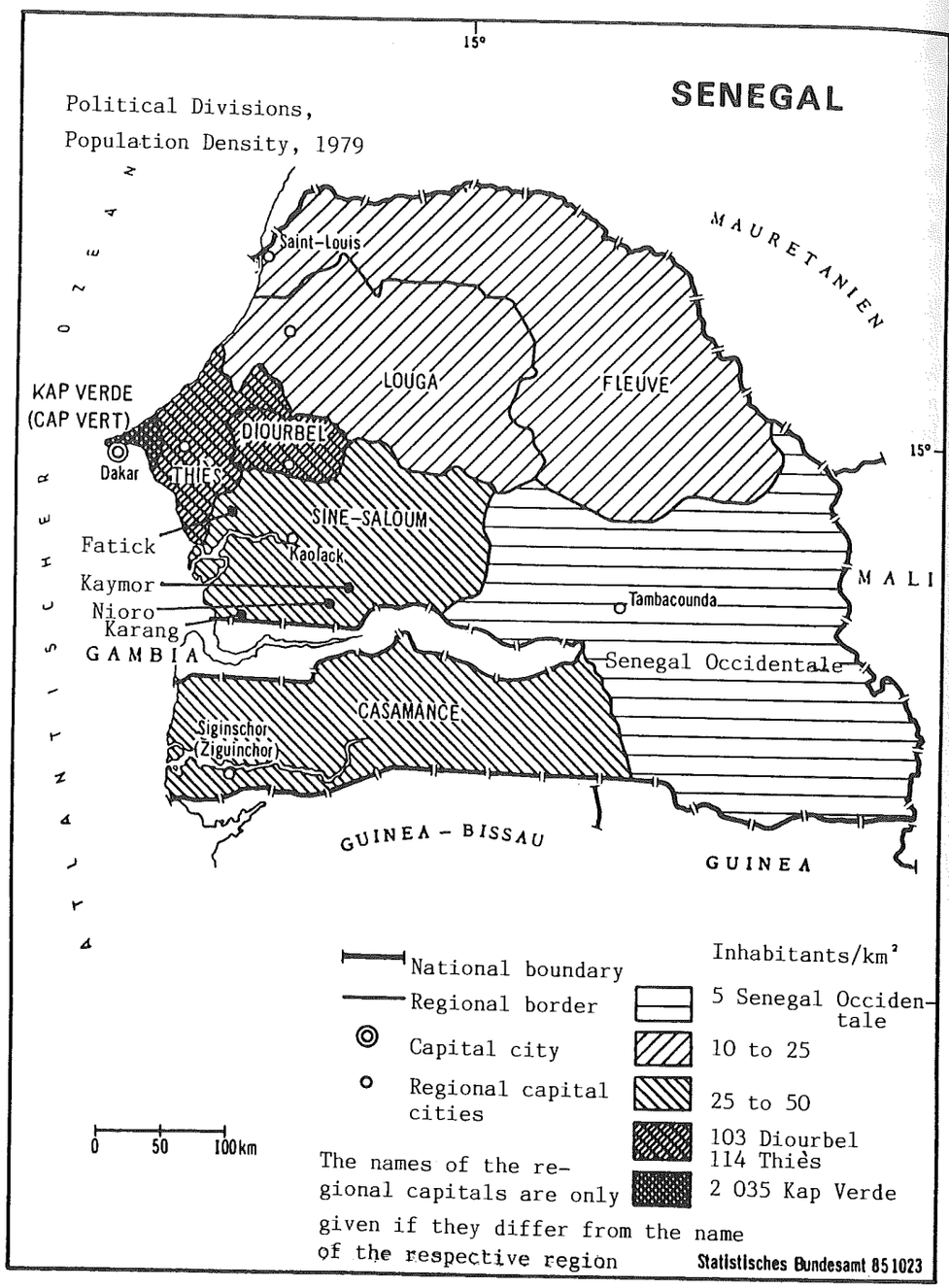


Fig. F 11: Senegal

rugineux Tropicaux – FS; Alfisol – USST) to clayey (Sols Ferralitiques – FS; Ultisol – USST). In some regions as in the Casamance rough relief is encountered, in which soil types change drastically within short distances between plateaus, slopes and valleys. On the slopes the soil is often clayey, in part with iron concretions which are difficult to till. In the valleys heavy alluvial soils (Sols Hydromorphes – FS) are found. The soils on plateaus and slopes are characterized by very rapid compaction during the dry season and render soil preparation most difficult (Fall and Ndiame, 1988a). Sandy soils are less fertile and have a weak structure. Surface crusting and compaction become a problem. Macropores can only be created on the basis of biological activity.

The coastal zone is flat, with the exception of the steep coast of Cap Vert, which is of volcanic origin (Statistisches Bundesamt, 1987).

3.3 Agriculture

3.3.1 Background information

In 1984, 5.22 million ha of arable land and permanent crops were registered. Approximately 2/3 of the gainfully employed inhabitants work in agriculture. They produce about 1/3 of the net export profits, especially from groundnuts and groundnut products and to a lesser extent from cotton. Staple foods are millet, rice, maize, beans, cassava and groundnuts. In the densely populated coastal regions vegetables are also grown. Tree crops are oranges, mangoes, bananas, coconuts and oilpalm. (Statistisches Bundesamt, 1987)

The two crops, groundnuts and millet, alone cover 88% of the cultivated land; they are produced across the whole of the country except for the Sénégal river valley. Cotton production takes up only about 1/20. It is found primarily in Sénégal Oriental and Casamance. 67% of the groundnut production originates from Sine-Saloum. Sorghum is grown especially south of Kaolack and rice in Casamance; dry rice is found in Sénégal Oriental and paddy rice along the Sénégal river. Maize cropping occurs only on a few areas in the south of Sine-Saloum, but mainly in Casamance and Sénégal Oriental. Niébé cropping occurs throughout the whole country, however is more prevalent near Louga. (Havard, 1988a)

Depending upon the weather conditions the yields of the individual crops fluctuate significantly in different years. On the whole, food production per inhabitant has declined approximately 1/3 in the past 10 years. Under a "new agricultural policy" an increase and diversification of own production of staple foods (millet, maize, rice) is to be achieved with a corresponding reduction of food imports, especially rice. (Statistisches Bundesamt, 1987 and 1985)

Animal husbandry only plays a small role in agricultural production. Cattle are reared predominantly in the north of the country and represent the most important activity with 2.2 mil animals (1985). (Statistisches Bundesamt, 1987)

3.3.2 Status of animal traction

Animal traction is considerably widespread in Senegal. More than 30% of all the farms

use draft animals (Starkey, 1988b). In contrast, in 1984 only 460 tractors and 145 combine harvesters were registered in the country (Statistisches Bundesamt, 1987).

In no other country of francophone Africa in the past has so much effort gone into the promotion of animal traction as in Senegal. For this reason there is hardly an animal-drawn implement in Africa that has not been tested in this country, either in this or a similar version. (Bordet et al., 1988) The dissemination of animal traction here was particularly associated with the expansion of groundnut cropping.

