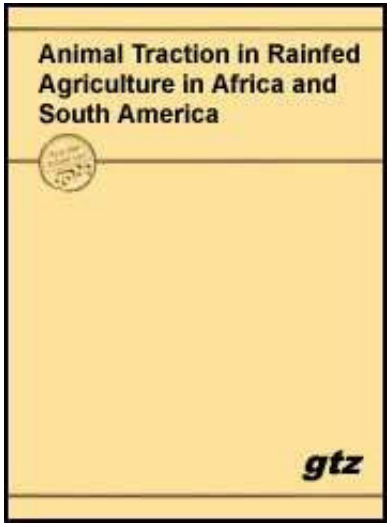


Animal Traction in Rainfed Agriculture in Africa and South America (GTZ, 1991, 311 p.)

G. Case study: Brazil

1. Overview

1. Overview

1.1 The country and the population

The 8.5 mil km Brazil takes up approximately half (47 %) of the South American continent. The population of 141.5 mil inhabitants is very unequally distributed across the country (Statistisches Bundesamt, 1988) (figure G 1). Very diverse climatic zones are found in Brazil: tropical rainy climate in much of the country;

tropical semi-desert and desert climate in the northeast; subtropical, permanently humid climate in the south (see figure C 4: Climatic zone map of South America). Brazil is today considered to be the eighth largest economic power of the western world. A high trade surplus is being realized (ranking third after West Germany and Japan), which however is required for repayment of foreign debt that has accrued during the recent rapid development, especially to finance large-scale government projects. Food products, raw materials and industrial products including high quality military equipment are exported. With an average annual growth rate of 7 % between 1950 and 1980 (industry 9 %; agriculture 4.3 %) a significant increase in the per capita income was achieved, however the industrialization of the country is connected with enormous social costs. A Brazilian economist has coined the term "Belgindia", indicating a small industrial country with a high level of consumption for 10 % of the population and simultaneously a large country in the Third World where misery, starvation and disease prevail. (Hurtienne and Ramalho, 1989)

1.2 Agriculture

While a rapid development is partially taking place in the country, a land tenure system that evolved during colonialization is being retained. Only in the south of the country has the spreading of smallholder agriculture with sufficient land been successful as a consequence of the high rate of immigration from Europe and Japan. In most of the country however control over the land is the privilege of a few landlords who essentially carry out extensive forms of production. This is one of the reasons for the rapid movement to the urban areas. In 1987 only 26 % of the population lived in the rural areas. Some migrate to the Amazon region and the midwest in the hope of finding land, where the ecology of great expanses of

land has been permanently damaged by deforestation and cropping with non-sustainable methods. This is one of the primary reasons for the extreme land and resource exploitation which is also leading to the destruction of the rainforest in the Amazon region.

A total of 3.76 mil km (44.2 % of the territory) is farming area. However, only approximately 7.5 % of the territory is used for growing crops, a further 1.4 % for perennials. About 20 % is pastureland, which partially could be used as cropland. The forest is in the process of rapid depletion. (Statistisches Bundesamt, 1988) In comparison to the industry agriculture has lost considerably in importance. Brazilian agriculture contributed 13 % to the gross national income in 1985 and employed 30 %, the industry 20 % of all the gainfully employed ranks (1986) (Haefs, 1988). Its share of the exports, especially coffee, soybean products, fruit juices, was 44 % (Calcagnotto, 1985). Food-product imports, especially wheat, have an 8 % share (1984) (Statistisches Bundesamt, 1988).

Of the 5.84 mil farms approximately half (53 %) are smaller than 10 ha; they cultivate 2.7 % of the total arable land. In contrast, the 10 % of the large farms control 4/5 of the area (Statistisches Bundesamt, 1988). Although the total arable land in Brazil is for example about 17 times as great as West Germany and the country only has somewhat more than double (2.3 times) the number of inhabitants, the problem of extreme land scarcity is acute. An effective agrarian reform announced by the government some years ago is not in view. Land occupation by landless peasants and violent evictions are a daily occurrence. In the past 25 years (from 1961 to 1985) agricultural production has undergone the following development:

- export crops (coffee, soybean products, etc) + 280 %
- industrial crops (sugar cane, cotton, etc.) + 216 % - food + 41 %

The production of food has experienced the smallest growth rate per capita; considering the population increase it has declined 20 % (Krause and Knichel, 1986). This drop can be attributed to the growing disproportion between export production and food production arising from the concentration of ownership, since the latter is primarily done on farms of under 10 ha. The expansion of soybean cropping is taking place at the cost of areas formerly used for food production (Calcagnotto, 1985). Until a few years ago research and development concentrated on the increase of production especially for industrial and export crops, but hardly on the crops and techniques of smallholders.

1.3 Mechanization

Still today on 54 % of all the farms in Brazil the land is exclusively cultivated manually. Draft animals are additionally used on 20 % of the farms, 14 % employ both animals and tractors (mixed mechanization), and on 12 % motorization is prevalent (EMBRATER, 1986a). Mixed mechanization is undergoing the most rapid increase (1975/80: + 132 %); use of tractors (without draft animals for individual work operations) increased by 44 %,while pure animal traction decreased by 22 % in this time period (IBGE, 1975 and 1980, in EMBRATER, 1986b). Overall, the proportion of farms with draft-animal use (including mixed mechanization) is increasing slightly (1950 - 80: + 19 %; 1970 - 80: + 1.3 %) Krause and Knichel, 1986).

Animal traction has developed in different ways over the years on the whole in

Brazil (figure G 2, table G 1). In the industrialized southeast and south of Brazil mechanization of agriculture with draft animals as well as tractors has advanced to a great extent. While animal traction in the southeast has already reached its peak, in the south its importance is being maintained and is even increasing in the northeast. In the tropical wet north it is of little significance. (1980, including mixed mechanization according to Krause and Knichel, 1986) Most of the oxen are found in the wetter south, while in the remaining areas horses are more highly represented. 95 % of the donkeys in Brazil are found in the drier north. The long-term development of mechanization is illustrated by the number of sales (figure G 3).

The number of cultivators sold increased, which indicates an expansion of the available array of equipment. In contrast a certain degree of saturation appears to have been reached with plows. This development can be attributed to the poor economic situation in the early 1980s and the reduction of loans (due to high debt, among other things). The rapid modernization of agriculture has reached a standstill since the early 1980s, having the following indicators: - considerable slowdown of motorization (figure G 4), - reduction of pesticide use from 1975 to 1986 about 44 % (tons of concentrated agents) (DERAL, 1986), - price increase of inputs; in 1984 for the same amount of fertilizer 60 % more maize had to be sold than 1979, and for the purchase of a 44 hp tractor in 1987, 40 % more coffee or soybeans, 49 % more beans and 79 % more maize required than in 1984 (Almanaque Abril, 1986 and 1988), - reduction of the alcohol scheme for the substitution of fossil fuels in 1989.

Even in a resource-rich country like Brazil it is becoming more difficult to modernize area-wise according to the example of former industrialized countries.

Animal traction, which creates a certain independence from fossil fuel sources (53 % of Brazil's imports 1984) (Statistisches Bundesamt, 1988), will be able to maintain its importance in the near future. The state of Paran provides an example of wide distribution of animal traction. In section G 2 the interaction between the natural endowment, farm system and mechanization is clearly illustrated.

2. Case study: Paran

2.1 The country and the population

The state of Parana has an area of 200,000 km and a population of 8.5 mil inhabitants (1987; Statistisches Bundesamt, 1988). The population density on the average is 42.7 inhabitants/km. An estimated 35 % of the people live in rural areas (Almanaque Abril, 1988). Paran can be subdivided into five zones: the coastal zone (Litoral), the mountainous zone (Serra do Mar) and the first, second and third Highlands. The highlands slope downwards to the west; thus almost all rivers flow into the Rio Paran. The region is predominantly very hilly.

The colonization of Paran occurred after the mid-16th Century following the four cycles: "tropeirismo", mate production, timber felling and coffee plantation. The "tropeirismo" phase is relevant for the history of animal traction, as the animals reared in the south were herded across Paran to the mines of Minas Gerais.

The naturally unforested areas on the second Highlands in Paran found halfway along the route served as pastureland. Here, the animals could rest and improve their nutritional condition. 50 years ago vast streches of Parana were covered by natural forest; with encroaching colonialization also the areas in the north and

west became deforested and were cultivated. This led to severe soil depletion in some regions, especially the sandstone area of Caiu in the northwest, so that in many cases only the possibility of pasturing remains.

Coffee plantation has lost significance after 1960 due to the world market development. The last most recent cycles also comprise soybean and sugarcane cropping. The soybean cropping was introduced on the basis of high subsidies for inputs (motor mechanization, fertilizers, chemical pesticides, improved seed), particularly where soils lend themselves to mechanization in the north and west parts of Paran. Traditional products such as maize, beans and rice have lost importance. Today, only 4 to 5 % of the total land area is naturally forested (Fuentes, 1988). 32 % is pasture and 30 % cropland (statistics for 1980; Fuentes, 1984).