Today, the number of draft animals is given as ca. 520,000, of which 200,000 are horses, 180,000 donkeys and 130,000 cattle (Starkey, 1988b). Since there is a good market for meat of young draft oxen they are considered to be a very economic investment (compare section D 5). In 1981 about 26% of the draft cattle were cows (Lhoste, 1986). The utilization of cows offers the possibility of having trained animals over a long time span and to assure reproduction (compare section D 1.3.1).

In the Thiès, Diourbel and Louga regions horses represent the greatest share of work animals, while in the south of the country oxen predominate in the Casamance region. Donkeys are used in the north and the east. Correspondingly, one can observe a transition from the donkey to the horse and then oxen with increasing humidity. The suppression of the tsetse fly due to aridity is an advantage for the penetration of the donkey in the south.

3.4 Work operations and implements

3.4.1 Overview

Bordet et al. (1988) estimate that in 1983 ca. 230,000 cultivators, 145,000 seeders, 100,000 carts, 67,000 groundnut lifters, 52,000 plows and 9,000 ridgers were being used. These figures show the significance of light cultivators (especially Houe occidentale and Houe sine) and the seeder (Super Eco).

After initially being used for groundnuts and later also for other crops (cotton and grain) the Super Eco was overtaken by light cultivators for weed control and for surface soil preparation in terms of sales figures. (Bordet et al., 1988)

The increase of sales of animal-drawn implements during the years 1960 – 1979 (figure F 12) must be viewed in connection with the "Programme Agricole" operational in this period in Senegal. Credits for procurement of inputs was made available to the farmers within the framework of this scheme, which was discontinued in 1980 because of open debts accrued by some cooperatives (Havard, 1988a). This directly affected a reduction of sales of implements. The decline is less attributed to the lower real demand of the farmers for implements than to the poor capability of building up capital. The farmers reacted by continuing to utilize their old implements in their poor condition, thus negatively affecting the work operations. (Havard, 1985)

The development of animal traction occurred primarily in the "Bassin Arachidier". 82% of the implements sold since 1950 went to the area, comprising the Thiès, Diourbel,

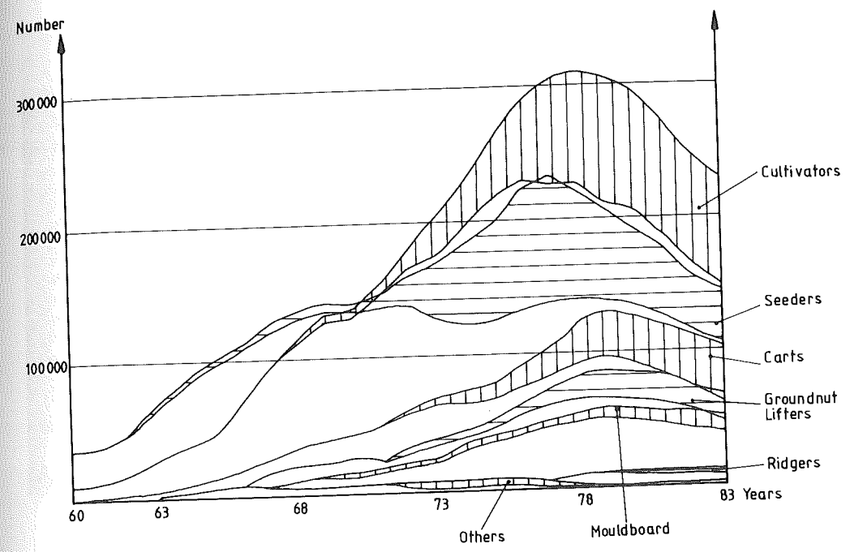


Fig. F 12: Distribution of animal-drawn implements in Senegal. Source: Havard (1985)

Louga and Sine-Saloum regions. Sénégal Occidental received only 9% of the total, including however 30% of the ridgers and plows. Casamance region absorbed 9% of the sold implements, which consisted of 50% of the plows and 65% of the ridgers. Animal traction has not been disseminated in the remaining regions. (Havard, 1988b)

In subsequent sections of this text the plow, ridger, Super Eco seeder, groundnut lifter and multipurpose Houe occidentale, Houe sine, Arara, Ariana and the polyculteur are introduced for each individual work operation. The implements available in Senegal are almost exclusively manufactured by SISMAR in Dakar. This company also offers other implements, which have however hardly found acceptance in agricultural practice. This also applies for prototypes.

3.4.2 Soil Preparation

Soil preparation with a animal-drawn plow was for a long time the object of the extension service programme in Senegal. However, the plow is not accepted by the farmers in the north of the country and in the Sine-Saloum region. The main reason is that the vegetation period is very brief in these drier regions. Sowing must take place as early as possible. A prior intensive soil preparation during the dry season is not possible in the dry and hard soil. Soil preparation after the first rain would delay the sowing date considerably and thus increase the risk for the yield and harvesting.

For this reason direct sowing with the seeder without previous soil preparation is prevalent in the northern drier part of Sine-Sa-

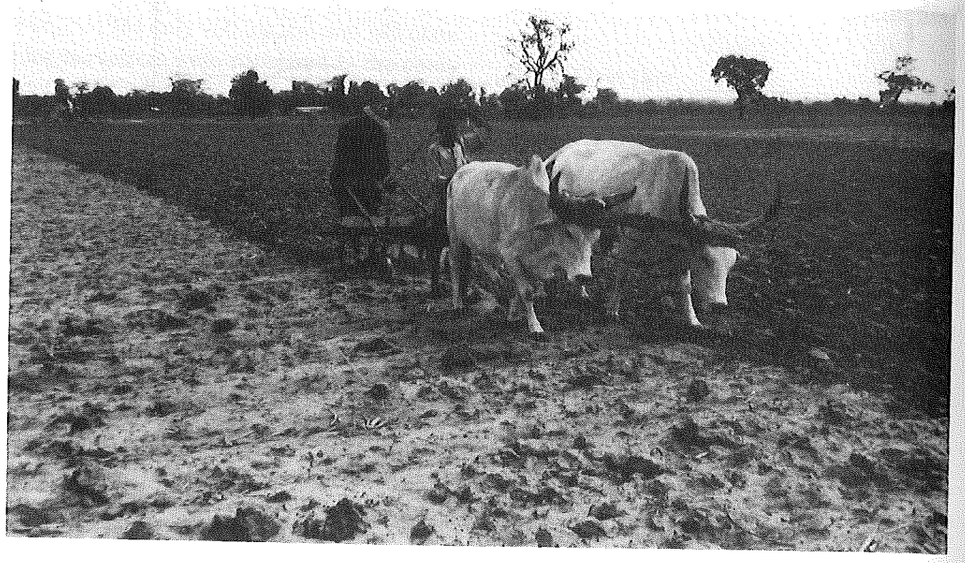


Fig. F 13: Surface soil preparation with the Ariana multicultivator in Kaymor (Photo: Schmitz)

loum, while in the south only a surface soil preparation occasionally takes place with the cultivator (figure F 13).