On 2.34 % of the total land area of Brazil, Paran grows 25 % of the agricultural produce of the country (IBGE, 1983, cited in Casao et al., 1988). In terms of the production quantity the most important crops of Paran are (proportion of Brazilian production in brackets): maize (26 %), wheat (52 %), soybeans (20 %), cotton (36 %), potatoes (25 %), beans (Phaseolus vulgaris) (20 %) and coffee (13 %) (1985; DERAL, 1986). Food crops are primarily grown on small - and medium-sized farms having under 50 ha. In comparison to the other regions investigated the farmers in Paran have larger fields. Farms with under 20 ha are considered small. A further concentration of land ownership occurred following 1970 because of the expansion of soybean cropping and the related motor mechanization (table G 2). Land occupation by landless peasants has increasingly become a daily normality since that time.

Fallow for the regeneration of the soil has at the same time been considerably reduced. Smallholdings, 71 % of all farms, cultivate only 15 % of the total land area, while 60 % is under the control of the 5.4 % of farms having over 100 ha (IBGE, 1985)

This development is one of the main causes of the massive rural exodus. Most of the rural inhabitants go to urban areas, a small proportion attempt to resettle at the "agricultural front", e.g. the Amazon. Landowners sell their farms and are able to purchase larger areas of land. There they employ inappropriate methods and begin to farm where no market exists. The migration intensifies the problem of the population centres on the one hand and leads on the other to unnecessary destruction of the ecologically intact region, although statistically seen there is sufficient land for the rural population in Paran. Thus, for social and economic reasons the retention of the farms is of critical importance.

2.2 Natural endowment

Parana lies between 23 and 26 latitude and approaches the tropic of Capricorn in the north. Most of the state is located at an elevation of 600 to 900 m above sea level where a subtropical humid climate prevails. According to Landsberg et al. (1966) it is a permanently humid and hot summer climate with a summer precipitation maximum

Rainfall in the highlands is 1200 to 1900 mm per annum and occurs predominantly in summer (December to February), but also in winter there is no dry season. At the time of seeding precipitation of 60 mm per hour or 250 mm per day is not uncommon; then considerable erosion problems are manifested (Derpsch et al.,

1988). At higher altitudes frost does appear. Towards the north and west there is a gradual transition to a tropical humid climate where moisture deficits can occur during any season due to the deviation from rainfall distribution. The coastal region (Litoral) lying at sea level has a tropical rainy climate with 9.5 to 12 wet months (according to Landsberg et al., 1966).

In the first and second Highlands the primary rock is granite, gneis and sandstone. Most of the soils have a low natural fertility. The primary rock in the third Highlands is basalt; soils having sandstone as primary rock are only found in the northwest. Soils originating from basalt are partially very fertile. (Larach et al., 1984) Nearly 40 % of the soils in Paran are easy to cultivate because of the favourable physical characteristics, including Oxisols (USST) found on slight slopes. These fields are easy to cultivate with a tractor and are predominantly in the hands of large landowners. Smallholdings where manual labour is common or animal traction, on the other hand, occur on land less suited to motorized agriculture due to steep slopes or a shallow topsoil layer. Most of the farms having draft animals cultivate soil that has a low natural fertility.

2.3 Farm structure, methods of cropping and mechanization

A tradition of animal traction exists in Paran. It is applied on 56 % of all the farms (1980) Some farms employ draft animals as well as tractors, whereby seedbed preparation is usually motorized and the subsequent mechanized work operations are carried out with draft animals. Mixed mechanization is found on 27 % of the farms. The number of draft animals in Paran is quoted as 480,000 in 1980, thereof 51.7 % horses, 23.4 % oxen, 24.5 % mules and 0.3 % donkeys (IBGE, 1980, cited in EMBRATER, 1985).

Animal traction has declined in importance by 10.5 % (1975 - 1980), whereby the proportion of horses increased slightly. At the same time motorization has increased. Between 1970 and 1980 the number of tractors increased fourfold to 82,000. Farms down to a size of 12 ha were subsidized (Klingensteiner, 1987). In spite of the rapid development only 12.3 % of the farms owned tractors in 1980; a further 30 % hired tractors. This development has noticably declined in the 1980s. As the number of tractors has increased to a small proportion since 1980, due to a reduction of credits (DERAL, 1986), to about 100,000 (IBGE, 1986) and the number of smallholdings has remained constant, one can assume that the use of draft animals has maintained its importance throughout the 1980s.

For a more exact scrutiny of animal traction it is necessary to classify farms according to their technical niveau. Since land area is a too inexact criterion for the investment possibilities of a farm, Yu and Sereia (1989) have made a more precise subdivision. They distinguish between five categories (table G 3); proportion of non-domestic labour forces, ability to accumulate capital and the relation of inputs to cost for outside labour are the differentiating factors.

In order to avoid misunderstandings it must be mentioned that the mobilization of tractors on subsistence farms can also be accomplished by relatives of the family or by mutual-help services. Moreover, the two first farm categories, which have an average land area of 7.8 or 16.5 ha, are classed as smallholdings on the basis of the economic situation. These make up 3/4 of the farms in Paran. Labour on the level of animal traction is predominantly found on these smallholdings. Surprisingly, draft animals are also employed on other farms to a large extent.

In Paran both shifting cultivation associated with manual labour - this is found on

the steep slopes of the last remaining agricultural fronts in the state located between the second and third Highlands as well as in the coastal region - and the production with intensive application of inputs and mechanization of most work operations are found in very close proximity to each other (especially on the more level fields in the highlands). In the highlands of Paran the following production systems can be roughly distinguished. As a rule soybean cropping, frequently in rotation with wheat which is harvested by mechanized means, as well as cattle raising is performed on medium-sized or large farms.

On smallholdings which also work with draft animals, especially maize and beans (Phaseolus vulgaris) are grown and mixed cropping is often found; in addition, pigs and poultry are raised and agroindustrial products (coffee, cotton, tobacco, mate), both in conjunction with the cropping of maize and beans. Maize is almost exclusively used as fodder, in part on the own farm. Beans are a staple food both for own consumption and for the market, and are usually harvested manually.

Draft animals are employed partially for the cropping of maize and beans, cotton, tobacco and coffee. Mixed cropping is found frequently, whereby very different methods exist. In fact, this changes from year-to-year on any one given farm. Mixed crops are almost always planted in rows. They can be differentiated according to types of cropping (e.g. in separate rows or together in one row) and time of sowing (e.g. beans before maize), depending on the climate. Some problems are encountered in the mechanization of mixed cropping. In many cases only one of the crops can be sown with the animal- drawn seeders, or the use of the cultivator is limited due to the density of the crops. Currently, the area under mixed cropping is declining. The reasons are: specialization of the farms, motor mechanization and the application of herbicides.

2.4 Animal traction in various regions

2.4.1 Overview

In order to characterize the various farm structures in the individual regions in Paran three large areas are distinguished, which can again be subdivided into 14 socio-economic homogeneous mesoregions (classification according to production, technological level and land distribution structure) (Yu and Sereia, 1989): -

The "green belt": Motorized mechanization dominates here since the soils lend themselves to this type of agriculture

Exceptions are the Southwest region (Region 12) which is difficult to till by tractor and where animal traction dominates (see section G 2.4.2) and Region 14, where coffee planting and cattle keeping are prevalent and chiefly manual labour is used. Frequently, one finds "mixed mechanization"; where the tilling operation is done by tractor and the subsequent runs are conducted by animal traction. Draft animals however play a significant role in the entire area (see section G 2.4.4).

The Litoral (1) and Ribeira (2) regions are poorly developed economically. Only few farms exist here and manual labour prevails. Animal traction is not significant. In Litoral the climate is tropically humid. Bananas are grown and small animals are kept; rice and cassava are cropped on smallholdings. In Ribeira smallholdings produce food staples (maize, beans), in part on steep slopes, followed by citrus fruits. On large farms of both regions the breeding of cattle and buffalo is increasing. - The rest of the region makes up the largest part of the land area in

the first and second Highlands. Most of the farms that work with draft animals are located here, e.g. the Irat region (6) with the greatest incidence of animal traction (see section G 2.4.3). The proportion of farms using the various sources of power is widely distributed. 93 % of the work in Ribeira (3) is done by hand, 57 % by draft animals in addition to manual labour (in Irat, 6) and 68 % (in the Western region, 13) where tractors are used in conjunction with manual labour and particularly animal traction (mixed mechanization).

In order to scrutinize the interaction of implement systems with the natural endowment and the agricultural farm system the use of implements in the three regions of Paran are examined more closely in the following sections. Clear differences are observed for climate, topography, soils, farm and cropping systems, and sowing times. The regions considered are the Southwest (12), Irat (6) and both Londrina (8) and the West (13) together. The harvest is done manually on farms having draft animals; this subject is therefore not treated here.

2.4.2 The Southwest region (12)

2.4.2.1 Description

The region was settled in the 1930s and 40s by immigrants from Rio Grande do Sul and Santa Catarina, which are to the south and were colonized earlier. Many of the settlers are of German and Italian origin. Narrow strips of land having approximately 24 ha on the slopes with access to water were distributed to the farmers (Rockenbach, 1987). The slopes are mostly used for growing crops, while the flat land in the valley was reserved for animal breeding and housing (see section E 4.3). Some areas were only colonized as recently as 20 years ago.