In contrast, the longer vegetation period in the more humid areas of Casamance allows a more intensive soil preparation. In this region crops are traditionally grown on ridges. Here, the plow has been used for seedbed preparation and to some extent for building up of ridges. A more intensive soil preparation is necessary, among other things, because of the high weed growth in wetter regions. Estimates assume that a large proportion of the plows in Senegal are to be found in this region (table F 5).

The practice of superficial soil preparation, as is conducted in Sine-Saloum, has moved in recent years to approximately 200 km to the south.

Harrows have not been seen in agricultural practice.

Plow

Two plows from SISMAR are being offered: the CFOOOP conventional plow with the Huard body (8" or 10") weighing 38 kg (figure F 14) and a 10" reversible (two-way turnover) plow with 2 bodies weighing 50 kg, which however is not widespread. According to company brochures both plows function at a working depth of 18 – 20 cm and an average draft power of 70 – 80 kp.

Table F 5: Regional distribution of plows (1983, estimated). Source: Havard in: Bordet et al. (1988)

	Casamance	Senegal Orientale	Sine Saloum	Thiès-Diourbel-Louga	Total
Plows	27,500	16,200	4,000	4,800	52,000

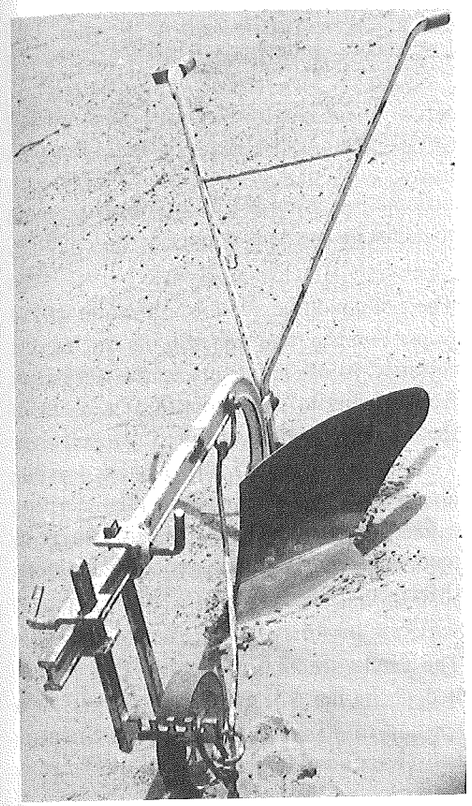


Fig. F 14: Conventional plow CFOOOP (Photo: Neunhäuser)

In Senegal the Huard plow body, especially with the CROOOP conventional plow and as a tool for the Arara cultivator, appears to have become widespread. This plow requires a team of animals (as a rule oxen).

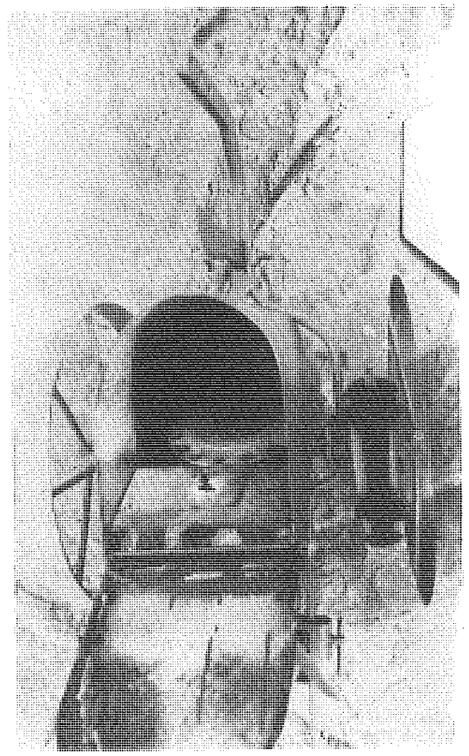
Ridger

SISMAR offers a ridging body, which can be mounted on multipurpose implements. In eastern Senegal and Casamance it is often found in combination with the Arara multicultivator, which is most widespread there. Another ridging body has been introduced from the Gambia to Casamance and is occasionally employed with the frame of the CFOOOP plow, after the "Programme Agricole" was discontinued in 1980 and no further credits were offered. It appears to achieve a better result in: some situations. (Fall, 1985 in Bordet et al., 1988)

3.4.3 Sowing

The Super Eco seeder was already introduced in 1930 for planting groundnuts and

Fig. F 15: Super Eco with slanting spacing wheel (Photo: Schmitz)



	Casamance	Senegal Orientale	Sine Saloum	Thiès-Diourbel-Louga	Total
Seeders	30,000	30,000	95,000	75,000	230,000

Table F 6: Regional distribution of seeders (1983, estimated, rounded figures). Source: Havard (1988a)

had substantial distribution. The implement is equipped with a furrow opener, two seed covering scrapers (adjustable in height) and a press roller. The exchangeable slanting spacing wheel assures a careful handling of the seed, which is particularly important for groundnuts (figure F15). The deeper point of gravity of the implement and its low weight facilitates handling. For transport the tools can be set to a higher position. The Super Eco is adapted to the draft power of the donkey (25 – 30 kp[1]) or horses (35 – 40 kp): with coulter, furrow opener and duckfoot shares it requires 20 kp on sandy soil and 30 kp on soils with a higher clay content (Havard, 1988a).

The implement received a good assessment from all the respondents and contacts. Its success is especially attributed to its appropriateness for direct seeding, which corresponds to the traditional method of sowing in some regions. In addition, the seed covering scrapers mounted on the implement simultaneously take care of weed control during sowing, an operation that is traditionally done by the farmers after the emergence. Seeding can be also done on low ridges because of the two side wheels (Metzger, 1988).

In practice the accessories, such as the knife coulter or the marking stick are not used by the farmers (Bordet et al., 1988). The furrow opener is often welded tight, in order not to become lost, even if it is no longer possible to adjust the working depth (Havard, 1988a).

The pre-condition for the utilization of the Super Eco is a field free of roots and harvest residues. Its use has displaced the work peak from sowing to weed control as a result of the now possible expansion of cropped area. The farmers often sow the greatest possible area and during weed control they can first assess how much they really will manage to tend depending on the climatic conditions (Metzger, 1988).

The Tamba seeder is used for sowing cotton; it deposits the 5 – 6 seeds in pockets at a spacing of 15 – 25 cm. The implement is considered inefficient due to the uneven distribution of the seed (Havard, 1988a).

Because of its rapid pace the horse is usually used for sowing. Frequently, children are given the task of seeding and weed control with animal-drawn implements.

The Super Eco has a varying distribution corresponding to the types of crops and cropping methods (table F 6).