Soils with a clayey texture predominate; these are based on basalt and possess a high fertility. On the peaks and the steepest slopes Solos Lit¾licos (Entisols, Inceptisols according to USST), very shallow soils having many stones on the surface, are found. Thus, they do not lend themselves to working with a tractor. The loss of the thin topsoil layer is always under threat of erosion. In part, they are associated with Brunizem (Mollisol - USST) or Terra Roxa (Alfisol - USST), a very fertile soil. The slopes are usually very steep. Only a few zones, e.g. north of Pato Branco, are hilly. Terra Roxa is prevalent on slopes of over 6 %, and due to the suitable physical characte ristics can easily be mechanized. (Larach et al., 1984; Fasolo et al., 1986; Vieira, 1987; Roth, 1986)

The average annual precipitation is between 1600 and 2000 mm, the temperature between 16 and 20 C. Characteristic for the region are the agricultural small-holdings producing food supplies and keeping animals (pigs, poultry). 83 % of the farms are smallholdings, of which 22 % are "subsistence producers" with an average land area of 5.4 ha, and 61 % are "small-scale market producers" for the market having an average 13.6 ha. They farm half the land area in the region. 47 % of the farms use draft animals, especially in the zones where steep slopes are present. On the other hand, one finds mixed mechanization in the more hilly areas, where both tractor and draft animals are employed. In total, 39.3 % of the farms use tractors. (Yu and Sereia, 1989) The most important activities are growing maize and beans, mainly as pure stands, raising pigs and poultry and soybean cropping. Because of the risk of erosion on the slopes, of which many farmers are aware, the building of stone walls has begun. The planting of green manure crops to cover the soil and the practice of minimum tillage ("cultivo minimo") is on the increase (see section G 2.5.2). Mainly teams of oxen are used as draft animals (ca. 600 - 700 kg per animal) equipped with the withers yoke.

2.4.2.2 Work operations

Field preparation

Since the soil is fertile there is no tradition of longer fallow. The survey showed an R value of 100 in the region. Burning to clear the field is only practised when weed invasion or harvest residues are particularly great. The farmers frequently allow the tree stumps to remain a long time in order to prevent erosion by means of the existing root system and to stabilize the water supply. Thus, in spite of the lack of fallow the tree stumps and roots hinder field preparation. Due to the widespread field storage of maize (bent-over cobs remaining on the stalk) the crops are harvested very late. This results in poorly decomposed residues. Only in a few cases, where several farmers have made a joint purchase, is the knife roller used to break up the residues (David, 1988).

Soil preparation

The preparation of the fields with oxen teams and the fuador (see below) already begins one to two months prior to seeding. On some farms Baldan disk harrows are used, which are well suited to working in green manure crops (David, 1988).

The fupador

The fufador consists of a wooden drawbar, which is fastened to the yoke of the draft animals, a leg and a shovel-like plow body. The distance between the plow body and the drawbeam is quite great; thus, no problem is encountered with clogging of organic material.

The entire implement is made of wood, except for the plow body. At 30 kg the

weight is relatively low. The implement cuts into the soil at a slight angle, which can be altered for different soils by setting the length of the brace. Neither the working depth nor breadth can be adjusted. The control of depth depends upon the amount of pressure applied by the farmer. Therefore, various depths are plowed in one furrow according to the condition of the soil. Tests yielded a working depth of from 13 to 17 cm, depending on the soil density, and a working breadth of between 40 and 50 cm. The specific resistance in comparison to the best mouldboard plows was one-to two-thirds greater. Because of the high draft power required it must be drawn by a team of heavy oxen. An area performance of 25 - 35 h/ha is achieved; 13.6 h/ha even have been attained in field tests. (Arajo, 1988b; Figueiredo et al., 1986) As with the ard plow and the chisel plow, the fuador loosens and mixes the soil, but does not turn it. Its working breadth however is considerably greater. The uneven soil tillage leaves a coarse lumpy surface, partially with unworked strips (Casao, 1987). Occasionally, a second working of the soil is carried out with the hand hoe.

The poor working in of organic residues and high incidence of weed has led to the practice of undertaking a second work operation and sowing on the ridge or the furrow. These ridges counteract erosion. The advantages of the fuador become more apparent on land having steeper slopes (up to 80 %), great quantities of tree stumps, root residues, stones and harvest residues. It is particularly suited for working on newly cleared areas, and it can "easily" be manipulated to circumvent obstacles; thus, the oxen do not need to reverse. However, the farmer must walk in a hunched position to accomplish the work. On steep slopes the advantage is that working the soil with a fuador gives rise to less erosion than the mouldboard plow, due to the coarse clods. It also does not contribute to soil compaction (plow sole).

The fuador is generally recognized to be a very robust implement; it requires no adjustment and can be applied for numerous purposes (e.g. for ridging and weeding, for the minimal soil tillage method "cultivo minimo"). It costs half as much as a mouldboard plow and can be manufactured by local artisans.

However, the work with a fuador is very strenuous for both man and animal. Because of the poor lateral control it presents a risk to the farmer's health since a great amount of energy is required. Many report of frequent injury to the spinal column arising from the hunched position held by the operator. The quality of the work done by the fuador is considered poor due to the inaccurate lateral control and lack of depth regulation. The plow body must also be sharpened very often (David, 1988).

The fuador is also used under conditions which today would no longer require its service. Since fallow is seldom practised anymore in the region, its advantages are limited on stony ground. Under these conditions the mobilization of mouldboard plows is difficult because it cannot negotiate obstacles easily and the share would become damaged.

The technique of soil preparation with teams of oxen and the fuador accompanied the migrants from the south. It is particularly widespread in South Brazil. There are 53,500 fuadors being used in Paran alone, approximately 18 % of all the plows in the state of Paran (Figueiredo et al., 1986). Harrowing Hand-made tined harrows are made of wood. The harrow is preferred for the removal of weeds from bean fields and on flat land where there are no tree stumps or stones. It is sometimes employed for levelling, however cannot be applied after second work operations with the fulpador which has already built up the ridges.

Breaking furrows and marking

Although scratching furrows could improve the performance of the seeder and cultivator, it is seldom carried out. This is mainly due to the great number of stones on the fields.

Sowing

Where the fuador is prevalent very few seeders suited to animal traction are found. The following difficulties are provided as reasons:

- The steep slopes make the handling of the implement cumbersome (about 70 % of the maize is cultivated on slopes of over 20 %). The implement weighs 50 - 70 kg and cannot easily be guided on the slopes. It often slips out of the furrow (Figueiredo, 1988).

- Seedbed preparation with the fuador produces a very coarse texture and obstacles lead to clogging in some cases (stones, tree stumps and roots, large amounts of organic material, especially maize stalks from the late harvest). In addition, sowing does not represent a work peak; it can be spread over a period of 2 months, as isthe case with maize. Applying the procedure for an animal-drawn implement can be problematic for mixed cropping. A second bean crop, for example, is grown on maize stalks. Under these conditions the Matraca manual seeder becomes a more attractive alternative. The planting of maize often takes place in the furrow that results from the second work operation with the fuador (Monegat, 1988). Therefore, only 5 % of all the farms use precision seeders drawn by animals usually being pulled by one harnessed ox.

The matraca (also called saragu) is a very sturdy hand-operated seeder, suited to dibbling of various seed types. It can easily be adjusted in order to adapt to different seed sizes. The dosage is inexact, but it satisfies the requirements of the farmers. It is suited for no-till cropping. Seeding on unprepared, relatively hard soil is strenuous however. The matraca proves to be the most efficient implement for sloped fields on poorly prepared, stony ground. Models that simultaneously apply fertilizer dressing are also available. Some devices will efficiently deposit both fertilizer and seed separately. This implement is well suited to crops having a greater plant spacing in the rows (for pocket-drilled maize, 40 - 60 cm). For small spacings (e.g. beans, 25 - 30 cm) it is difficult to adapt to the small distancing of only about a foot. In this case animal-drawn seeders are more frequently employed. When fertilizer is applied simultaneously the overall weight increases considerably.

Generally, its success is attributed to the fact that the machine does not become clogged, aside from the low price and easy operation. The device is still being used for small plots of land, even though seeders are available for animal traction. (see also: Copestake et al., 1988; Wijewadene and Waidyanatha, 1984)

Weed control

Weeding is primarily done with the hand hoe. In approximately 15 to 20 % of all the farms it is accomplished by animal-drawn cultivators which are usually only equipped with one blade; this represents a smaller version of the fuador. For surface weeding, e.g. of beans, a swallowtail blade is used. And for mixed cropping of maize and beans the small fuador is employed that penetrates the soil more deeply; the fuador is even occasionally used with maize in pure stands. The

farmers normally undertake weeding quite late in the season.

The small fuador is well suited for work where weeds proliferate. For beans the row spacing at 40 to 60 cm is very low so that the rows must be precisely placed, and the oxen have to be properly trained. As a rule, single oxen are employed. Chemical pesticides are increasingly being applied, especially on fields having many stones.

2.4.3 Irati region

2.4.3.1 Description

The area was colonized by European immigrants, especially Ukrainians and Polish at the end of the previous century. They were acquainted with the technique of animal traction with the horse. The region has a subtropical permanently humid climate with frequent frosts in the winter. The annual precipitation is between 1300 and 1800 cm. Temperatures range from 14 to 18 C. It is somewhat cooler and dryer than in the Southwest.