3.4.4 Weed control

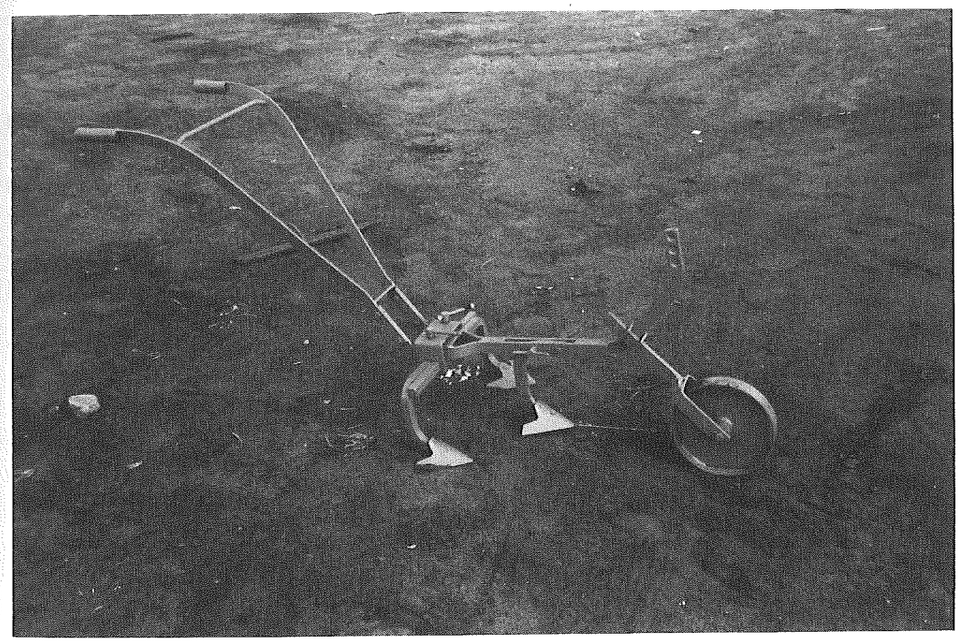
This work operation is carried out almost exclusively with multipurpose toolbars having 3 or 5 cultivating tools, which are suited for both weed control and surface soil preparation. In addition, they can be equipped with a ridger, plow body or groundnut lifter.

For the following two implements a width adjustment of maximum 45 cm is possible (the spacing of the groundnut rows is between 50 and 60 cm). As a rule only one draft animal is used for this work operation, normally the horse or donkey. (Bordet et al., 1988)

Houe Occidentale

The Houe Occidentale is a light cultivator. It can be used with 3 or 5 cultivating tools or 3 chisel-plow tines and can easily be adjusted for width without the aid of a spanner. Moreover, a ridger or a plow body (6 or 8") can be obtained for this implement and groundnut lifters manufactured by artisans are often utilized. It weighs 18 – 25 kg. (figure F 16)

Fig. F 16: Houe Occidentale multicultivator (Photo: Schmitz)



The Houe Occidentale has achieved similar success to the Super Eco in Senegal. In contrast to our experience that weed control as a rule is mechanized before seeding with draft animals (compare section E 1.4), the cultivator (here the Houe Occidentale) required a longer introduction period than the seeder. Its wide distribution is however attributed to the fact that the draft power of the donkey is sufficient for the task of weed control, as is the case with the Super Eco.

Houe Sine

The Houe Sine is a medium-weight cultivator. The tools can be adjusted in width simply without a spanner (figure F 17). It can be equipped with 3 cultivating tools, 3 chisel-plow tines, a ridger, a plow body (8 – 10") or a groundnut lifter. It is also used primarily with cultivating tools. It is also used in com-

1 for a working day of 6 – 7 hours

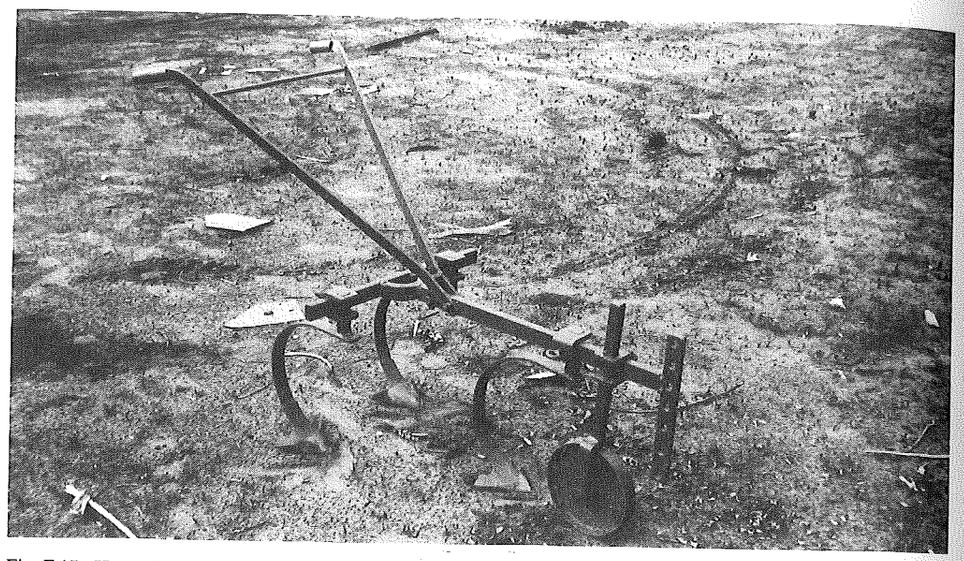


Fig. F 17: Houe Sine multicultivator (Photo: Schmitz)

bination with the Firdou groundnut lifter, and to some extent with the ridger or plow body (both for draft oxen).

It weighs 30 – 45 kg. Since it was subsidized after 1966 it is about the same price as the lighter Houe Occidentale, which boosted the sales of the Houe Sine (Bordet et al., 1988). Cattle and horses are preferred for pulling the Houe Sine.

3.4.5 Harvesting

The only implement used for harvesting is the groundnut lifter; the sales have increased appreciably in recent years (figure F 12).

There were an estimated 67,000 groundnut lifters in 1983. The low number of lifters in Casamance is attributed to the widespread cropping on ridges; the implement is less suited for this method. The figures in table F 7 reflect merely the industrially manufactured implements. Havard (in Bordet et al., 1988) estimates that 60% of all groundnut lifters (frame and tools) in Senegal originated from local workshops and the tools (shares) for the majority of the remaining implements from industrial manufacturing are made by artisans.

For the past 15 years the same tool model (Arara Firdou) has been sold; it can be mounted on all multipurpose toolbars of-

Table F 7: Regional distribution of the groundnut lifter (1983, estimated). Source: Havard in: Bordet et al. (1988)

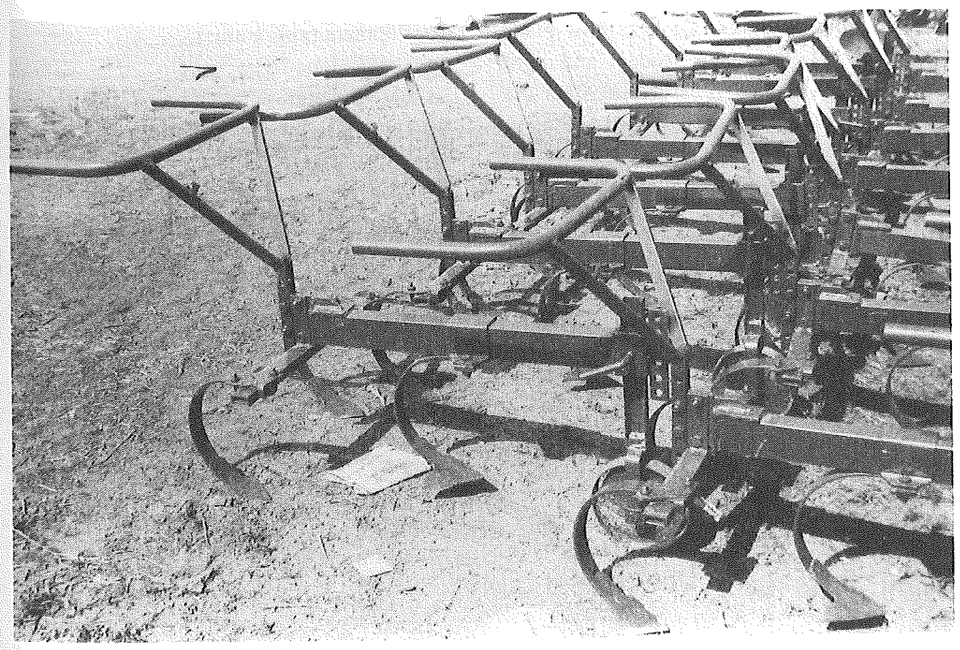
	Casamance	Senegal Orientale	Sine Saloum	Thiès-Diourbel-Louga	Total
Groundnut lifter	500	5,500	37,000	24,000	67,000

fered by SISMAR. This a type of sweep share manufactured in 200, 350 and 500 mm widths. The 350 mm share has found the widest distribution. Hand-manufactured shares are often used, which are poorer in quality but 6 -7 times cheaper than the Firdou. These are the only animal-drawn implements that the farmers can purchase without taking advantage of credit facilities. (Bordet et al., 1988)

Arara

The Arara multipurpose toolbar was developed initially for groundnut harvesting. The same mounting tools can be used for the heavy frame as for the Houe Sine, aside from the fact that 5 chisel-plow tines can be attached (figure F 18). (Bordet et al., 1988)

Fig. F 18: Arara multicultivator (Photo: Schmitz)



Also called the Araire the implement weighs 31 – 46 kg, depending upon the mounted equipment. A team of two animals is required for draft power.

The Arara has been distributed as a toolbar for the groundnut lifter in the groundnut region, and for the plow and ridger body in cotton-growing areas. 18,000 were sold by SODEFITEX from 1976 to 1979. Aside from Senegal it has become widespread in Benin, Niger and the Ivory Coast. Since its development was primarily directed to utilization for digging groundnuts it is quite cumbersome to handle for plowing. Further disadvantages are the high draft power required, rapid rusting of the bolts and the necessity of a spanner for mounting the tool to the frame. (Bordet et al., 1988)

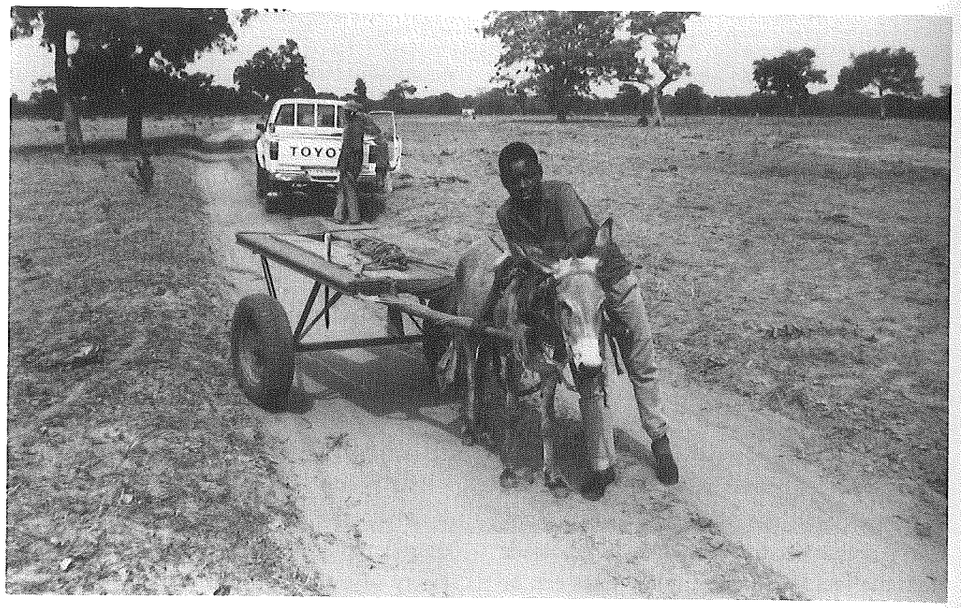


Fig. F 19: Cart with air-filled tires (Photo: Schmitz)

3.4.6 Transport

The distribution of carts takes third place (figure F 12), following seeders and light cultivators. Air-filled tires are used on the carts (figure F 19) offered by SISMAR having various sizes and weights, depending upon the type of animals used. The carts have hardly changed appearance since the independence of Senegal in 1960. Some have been in use for a long time. Often they have been distributed under the auspices of development programmes.

As table F 8 shows, the largest proportion of donkey and horse carts are located in areas where the tsetse fly is less prevalent. The figures do not include the carts manufactured by local artisans, which have been usually built from scrap metal for a number of years.

Table F 8: Regional distribution of carts (1983, estimated). Source: Havard in: Bordet et al. (1988)

	Casamance	Senegal Orientale	Sine Saloum	Thiès-Diourbel-Louga	Total
Carts:					
Donkeys	800	6,000	28,000	24,200	59,000
Horses	7,700	4,100	2,200	4,000	18,000
Oxen	9,200	1,900	5,300	7,600	24,000
Total	17,700	12,000	35,500	35,800	101,000

3.4.7 Multifunctional implements

Most of the above mentioned implements are multipurpose toolbars that have achieved special importance for certain work operations. The Houe Occidentale and the Houe Sine are used primarily for weed control and surface soil preparation; the Arara has mainly become significant in the harvesting of groundnuts.