The soils vary considerably and have predominatly a medium texture - a sandy, clayey loam. Cambissolo (Inceptisol - USST) occurs on hilly fields. It is characterized by low cation exchange capacity, low pH values and high free aluminium content. Therefore, the root penetration is poor for plants such as beans, which are sensitive to acidic soils, and the moisture supply is then threatened. Risk of erosion on this soil is considerable with motorized mechanization, thus the potential for exploitati on depends on the steepness of the slopes. Podslico Vermelho-Amarelo (Ultisol - USST) is found on the slopes, which

shows up a great texture difference between the A and B horizons and is erosion-prone. On the peaks and the steepest slopes Solos Litlicos (Entisol, Inceptisols - USST), very shallow soils, in part having many stones on the surface, are found.

They do not lend themselves to working with a tractor due to their shallowness and the steep slopes. The supply of moisture for the plants is always threatened when there is a temporary lack of rainfall, due to the thin soil layer and poor root penetrability. Generally, the soils have a low fertility and high aluminium content.

The topography is hilly to steep. (Larach et al., 1984; Fasolo et al., 1986; Vieira, 1987; Roth, 1986) The slopes are primarily used for crops, while the valleys are reserved for woods, houses and the keeping of animals; easy access to water plays a central role. Extensive woods (called faxinal) exist in the valleys (Yu, 1988). Mate trees are planted here and fuelwood is cut, which is primarily used for drying tobacco. One of the reasons for this type of application is that the soil on the slopes is less acidic. A further reason could be the generally easier tillability of the medium slopes (see section E 4.3). The marshes in the valley bottoms have only recently been tilled by tractors; this has led to the gradual displacement of the faxinal system.

The farms are larger than in the Southwest region. The smallholders farm 50 % of the area. "Subsistence producers", representing almost one-third of all farms, have available an average of 14 ha; for "small-scale market producers" this figure averages 31 ha. The use of draft animals (without mixed mechanization) is very high at 57 %. (Yu and Sereia, 1989)

Primarily food crops are grown. Beans, mainly in pure stands, rank first, followed

by mixed cropping of maize and beans. Partly also dry rice is grown. Irat is called the capital city of the bean growers. Tobacco plays a special role for the "small-scale market producers". The crop is labour intensive and this specialization requires little space. In 1980, 99 % of Paran's tobacco originated from farms of under 10 ha (DERAL, 1986). The industry prescribes the procedures of contract cropping, purchases the entire output and promotes the dissemination of animal traction. The production of maize and beans is comprised in the system. Further activities of the smallholders are the keeping of pigs and poultry as well as the production of mate. Soybeans and potatoes are cropped, usually with the aid of a tractor, whereby the latter occurs in combination with animal traction on smallholdings. The horse (ca. 300 kg) is prevalent in the region, followed by the mule (ca. 250 kg). They are pastured on 0.5 ha plots near the houses or on the faxinal. The breast harness is used almost exclusively.

2.4.3.2 Work operations

Field preparation

Fallowing is still widely practised; it is necessary due to the low soil fertility and the high proportion of the subsistence farms that are not in a position to apply mineral fertilizers. The average fallow period lasts 3 - 4 years and the duration of cropping is 2 -3 years (Arajo, 1988a). Permanent cropping is done to some extent. Prior to field preparation the fallow field is manually cleared and the organic material is burnt off. Maize is stored in the field; the dry cobs are bent over by the farmers and simply remain on the stalk. After the first frost, which partially kills the weeds, the maize is easier to harvest. The winter rains account for the proliferation of weeds before the next cropping cycle; in conjunction with the

harvest residues this leads to serious clogging of the implements in subsequent work operations. In order to prevent this the farmers undertake burning.

Soil preparation

Plowing is done with two horses and the reversible "pointed share" plow type an implement requiring less draft power than the fuador (see section E 5.2.1.3). It is mostly widespread in South Brazil. The "pointed share" plow type is well suited to soils of medium texture and where weeds abound, although the extension services have mentioned that clogging is a problem for some models. Except for the plow body, the implement is manufactured by artisans. The farmers prefer this version because of the better quality and easier access to the industrially fabricated plow (usually the "twin-share" plow type BALDAN or TATU). The latter is only used in heavy soils or by farmers who have immigrated from the south of the state of Sao Paulo to the north (Ara·jo, 1988a). The ridger is employed on potato fields.

Harrowing

Harrowing is done with draft animals on an estimated 70 % of the farms prior to sowing of maize, beans and tobacco. Usually the rectangular tine harrow manufactured of wood by the farmers themselves or local artisans is used. Only the settlers from the south prefer the metal harrows. The harrow may be applied to drag off harvest residues prior to plowing. Weeding is carried out before sowing by means of two harrow operations. The clods are not completely crumbled, so that the danger of erosion remains limited.
Breaking furrows and marking

Marking enables an exact sowing in rows, also prior to the use of hand-operated seeders or the planting of mixed crops; the subsequent weeding operation therefore becomes easier. To facilitate marking a simple wooden device with several tines is employed. The furrow breaker is also used for marking. In addition, sowing with an animal-drawn implement then becomes easier, which is necessary for some seeders (information from Regncia farm machinery distributor in Irat, 1988). Approximately half of the farmers apply this work operation. The furrow breaker consists of a wooden frame without a support wheel upon which a share is mounted.

Sowing

80 - 90 % of the seeding is done manually. Over half of the maize, beans and rice are sown with the matraca (section G 2.4.2.2); in part it is also carried out with a sacho (small hoe) or a sengo (long handle with spade-tape tool). The matraca is most commonly used because of its efficiency. Animal- drawn precision seeders are employed on 10 to 20 % of the farms. Generally, they are more frequently used for sowing beans and the matraca for maize.

There are several reasons for this:

- The advantage of the precision seeder, to deposit the seed for an optimal exploitation of the growth factors with even row spacing, is frequently not appreciated by the farmers. Normally pocket dibbling is practised with the matraca.

- The dibbled spacing in rows is at approximately 1 m, greater for maize than for

beans, which are spread out at a distance of 30 cm. Thus, maize can be planted by a comfortable step spacing of 1 meter with the matraca; it also achieves a high area performance. The sowing of beans can be more easily accomplished with a seeder due to the small spacing

- The weight of the maize seed is considerably less than for beans. The farmers frequently select a lower seeding rate than recommended by the extension services. For beans the seeding rate is usually over 60 kg/ha (120,000 plants/ha and more); for maize it is often less than 10 kg/ha due to the low soil fertility and the proportion within the mixed cropping system. For example, for maize with 1 m row and pocket spacing and ca. 3 plants per pocket this results in a seeding rate of 30,000 plants/ha (ca 7.5 kg/ha), which is adapted to the fertility of the soil. In many cases the rate is lower however for smallholders in the region (Ramos, 1987).

- Since beans are of greater economic importance for the farmers than maize, mineral fertilizer (phosphate) is used more often as dressing for beans, especially if they are in a pure stand in close spacing. Because of the additional weight the simultaneous fertilizer distribution and sowing of beans is conducted by animal-drawn seeders.

- Maize is often sown later than beans in a mixed cropping system. This can be done more efficiently with the matraca.

- The sowing of maize can generally occur within a longer time period of more than 2 months. Bean sowing is limited to a timely period of 1 month.

Dry rice is very susceptible to weed competition during its slow initial development. Therefore, only small plots are plowed and immediately planted (Arajo, 1988a). The total area under rice is not large, thus the matraca is an appropriate implement for this purpose.

The SANS seeder is the most popular implement. It was the first seeder to be introduced in greater quantities in the district of Irat as of 1978 (Coelho, 1988).

An appreciable share is also attributed to HMC implements, which are similarly designed. In recent years more light seeders having double disk shares for opening the furrows are being sold (e.g. TRITON, ISOL) (see section E 6.2.2).

Weed control

The hand hoe is used for weeding on over half the farms. One-third to one-half use both the hand hoe and animal-drawn hoeing implements. Only a few farms work exclusively with draft animals and do not practise manual weeding by hand hoe in the rows (Arajo, 1988a).

Weeding beans is primarily done with the hand hoe due to the small row spacing. In part, however also draft-animal implements with one share are used. But the danger exists that the plants will be trampled or damaged. This applies especially when beans are not precisely planted in rows with the matraca.

The animal-drawn hoeing implements are almost exclusively cultivators manufactured by artisans; the devices weigh about 30 kg and the breadth cannot usually be adjusted. They are equipped with three blades, of which one can have an accessory to heap up the maize rows. Because of the lack or limited possibility

for adjustment two work operations are necessary for maize. Tobacco is also heaped up; for this purpose a special device having two disk blades is used. One seldom encounters the Planet cultivator that has five blades.

Considering the high labour investment for weeding the farmers must decide to either limit the size of the fields under crops and direct attention to the plants or to risk an inadequate weeding, e.g. only one instead of three or four operations up to the point where the crop becomes overgrown. In the latter case the farmers must work more land and correspondingly plant greater amounts of seed in order to achieve the same yield. This means higher costs and redirects the labour to other operations. Many farmers conduct weeding operations when the weeds have already grown to a mature height.