Further multipurpose implements of relevance are:

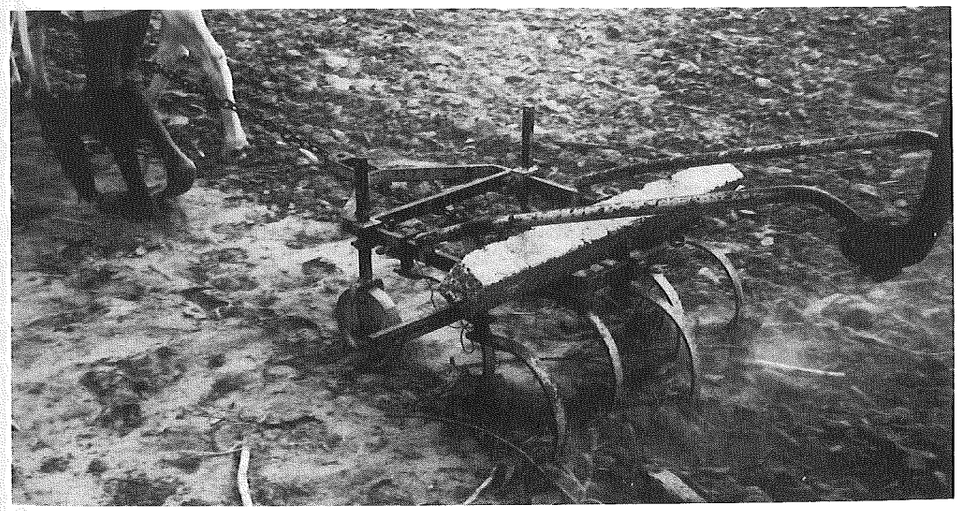
Ariana

The implement is heavier and more stable than the Houe Sine and is equipped with wheels on both sides, thus facilitating transport. (figure F 20) It can be used with 6 to 8 hoeing implements, one ridger, 1 – 2 plow bodies (10"), one reversible plow having two bodies (1/4 turn) or a groundnut lifter. It weights 58 – 92 kg, depending upon the equipment. It corresponds to the Brazilian Policultor 600, which was developed in cooperation with CEEMAT.

The Ariana offers the possibility of working two rows simultaneously when sowing or carrying out weed control. Multi-row implements however have generally not been accepted in practice.

At the end of the 1970s the Ariana was sold at a subsidized price which included the plow, ridger, cultivator and groundnut lifter. This entire implement array was cheaper than the package without the plow. At the same time, the Houe Sine with a chisel plow and groundnut lifter was also offered at a subsidized price, equal to 1/4 the price of the Ariana. The tools delivered with the Houe Sine were actually those needed by the farmers. For this reason only a limited number of the Ariana could be sold. (Bordet et al., 1988) All implements are pulled by oxen.

Fig. F 20: Ariana multicultivator performing surface soil preparation (Photo: Schmitz)



Polyculteur (Wheeled toolcarrier)

The Polyculteur has hardly been used in agricultural practice. The heavy model, "à grand rendement" costs 22 times as much as the Houe Sine and therefore only a few are found. It has been purchased by experimental stations and wealthy farmers. Ariana and Polyculteur are often considered to be status symbols (Pocthier, 1988). If one considers the difficulties occurring with the maintenance and servicing of simple implements and that the supply of spare parts is not attractive to the artisan due to the low distribution rate, then it is understandable why this implement will be found in a defective condition (figure F 21) (for further reasons why the implement has been a failure see Starkey, 1988a).

Fig. F 21: Polyculteur "à grand rendement" in Kaymor (Photo: Schmitz)

3.5. Regional cropping practices and implement use

Two regions, Bassin Arachidier and Basse Casamance, are now described in more detail.

Bassin Arachidier

Three zones are distinguished in Bassin Arachidier.

The northern zone (essentially the Thiès, Diourbel and Louga regions) has 300 to 500 mm annual precipitation (figure F 22). There is practically no primary tillage here. The average farm (carré) has 5.8 ha, with 2 Super Eco, 2.2 cultivators (87% Houe Occidentale), 1.2 groundnut lifters mounted on cultivators, 1 cart and 2.6 animal spans (80% horse and 20% donkeys) (table F 9). (Havard, 1988b)

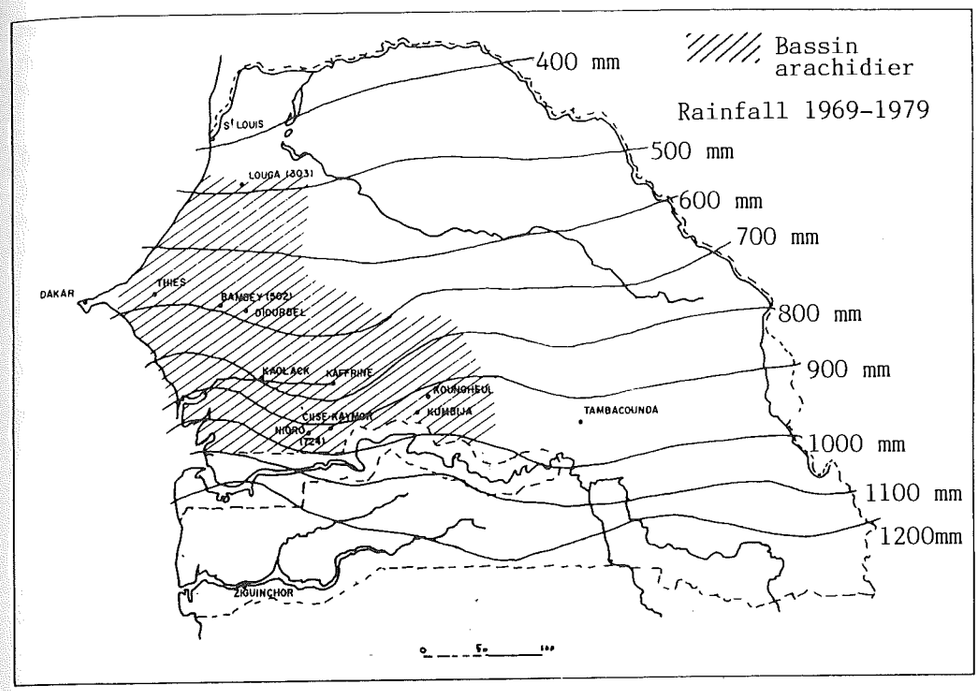


Fig. F 22: Map of the Isohyeten. Source: ISRA; CIRAD; FAC (1986)

A middle zone covers a width of 60 km from Fatik via Kaolack to Koungheul between the Isohyeten which have 500 to 600 mm rainfall. Here there is a transition from the Houe Occidentale to the Houe Sine and a higher incidence of the industrially manufactured Firdou groundnut lifter. 80% of the farms have available the seeder and cultivator implement package for harnessing horses, in part with the groundnut lifter (65%). (Havard, 1988b)

Table F 9: Regional distribution of implements per farm (carré). Source: Havard (1988b); Fall and Ndiame (1988a)

Departem. / Region	Thies-Diourbel-Louga	Sine-Saloum		Casamance	
		Fatick	Nioro	Zone A	Zone B
Seeders	2.00	1.12	1.45	0.33	---
Cultiv.	2.20	1.30	1.55	0.13	---
Plows	---	---	0.07	0.67	0.10
Ridgers	---	---	0.07	0.17	0.33
Carts	1.00	0.50	0.60	0.50	0.20