Then, it is attempted to bring the weeds under control by heaping. Because of the great manual labour investment for weeding in mixed crops, pure stands have increased to facilitate the use of the cultivator, especially on farms growing labour-intensive tobacco. For a reduction of the use of hand hoes in mixed crops both can be sown in a single row to increase the amount of shade. During rainy years the problems with weed control multiply. Thus, an increasing number of farmers apply herbicides with the knapsack sprayer (e.g. band spraying in the rows instead of the hand hoe)

2.4.4 Londrina (8) and West regions (13)

2.4.4.1 Description

With the settlement of these regions located in the third Highlands there was a

high influx of immigrants from the state of Sao Paulo bordering the north of Paran. The climate is warmer and dryer than the Southwest and Irat regions and frost seldom occurs in the winter. This allows the growing of crops sensitive to cold, such as coffee. The average annual temperatures lie between 19 and 22 C and precipitation between 1300 and 1600 mm; fluctuations in rainfall can lead to deficits in the moisture supply. Most of the soils possess a clayey texture. On flat fields Latossolo Roxo (Oxisol - USST) is found. On slopes of over 6 % one encounters Terra Roxa (Alfisol - USST), an extremely fertile soil. The soils are very suited for mechanization due to the good physical characteristics. On very steep slopes shallow soils are found: Solos Litlicos (Entisols, Inceptisols - USST). Due to their shallowness and the steep slopes they can hardly be worked with a tractor. The thin soil layer is very susceptible to erosion. The shallow soils are especially endangered with rainfall fluctuations, as the moisture storage capacity is low and poor root penetration limits the moisture uptake of the plants.

However, in general the soils are very fertile. The smallholders (69 % of the farms) till only 25 % of the farm land. The "subsistence producers" have an average 5 ha and the "small-scale market producers" over 11 ha. Thus, the farms are smaller than in the other two regions (Yu and Sereia, 1989). Motor mechanization is predominant here, also on smallholdings; in the Londrina region on 52 % of all farms and 68 % in the Western region. In part, it is used for soil preparation and subsequent work operations are done with draft animals. Animal traction is applied on 17 % of all the farms. Manual labour is found with subsistence farmers more frequently than in the Southwestern and Irati regions.

In the Western region (13) primarily soybeans are grown on all sizes of farms,

partially in rotation with wheat. While the further activities of smallholders are maize, cotton, coffee and bean growing as well as keeping animals (pigs, poultry, cattle), on large farms raising cattle and pigs as well as growing coffee follow in importance. Farming activities in the Londrina region (8) are similar; however, growing soybeans is here restricted to the large farms. Since soybeans can be reaped with a combine harvester they are grown in pure stands and are mainly produced on technically well equipped farms, frequently in rotation with wheat as a winter crop. Maize is not included in the rotation as often.

Characteristic for the soybean-wheat crop rotation is the high requirement of inputs. (Dossa, 1988) Labour-intensive crops such as cotton and coffee are primarily produced on smallholdings, where the employment of the entire family is possible. The cropping area is therefore dependent upon the number of family members that assist in the work. Production of cotton is also connected with mixed cropping of maize and beans. In growing of coffee draft animals are merely used for weeding. On large coffee estates animal traction is seldom employed. Sugarcane, used to a great extent for producing alcohol as a fuel, is predominantly grown on large farms. On smallholdings it is grown only for own use (food, fodder); the plants could serve the purpose of erosion control on slopes or to fix the contour bunds. The horse and the mule are the main draft animals and frequently the collar is used for harnessing them.

2.4.4.2 Work operations

Field preparation

The practice of burning is often observed since a large amount of post-harvest

vegetation and harvest residues remain on the field, especially due to the field storage of maize. Thus, the problems of clogging during seedbed preparation and the subsequent work operations is avoided. This practice generally does not occur when the tractor is employed for seedbed preparation.

Soil preparation

Only a small proportion of all the farms (ca. 10 %) use draft animals for soil preparation. This work is already done 2 months prior to the sowing of beans, shortly after the harvest of the previous maize crop. For this purpose either the bico de pato (see below) with only one draft animal is used or the mouldboard plow, usually the reversible type with teams of horses or mules. Because of the clayey texture the reversible "twin-share" plow type (TATU or BALDAN brand) is widely distributed; it is quite suited to these soils.

The bico de pato

The bico de pato, a type of chisel plow, consists of a plow frame made of wood, upon which a sweep share is mounted. It is employed for both seedbed preparation as well as weed control. Since it only works the surface of the soil it requires little draft power. The device is therefore pulled by only one horse or mule. It can achieve a high area performance (13 h/ha; Arajo, 1988b), which is partially due to the low tendency to clogging by organic material. However, it leaves unworked strips and does not work in the vegetative residues, so that cleaning must be done by hand hoe or several runs must take place. The regulation of the working depth must be accomplished by the energy expended by the farmer (Casao, 1987).

Since only the surface of the soil is worked (under 10 cm) the subsequent seeding with animal-drawn seeders is rendered more difficult, especially with cotton. According to Hadlich (1988) cotton requires a thorough seedbed preparation because it has deep root penetration. Nevertheless, the bico de pato is also used for this crop. An advantage is that the implement can also be employed for weeding. On suitable terrain soil preparation with the disk plow or the disc harrow pulled by tractors in exchange for wages is widespread, while most other work operations are achieved manually or by draft animals.

Harrowing

Harrowing with a tined harrow or simply with a wooden leveler follows seedbed preparation. If a tractor is used for this purpose, harrowing is generally not carried out prior to sowing.

Breaking furrows and row marking

The breaking of furrows is conducted before seeding, especially for cotton. At the same time, fertilizer is deposited in the furrow.

Sowing

Animal-drawn seeders are frequently used for sowing cotton. SANS and HMC seeders are the most popular. Fertilizer distributors are normally not employed, as the fertilizer has already been applied manually. The matraca cannot be used for cotton, since the seeds contain fibres. Therefore, seed distribution is undertaken with animal-drawn seeders; for cotton seed it is equipped with an exchangeable toothed planting wheel and a dispensor disk. Precision seeders are also used for

maize and beans.

A matraca is employed if beans are to be sown in autumn following the bending over of the husks prior to harvesting. In this case the seeder can hardly be used. The matraca is preferred to the seeder because it is easier to handle. Complaints are often uttered regarding the tendency of animal-drawn seeders to clogging. This presents no problem after seedbed preparation with a tractor, since the organic matter has been more efficiently worked in.

Weed control

The majority of the farmers also use the bico de pato for weeding. Two runs are necessary for cotton and maize; heaping up occurs simultaneously. The work in the rows is carried out with the hoe. Thinning of cotton is incorporated in the task. Weeding of beans consists only of one run with the bico de pato between the rows. The bico de pato can also be employed if the sowing in rows is not precise. The use of the cultivator with 3 or 5 shares would become more difficult. In coffee crops draft animals are only used for weeding. The bico de pato should not be employed, according to the extension services, since it can easily damage the roots of the crops. Generally, mechanical weeding is being replaced by the application of pesticides, particularly in rainy years.

2.5 Discussion

2.5.1 The regions

The Southwest region was first opened up in the 1930s by settlers from the south, many of German and Italian descent. Despite the short duration of utilization,

fallow is no longer practised. Agriculture consists of smallholdings, which farm 50 % of the total arable land area in the region. The share of family members participating in agricultural activities (in total 0.155 labourers/ha) is very high at 86 % (according to Fuentes, 1984). 47 % of the work on the farms is based on animal traction; in addition, draft animals are employed for mixed mechanization. The essential natural characteristics of the region are the fertile soils, the high proportion of very steep slopes and the stony ground. The main implement sequence consists primarily of the fuador, the matraca and the hand hoe for weeding. The stony soils and the coarse, cloddy seedbed preparation with the fuador render the use of further animal-drawn implements more difficult, especially for seeding. Weeding occurs in part with a simple shared cultivator. Overall, a great deal of manual labour is required for the individual work operations. Oxen are used as draft animals.

Polish and Ukrainian immigrants were very instrumental in settling the Irat region. The territory has been settled for a longer period, however the practice of fallow is not widespread here. This is because of the low soil fertility and the larger area farmed in comparison to the other regions. The soils are lighter and the slopes less steep than the Southwest. Smallholders farm 50 % of the total area in the region. Particularly family members undertake the work (84 %; in total 0.84 labourers/ha; according to Fuentes, 1984). The implement sequence used in Irat is greater than in the Southwest: the reversible "pointed share" plow type, harrow, furrow breaker, animal-drawn precision seeders or matraca, cultivator, usually with 3 blades. The draft animals are horses or mules. The "pointed share" plow type is especially suited to the soils of medium texture and lush vegetation.

The Western and Londrina regions were first settled in the early 1930s, strongly

influenced by the northern neighbour, the state of Sao Paulo. The soils are appropriate for mechanization and fallow is no longer practised. Smallholders farm only 25 % of the total area in the region; coffee and cotton are the most frequently found crops. The share of farm labourers of all the agricultural labour forces is very high here (33 %, total of 0.126 labourers/ha; according to Fuentes, 1984).

Tractors are employed for soil preparation. In this work operation with draft animals the bico de pato with one animal or the reversible "twin-share" plow type, which is suited to the clayey soil, is harnessed to a team. Subsequent work operations are to a great extent carried out with draft animals, especially seeding and weed control. The bico de pato, which only works the soil surface, is adapted to dryer climatic conditions in this region. The common use of animal-drawn seeders is related to the cropping of cotton, which cannot be done with the matraca hand-operated seeder. Horses and mules are used as draft animals.

2.5.2 Constraints and work operations

Work peaks

Weed control represents the greatest work peak of all in the three regions portrayed. It requires almost half the labour investment for rice because of the slow initial development of the crop (Arajo, 1988a). However, it is flexible in that the farmer can determine the time and intensity himself, but with a direct effect on the final yield. In northern Paran the greatest amount of labour is expended during the harvest, but it can be more widely distributed, either over a greater time period (maize) or to additional labourers from outside (cotton). The harvesting of

beans also represents a work peak. Since the reaping occurs during the rainy season, the beans must be quickly gathered. In southern Paran however less labourers from outside are available.

Field preparation

The high proportion of organic material on the fields, for example vegetation from the fallow period or undecomposed harvest residues from the late maize harvest, is a considerable problem for the utilization of draft-animal implements. The practice of burning is therefore frequently resorted to. The late harvesting of maize serves a purpose from the viewpoint of the farmer, since it facilitates the distribution of a high labour load over a greater time span; thus primarily family members become involved in the harvest. With the mixed cropping of beans in the maize rows still standing in autumn the maize contributes to a favourable microclimate (stabilization of moisture resources). As a matter of fact, the practice may be attributed to the limited storage space available for keeping the maize cobs.

For the processing of organic trash on the fields the extension services recommends using the knife roller. Its efficiency however is hampered by the late maize harvest. In the southwest a further hindrance is that the knife roller does not function on steep slopes and where there is a high occurrence of stones. The introduction of this long-known technique in South Brazil has thus been less successful

Soil preparation

For a field size of 10 ha in the southwest approximately 50 workdays are required for the fuador. In Irat the same field area can be worked somewhat more rapidly with a reversible plow (in ca. 42 workdays). Assuming a cropping area of 15 ha then 63 workdays are necessary, approximately 20 months. On smaller cropping areas in the north and west, of 8 ha about 18 workdays are required for the bico de pato.

Since the most rainfall occurs in Paran during the time of soil preparation, erosion becomes a severe problem, especially with the predominant use of heavy tractor-pulled disk harrows. With the preparation by animal-drawn implements the lack of a pulverization effect and low soil compaction cause significantly less erosion due to the small working depth. Nevertheless, the uncovered surface offers a substantial exposed area for the thunder showers occurring during the long period from the beginning of soil preparation until a crop cover exists. Especially the slopes of the small farmers are endangered. An alternative to the use of the mouldboard plow would be minimum tillage.

Preparation with the bico de pato, which is similar to the chisel plow, is significantly less intensive. In the Southwest region, where land-use intensity is high (R value = 100) and suitable green manure crops exist, the minimum soil tillage method "cultivo minimo" is becoming popular with the farmers (on 1 - 5 % of the farms) (Monegat, 1985). Thereby, a furrow is drawn in the winter green manure crop with the fuador in order to sow the summer crop, e.g. maize. The soil therefore remains essentially covered. For direct seeding, which is widespread among the larger farms (an estimated 8 % of the cropland in Paran), no appropriate methods and techniques are available for the smallholders (Siqueira et al., 1986; Schmitz, 1988).

Fertilizer

Manure is still seldom spread on the fields, although especially in the southwest large quantities become available from feeding of swine. Only chicken manure is used for fertilizer (Rockenbach, 1987; David, 1988). The neglect of organic fertilization has been mainly due to either the high fertility and the short period of utilization of the soil or the practice of fallow. In addition, the transportation represents a substantial obstacle, often increased by the steep slopes of the fields. Since pig manure is very fluid, a collection device in the stall as well as a tank for spreading would be necessary. For the distribution of basic fertilizer, dispensors and animal-drawn seeders with a dispensor are being marketed. Frequently, fertilizing is not done with the seeder, but rather during breaking of furrows prior to seeding or later in a subsequent work operation either manually or with draft animals.

Liming and the spreading of phosphate is important for the predominating soils (Podslico Amarelo, Cambissolo) on draft-animal farms, however this is connected with high costs. As this practice has been only recently subsidized, suitable implements are not yet available to the farmers.

Sowing

On the whole, one can assume that seeding does not represent a work peak because of the small plots which are planted on a staggered time schedule to distribute the risk factor. The sowing of maize on 4 ha, a typical cropping area for maize, can be accomplished in 2 days with animal-drawn implements and in 4 days with the matraca. Thus, the time benefit with the use of the expensive seeder

is relatively small for animal traction. This only becomes attractive if, for example, beans with a closer density and pure stand are planted and mineral fertilizers are spread with the implement. Additional problems arise such as clogging or poorly distributed seeding, especially when vegetation residues are encountered. The price for the implement is therfore not affordable for many farmers.

The advantage of even spacing between the plants in the rows is often not appreciated by the farmers. Also for the use of hand seeders a marker can assist in keeping precise rows for proper weed control. Therefore, it is not surprising that animal-drawn seeders have become widespread primarily for planting cotton, which cannot be carried out with the matraca. This is purely a market crop, which means a simplification of investment for mechanization. In addition, the seedbed preparation in the cotton-growing areas is predominantly done with tractors and clogging then presents no problem.

Weed control

For weed control the difference of area performance between the hand hoe and the draft-animal hoe is considerable. For maize it requires 6 - 8 days/ha with the hand hoe and 4 to 10 h/ha with the cultivator, depending upon whether one or two runs are necessary between the rows. Frequently, one of the tools of the three-share cultivator is clad with a ridging accessory and two passages per row are carried out simultaneously. The spacing between rows is only about half for beans, and thus approximately 10 h/ha are necessary. For an arbitrary 10 ha 68 workdays would result for three-run operations.

The extension services recommend the Planet cultivator (with 5 blades)

distributed by SANS, TATU or BALDAN. It is however not widespread. The farmers more frequently use the cultivators with three blades manufactured by artisans (partially with adjustable width) or with one blade, consisting of a simple wooden frame and upon which various tools can be mounted. The extension services is of the opinion that the single-blade implements work too deeply and damage the root system of the crops (Hadlich, 1988).

The following reasons however speak against the utilization of the Planet:

- It plugs up easier than for example the single-blade cultivator, especially when harvest residues have not been sufficiently worked in, as is the case in the Southwest region, or if the farmer does weed control late in the season when the weeds are already high,

- on fields with obstacles the Planet is not sturdy enough according to the opinion of the farmers,

- it costs significantly more than an implement with three blades that has been manufactured by artisans.

In addition, the farmers have easy access to the local artisans.

At the same time, chemical pesticides are becoming widespread, even for the purposes of shifting cultivation, and animal-drawn implements are already on the market for spreading herbicides.

Harvesting

The harvest is carried out exclusively manually on most of the draft-animal farms: pulling out the beans, bending over and gathering the maize cobs. Harvesting requires the greatest labour investment for some crops. The available labour force limits the cropping area for cotton. With maize the work is distributed over a greater time span of about 4 months due to the facility of "field storage." Research and extension services favour the introduction of a mowing bar equipped with a windrower for wheat.

Other draft-animal activities

Transportation with animal-drawn carts that are totally built of wood and are equipped with spoke- wheels plays an important role and advances the profitability of animal traction. Moreover, already formerly animals were attached to a whim for crushing mate leaves.

2.5.3 Prospects

The cropping area which can exclusively be worked with draft animals (with one span) is approximately 15 ha. According to Fuentes (1988) a transition to motorization takes place at between 15 and 20 ha depending upon the specific area of activity on a farm. Plowing for wages also occurs on smaller farms.

Considering the various possibilities of utilization of the individual soil types as well as the topography, then an estimated 50 % of the area of Paran is not suited for motorized agriculture (see Casao, 1988; IPARDES, 1985; own calculations). This is based on the shallow soils, the extreme risk of erosion or the steep slopes. Approximately 10 % of these soils (2 mil ha), somewhat less than the farms under

20 ha have tilled in 1980, can however be cultivated with draft animals or by hand. The future importance of animal traction depends, among other things, on which cropping systems will become prevalent on these areas.

Alternatives would be the growing of permanent crops, for which however no market is in view at present, or animal husbandry, which is occurring currently with large farms on these areas; this could lead to a further displacement of the small farmers. A part of the areas used by smallholders for cash crops could be applied to fodder crops and thus be adapted to the low soil fertility and the topography, in the opinion of the extension services.

Approaches of various institutions to improve the situation of the smallholders and the further development of animal traction concern

- the retention of soil fertility by growing green manure crops; the processing of the organic material could be done with the knife roller,

- a breeding scheme for horses (crossing with Bretons) in order to obtain stronger draft animals,

- the development of new implements (reversible "twin-share" type plow tamand·a-IAPAR, precision seeder for no-tillage under mulch). (Casao, 1988a; Schmitz, 1988)

2.6 Manufacturers, prices and sales figures

Implements for animal traction have been introduced by European immigrants since the second half of the 19th Century. Also, some North Americans brought

their techniques along to the state of Sao Paulo, where the greatest proportion of the farm machinery industry is located, after the War of Secession. The manufacturers in the state of Sao Paulo have been influenced by North America to a considerable extent. Further south the influence is more European. In principle the implements originate from that time and have hardly been further developed. Innovation on draft-animal farms is minimal, i.e. many implements have been used 15 years or more. For example, in Mambor the only draft-animal implement sold for weed control after 1970 was the bico de pato (Freire, 1988).