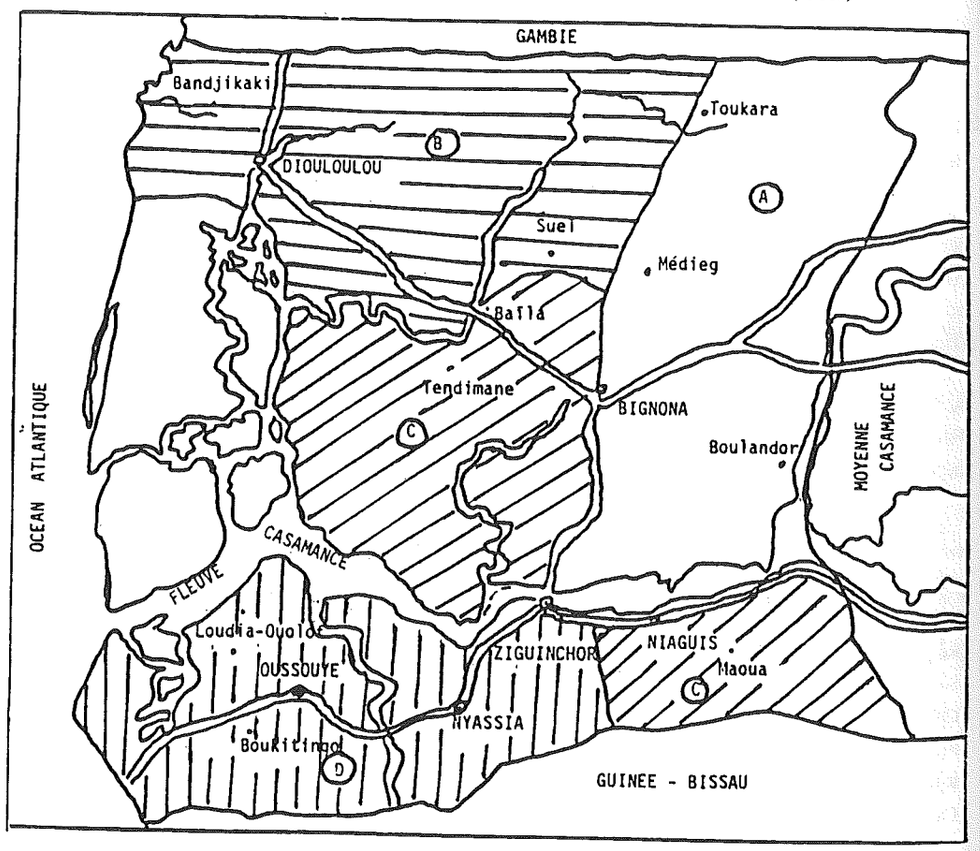
In the southern zone between the Isohyeten of 600 to 800 mm the donkey is replaced gradually with oxen and the proportion of horses remains the same. Non tillage or some superficial working of the soil is practised. Thereby an area performance of 5 h/ha is achieved. Plowing, which would require 25h/ha, is not done (Metzger, 1988). In addition, the chisel plow can be used as a cultivator for weed control. The Houe Sine replaces the Houe Occidentale. In the Nioro region, located in this zone, the following array of implements is found: cultivator (1.5 per farm <carré> especially the Houe Sine), seeder (1.45), groundnut lifter (1.1) and cart (0.58). The plow and the ridger are seldom found here. (Havard, 1988b)

Also, in traditional cropping on the level of manual labour, only a superficial loosening and weed control is done with the "iler" (figure F24).

Basse Casamance

In the Basse Casamance region there is a wet and dry climate with an annual precipitation of 1000 mm. Plateaus and valleys alternate; in addition a large flood plain exists.

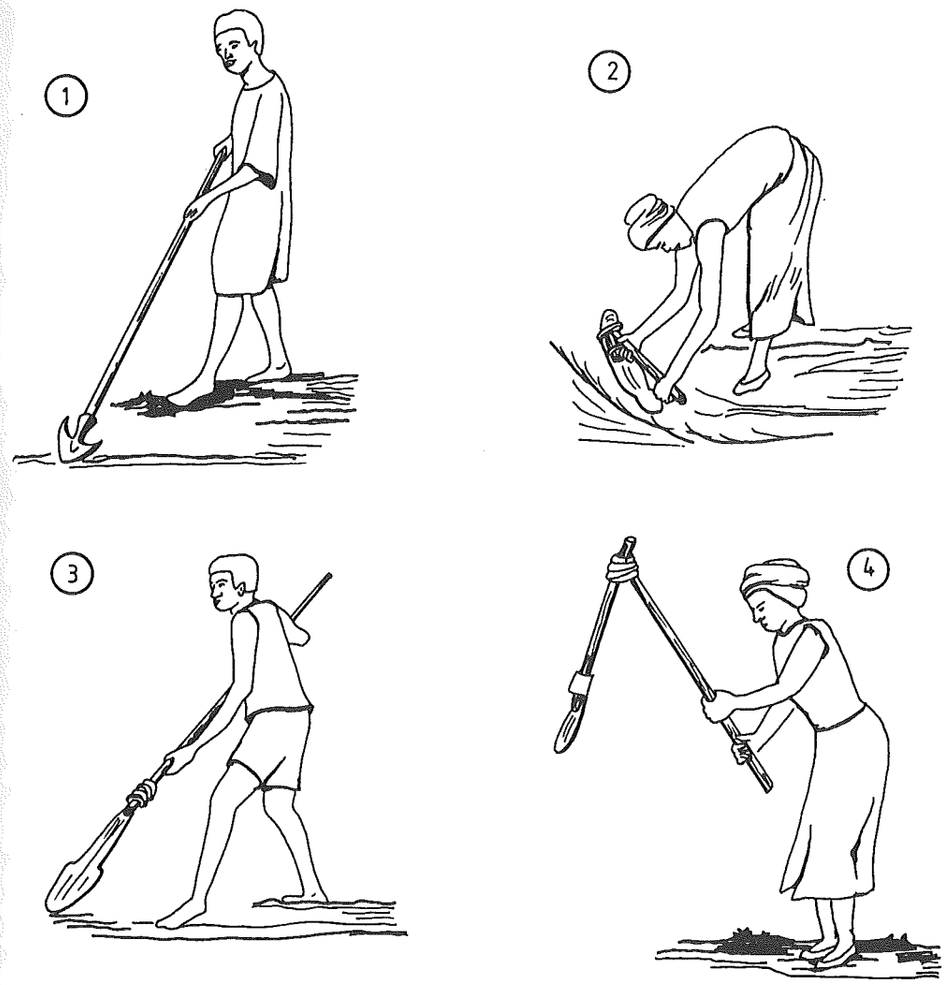
Fig. F 23: Zones with various cropping methods in lower Casamance. Source: Fall and Ndiame (1988a)



Animal traction (including for transportation) is utilized on 36% of the farms in the lower Casamance. Two prevalent cropping systems exist with a varying labour distribution between the sexes: the Mandingue system, named after the Mandingue minority and the Diola system, which represents 83% of the population (Fall and Ndiame, 1988a):

– the Mandingue system (zone A, figure F 23): In this zone the men cultivate the pla-

Fig. F 24: Handtools in lower Casamance: (1) Iler, (2) Donkotong, (3)Kayendo, (4) Fanting. Source: according to Marzouk-Schmitz (1984)



teau and the women are responsible for the rice crop. The "donkotong" (similar to the daba for ridged crops, section F 2.5.1) is the hand tool used mainly by the men for soil preparation; the women use the "fanting" (figure F 24). Both tools are hoes. Animal traction is used to a considerable extent, but only by the men for work on the plateau. The plow is the most prevalent animal-drawn field implement, and the ridger is also common. The following array of implements reflects an average distribution rate: 1 plow per 2 farms, 1 Arara with a plow or ridger per 3 farms, 1 Super Eco per 3 farms, 1 Houe Sine per 8 farms and 1 cart per 2 farms (table F 9). (Fall and Ndiame, 1988a)

– the Diola system (zone B, figure F 23): The men are responsible for soil preparation on the entire relief, while the women do the easier tasks of seeding and weeding. The most important handtool is the "kayendo". It is used for building up the ridges on the plateau as well as for rice cropping on the slopes and in the valleys and for harvesting groundnuts. It functions somewhat like a shovel (handplow) and is particularly suited for cropping rice in the flood plain. (Marzouk-Schmitz, 1984) Animal traction is less prevalent. It first serves the purpose of soil preparation on the plateau, which is done by the men, and secondly the soil preparation in the rice fields tended by the women. With the increasing aridity the Mandingue system moves southwards, so that the women have to work their fields in the valley with the "fanting" when the rainy season does not occur early enough (Lo, 1988). The ridger is the most popular animal-drawn implement. Neither seeders nor cultivators are used because of the ridge cropping. The following array of implements is found: 1 plow per 10 farms, 1 ridger per 3 farms, 1 cart per 5 farms (table F 9). (Fall and Ndiame, 1988a)

In the remaining zones (C and D) animal traction is scarcely used and only there where Mandingue or immigrants from northern or central Senegal live (Fall and Ndiame, 1988a).

3.6 Manufacturers and artisans

The implements are almost exclusively manufactured by SISMAR, one of the largest West African metal-working factories.

Until 1980 a large percentage of the implements were purchased on credit under the "Programme Agricole". Since 1980 (until 1986), for example, seeders were exclusively and cultivators were predominantly bought in a used condition in the Fatick Department. Only carts were purchased new in significant numbers without loans. Also, groundnut lifters, mainly built by artisans, have been bought new. (Havard, 1987a)

According to an analysis of animal-drawn implements, it would have been necessary to replace abrasive parts on 30 to 40% of the implements, 15 to 20% of the axles of plow wheels or press rollers and 10% of the gears and further parts of the dispensor mechanisms on seeders. The distribution of original spare parts functions very poorly according to Havard (1988a), so that the place of the artisans is of utmost importance. All spares (duckfoot shares, furrow opener, spacing wheels, gears) are available in the towns. These are all manufactured by artisans and cost 1/3 the price of original parts. Only bearings, tires and tubes for the carts must be supplied by the industry. (Havard, 1987a)

Most of the blacksmiths have a very meager supply of equipment. They are able to assemble parts and manufacture simple abrasive parts such as shares. Generally, they have templates for fabricating the most important parts such as duckfoot shares for cultivators and furrow openers for the Super Eco seeder. Only 10 % can do welding (figure F 25) (Havard, 1987a). Smiths having arc welders use various types of welding rods. They can, for example, cut threads, weld breaks in the frame or produce seed hoppers.

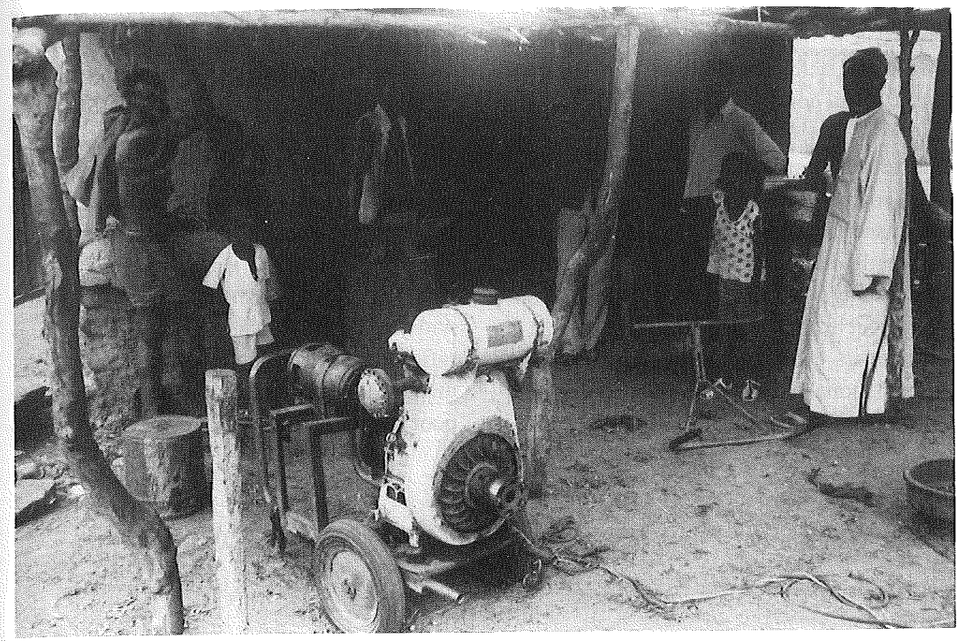


Fig. F 25: Blacksmith with welder in Karang (Photo: Schmitz)

The supply of materials is the most serious constraint for the artisans. 60% have no supply in store, the remaining 40% can only manufacture spare parts from their material supplies for the stocks. The following list of the commonly used material exemplifies the problem of material supplies: leaf springs from trucks, building steel, sheet metal from old cars and sporadically collected parts. (Havard, 1987a)

Frequently, smiths also work in agriculture. Most of the smiths in Basses Casamance mention this as their most important activity (Fall and Ndiame, 1988b).

3.7 Summary

Animal traction is widely distributed in Senegal. Due to the rapid succession of climatic conditions the cropping patterns and the sequence of implements used change considerably within relatively short distances. In semihumid/semiarid areas direct seeding is common due to the short vegetation period

and favoured by the light soils. Efforts to introduce a more intensive soil preparation have failed here. The draft animals used are donkeys and horses.

Due to the wetter climate very intensive weed control prior to sowing is necessary in Casamance and Sénéngal Occidentale. Longer vegetation periods allow the use of the plow or ridger prior to seeding. Ridged cropping, which hinders the use of seeders, is widespread. Oxen are used as draft animals. In transitional zones superficial scratching and sowing is practised.

Animal traction is primarily introduced in connection with the Super Eco seeder. In numerous development projects many implements have been tested in Senegal. SISMAR represents the existence of a viable farm machinery manufacturer in the country. Nevertheless, the supply of spare parts functions poorly. However, the artisanal system is well developed. The ability of the artisan to repair as well as to manufacture spare parts with the aid of templates has contributed significantly to the wide distribution of implements. A severe constraint is the extremely poor supply of materials.

G. Case study: Brazil