Little support is given the further development of implements, since the industrial sector invests in motorized mechanization, although 10% of the turnover of Marchesan (Tatu brand), one of the largest farm machinery manufacturers in the world, is in the field of draft-animal implements (Casao, 1988). The fabrication of newly developed implements only becomes profitable with more than 100 machines per month for this company (Fabry, 1989). Thus, this sector remains in the domain of the artisans.

In the South of Brazil an entrepreneurial network of artisans exists, the majority of whom are immigrants. The manufacturing of plows, furrow breakers, cultivators, harrows and carts takes place primarily in these companies. The farmer has easier access to these local artisans and appreciates the quality of their products, even if the price is higher than the industrial goods. Only complica ted seeders and motor-driven post-harvest techniques are manufactured exclusively by the industry. Artisans have difficulty with the legalization of their companies, the pre-financing of the material, electrical arc welding and the labour distribution: work peaks especially at the beginning of the agricultural season and at harvest time stand opposed to a lack of orders during the rest of the year. Work

on plows is the most important activity. Particularly the reversible plows require a thorough repair, which the farmers cannot do on his own. Even the artisans do not all know how to install the correct cutting angle on the plow bodies, especially the "pointed share" plow type. The plowshares must be replaced every year. It would be important to start a scheme to improve the quality of the artisans' workmanship (compare ACARPA, 1986).

Assuming that in Irak municipality about 60 % of the 3000 farmers work with draft animals, with a life of 15 years there must be a demand of approximately 120 implements per annum for the individual work operations. The sales figures for the farm machinery dealer Regncia in Irat for draft animal implements reflect the current state of innovation. In 1987/88 the following numbers of machines were sold per annum: 3 disk harrows, 80 seeders, 18 ridging plows and 40 cultivators. Others, especially artisans, also frequently have implements such as plows and cultivators on offer. The price of the items generally depends more on the weight of the material than the amount of labour investment.

It was first in 1979 that the national extension service of Brazil EMBRATER and the organizations in the individual states turned their attention to the dissemination of animal traction. Courses for animal traction last 40 hours and the practical aspect takes up 90 % of the time (Reis and Baron, 1986). The state extension organization of Paran EMATER-PR has 1000 officers who advise smallholders in particular. With 400,000 smallholders there is one officer per 400 farmers. Advisory services for large farms is privately organized. Officers have in general too little preparation for animal traction; for example there is no training center. (Hadlich, 1988)

2.7 Conclusions

- Animal traction has a specific tradition in Paran. This is built up on the experience of European and Japanese immigrants who have created agricultural structures in the south of Brazil based upon the smallholder economy.

- At the same time, an artisanal system developed with the immigration. The industrialization of the south strengthens its base and secures the supply of materials.

- The farmers have a great variety of implements available; in some regions however there is some difficulty in obtaining all the implements.

- The array of implements is partially quite developed. Aside from infrastructural conditions (market access, supply of materials and spare parts) this is because the transition to permanent cropping in many regions of Paran has taken place and row cropping, also for mixed crops, is widely found. Moreover, animal traction is found to a great extent where fallow is commonly practised.

- Animal traction is applied predominantly by smallholders who are at a disadvantage with regard to investment possibilities, quality of soils, farm size, topography etc. The economically better-off farms have already shifted to motorization. Animal traction dominates where tractors cannot be employed due to steep slopes and shallow soil layers.

With the reduction of loans and subsidies because of the economic situation in Brazil the interest again has returned to increase animal traction, so that the sales figures for draft-animal implements are undergoing an upturn (David, 1988). Even

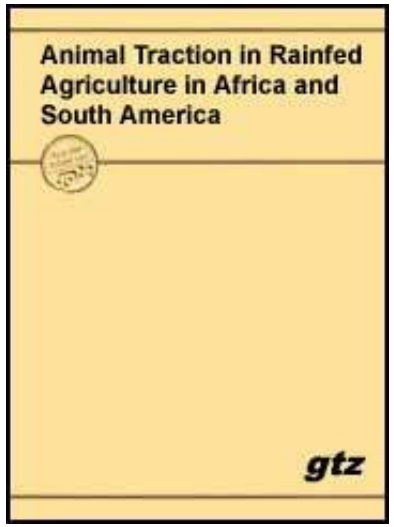
if the high work performance must be attained, as with harvesting, which also is rendered more difficult due to the rural exodus and the low supply of labour forces, no new innovations e.g. mowing machines, have developed on the draft-animal level. Obviously, the highest development in animal traction, with the simultaneous distribution of motorization, has been achieved with the seeder, which has only become disseminated on some of the farms in Paran. Many farmers with animal traction feel inferior, although they are aware that draft animals damage the soil less. They blame themselves for not working with a tractor. In some cases the farmers must purchase tractors to keep their sons, although they would reject the idea for economic reasons. The youth do not want to take up the drudgery of plowing with draft animals any more.

Nevertheless, in consideration of the problems which motor mechanization evokes regarding social differentiation and erosion, animal traction is again becoming interesting for agricultural research and extension services organizations, with the aim of counteracting the exodus from the rural areas. Due to the unsuitable conditions (soils, steep slopes) for motor mechanization and because of the limited possibilities for investment for many farms draft-animal power will be of importance in the future.


Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Animal Traction in Rainfed Agriculture in Africa and South America (GTZ, 1991, 311 p.)

H. Summary and conclusions



Animal Traction in Rainfed Agriculture in Africa and South America (GTZ, 1991, 311 p.)

H. Summary and conclusions

1. Decision-making factors:

All over the world farmers are rationally thinking people, since they have to deal with costs, profits and risk. A farm in the tropics and subtropics is a complex system, in which the household and the productive branches must be coordinated. Risk minimization is one of the most important strategies of farmers, both male and female, especially on smallholdings. Intervention assumes a good apriori understanding of the system.

2. Conditions of agriculture in the tropics:

The natural spatial conditions and thus the character of agriculture can fluctuate

considerably within a short distance. In many locations in humid climatic zones the nutrient supply for the plants is a limiting factor, which is aggravated by the decline of fallowing and rapidly reducing humus content due to a more intensive soil preparation. The lack of a crop cover causes severe erosion set in motion by heavy rainfall. High weed growth requires an appreciable labour investment as the period of fallow is reduced. The work calender is relatively balanced out in the humid tropics because of the low seasonality. The crops (permanent and root crops) grown here are difficult to mechanize. Animal husbandry, fodder as well as the extra energy expended for clearing land, which is necessary for utilizing implements, all require a substantial investment

In the drier zones soil fertility is generally higher. The investment for clearing is less and weed invasion is less marked than in the humid tropics. The crops grown here can easily be mechanized. Since the yield is lower and frequently only one crop per year is harvested, a greater area must be cultivated. Also, work peaks occur for planting, due to the distinct seasonality of precipitation and the limitation of the growing season, which favour animal traction. If the duration of the vegetation period is too short, the introduction of draft-animal mechanization is no longer worthwhile since animals and implements are not used to capacity.

3. Transition from the hand hoe to the plow:

Farming systems undergo constant change, e.g. due to population expansion, alterations in the structure of land tenure and increased market access. Usually this leads to a higher land-use intensity, i.e. to a reduction of fallow. Shifting cultivation is optimal in respect to labour productivity and distribution, also in terms of the ecology. The soil is loose and weed invasion is minimal. Any

mechanization measures would only be connected with an additional investment for thorough clearing and draft-animal husbandry. The labour investment increases with greater land-use intensity in the hand-hoe system, especially for weed control, and animal traction serves the purpose of heading off the declining labour productivity. The introduction of animal traction is therefore only beneficial after a certain level of land-use intensity has been attained. Animal traction is as a rule only introduced prior to this time point in regions where the input for clearing is low dry regions, grass savanna, flood plains) or where soil preparation is difficult with the hand hoe. An acceleration of mechanization also occurs when migrants bring along their experience with draft-animal techniques (e.g. in South Brazil).

4. Factors of production -land, labour and capital:

In the industrialized countries mechanization occurred when the production factor, labour, in comparison to land, was scarce and an increase of labour productivity was desired (replacement of labour with capital). In the sparsely settled, expansive agricultural areas of USA (savanna) there was a low supply of labour forces and due to the industrialization a purchasing power demand and thus sufficient capital available. An intensification (e.g. with the help of fertilizer or improved seed) occurred when the land became scarce. This was the case in the heavily populated countries such as Germany and Japan where the land area was small. Mechanization first happened in connection with the migration of many labourers to the industry.

Under the conditions of the vegetation of many tropical regions the labour productivity in the case of low land-use intensity cannot be increased by means of

draft-animal mechanization. The necessary pre-conditions can first be created by a more intensive input of labour and capital, which is not possible for the existing farms, in order to satisfy the needs of a purchasing power demand and an increase of benefits. In general, both the purchasing power demand and the necessary capital is lacking, so that the development progresses more slowly. Therefore, animal traction will retain its significance for a long time to come.

5. Aims of draft-animal use:

Animal traction primarily serves the purpose of reducing work peaks by means of mechanizing work operations, expanding cropping areas, easing the work load or facilitating the tillage of heavy soils (e.g. in river bottoms). In general, mechanization initially takes place for the energy-intensive work operations of soil preparation and transportation. The more control a work operation requires (e.g. harvest), the higher the labour costs must be, in order that the purchase of a machine becomes worthwhile. At the beginning of the introduction of animal traction the animals are only used for a few work operations, so that the labour productivity in comparison to manual labour does not increase. Also the area performance generally does not increase; it can actually decline due to a reduction of mixed cropping. On the other hand, the yield can be increased because of the more frequent weed control, which is possible with mechanization. Greater intensity of draft-animal use, i.e. for further work operations, and especially hiring out of animals and implements increase the profitability substantially. The latter is only possible as long as their is a small number of draft-animal farms.

6. Status of animal traction:

Asia has the highest density of draft animals, where in the areas of concentration, e.g. Nepal and Bangladesh (with more than 100 animals per 100 ha of cropland), there is also a high population density. In Africa and South America figures for draft animals are generally lower, although in some zones an intensive use is recorded. In the Mediterranean countries of Africa and in many countries of South America draft animals are being displaced by tractors.

7. Constraints of draft-animal use:

Difficulties in the infrastructural sphere were particularly mentioned in the responses to our survey: veterinary services, loans, animal purchases, fodder and repair of the implements. Problems that cannot be solved in the short term are simply set aside. This is attributed to the fact that the responses originated from regions where animal traction has already been disseminated. The problems caused by the introduction of draft animals under the auspices of development cooperation endeavours, which are not suited to land-use intensity or the cropping system, are frequently ignored by the participating institutions. Draft-animal measures were generally considered unpopular in regions where they competed with motor mechanization.

8. Procurement of animals:

Regarding the selection of draft animals the potential of multiple application (e.g. meat, milk) is important, aside from availability, price, adaptiveness to a region, the requirements of the farm and the work to be carried out. Monofunctional use, as is the case for horses, is only worthwhile if the capacity of the animal is fully exploited. Oxen are primarily utilized for the purpose of soil preparation. Cows

possess high demands in terms of husbandry and management, in order that the reproductive performance and milk production be maintained. The price of cattle depends upon the demand for meat. Donkeys are predominantly used in more arid regions, especially for transportation and to a lesser extent for easier tasks such as seeding and weed control. Horses and mules are utilized for all work operations.

9. Draft power:

The draft power and the performance of the animals is proportional to the weight of the animals. The draft-power requirement depends upon the soil conditions, the work operation and the type of implement. Generally, for horses and cattle 1/10 to 1/7 of the body weight is mentioned with a daily work time of 5 to 6 hours. Donkeys and mules achieve better results. Higher values are often recorded (up to 23 % of the weight). Standardized procedures for measuring draft power are lacking in any case, which could also assess draft capacity and the load duration of the animals (weight, nutritional condition) existing on the farms under normal operational conditions.

The potential of draft-animal use is predominantly independent of the size and weight of the locally available animals. More important is the adaptiveness to the local conditions, especially in consideration of the fodder and risk of disease. Furthermore, a critical constraint is the lack of suitable implements (e.g. various plow sizes) and methods of harnessing. Crossing small-framed indigenous breeds with larger exotic breeds for an increase of draft power is possible, but this has not been proven viable in some cases due to a lack of adaptation to the smallholding structures. The absolute lack of draft animals is no long-term limiting

factor in regions where animal traction can effectively be implanted. Here various measures of assistance could accelerate the process.

10. Fodder:

Low animal performance as a result of their poor nutritional condition was mentioned in the survey in more than 50 % of the cases, especially after the fodder-scarce dry season at the beginning of the fieldwork period. The publications consulted also considered the main constraint of animal traction to be the poor feeding condition of the animals. In approximately half the cases exclusively grazing (natural pastures, fields with harvest residues) were mentioned; the remainder also supply additional fodder. Expenditures for purchasing fodder and the water supply for the animals receive more attention with increasing land-use intensity and dissemination of animal traction as well as aridity, meaning an increased load on family labour, especially the children. Primarily stall feeding, as for example with the intensive systems for the integration of animal husbandry known in cropping in Asia, does not exist at all. In comparison with these systems where already the limits of fodder supply have been reached, the provision of fodder can be considered as extensive in Africa and Latin America. Since here, nevertheless, the poor nutrition and the low performance are mentioned as constraints, the question still arises whether this bottleneck is also recognized by the farmers or if it is merely a problem at the level of specialists and technicians. In a survey on Malawi for example most of the farmers interviewed were of the opinion that the conditions of the "lean" oxen did not present a problem at the beginning of the fieldwork season.

11. Integration of animal husbandry into the cropping systems:

In approximately one-third of the cases in our survey stall-keeping occurs at night. Optimal fodder exploitation and the collection of dung, essential reasons for stall keeping, only are feasible to a limited extent. The utilization of manure is little developed and limited to plots and gardens near the farmyard. Moreover, the natural soil fertility and its restoration following fallow can still be relied on.

12. Training and duration of use:

In countries having a tradition of animal traction the managing of the teams takes place mainly by one person, while in regions where it has been more recently introduced 2 to 3 people are necessary. This can be essentially attributed to the intensity of the contact between man and animal. The training condition of the animals is all the better, the higher the annual duration of use and if work operations such as weed control and seeding, which require more precision from the animals, are mechanized. The older and more experienced the draft animals are, the better developed the overall draft potential and skill. Poorly trained animals which are used for a short duration require more control and thus more people to guide them when employed for pulling implements, thus reducing an increase in the labour productivity aimed for by the mechanization. A short working life of draft cattle can however be an advantage if there is a high demand for beef

13. Structure of the draft-animal farms:

In the regions having a more recent history of animal traction the draft-animal farms have an above average access to facilities, which enables them to produce an enormous capital investment in relation to the hand hoe operations. In

countries with a considerable proportion of motor mechanization, on the other hand, the smallholders utilize animal traction. Animal traction is introduced initially by farms with large families, and motor mechanization by farms having more cropland. Animal traction usually leads to an expansion of the cropping area per farm. The maximum area worked per span depends, among other things, upon the length of the vegetation period. Depending upon the climate this can vary between 4 and 15 ha. Assuming the profitability limit for the use of tractors in rainfed cropping e.g. 35 ha in South Brazil, a gap of between 15 and 35 ha arises which can only be filled by hiring out tractors, if state subsidies are excluded. According to the survey the average cropping area in the draft-animal regions lies between 2 and 5 ha in 40 % of the cases and the plots between 0.2 and 0.4 ha by 40 %.

14. Crops:

Only certain crops are suited for mechanization. Permanent crops and perennials play a subordinate role in terms of animal traction. Most annual crops can easily be mechanized. Crops that are usually broadcasted, such as wheat and barley, only require draft animals for soil preparation, while for maize, beans, sorghum, cotton or groundnut seeding and weed control can also be simply mechanized. Since animal traction frequently is connected with the introduction of more labour-intensive cash crops, a considerable surplus labour input is required at harvest time. Only harvesting of groundnuts is accomplished with draft-animal implements. Mowing of grain and digging of tubers, which was done by draft animal in earlier industrialized countries, is conducted exclusively manually. Due to the possibility of mechanizing the harvest with the combine harvester, for certain crops such as wheat and soybeans it is more advantageous to produce

them in Brazil on large farms, while maize and beans are primarily grown on smaller farms. Mixed cropping, which can be done in rows, allows the mechanization of most work operations as soil preparation, seeding and weed control. However, the share of mixed cropping is declining, since it is easier to work with the cultivator, or to synchronize the application of fertilizer and herbicides on the crops. Mound crops cannot be mechanized.

15. Labour distribution:

Mechanization removes or increases the burden on men, women and children to a varying extent. Changes in the investment for the individual work operations have a direct effect on the remaining work. Thus, the mechanization of the soil preparation transfers the work peaks to the weed control and harvest, especially if the cropping area is being expanded. Part of the work can be accomplished by means of placing a greater load on the family members or a displacement to seasonal workers. As long as some work operations are not mechanized animal traction can lead to a higher demand for hired labour, especially seasonal workers. In general, draft-animal work is carried out by the men. The danger exists that they improve their economic position over against the women.

16. Work operations:

Soil preparation, followed by transportation, weed control and seeding represent on the average the largest share of work by draft animals, in this order. Clearing, harvesting and other work operations, on the other hand, are of minimal importance. There is an absence of soil preparation exclusively in a few regions where no-tillage is practised as in Senegal. Only when a greater distribution of

animal traction occurs, are the weed control and seeding operations conducted with animal-drawn implements. The introduction of row cropping necessary for this purpose appears to present no great long-term hindrance, as it usually takes place to make weed control easier. Weed control is carried out much more frequently with animal traction than seeding. Seeding with the seeder is no prerequisite for working with a cultivator. Nevertheless, in spite of the considerable potential for an increase of the labour productivity, a relatively greater share of 30 % of the cases in our survey conducted weed control exclusively manually.

Seeding is a work peak in regions having a shorter vegetation period. This can only be done with higher investments and demands on manufacturing, maintenance and repair. For this reason it is only undertaken in one-third of the regions investigated, mostly only by a smaller share of the farms. Seeders are utilized where the overall technical level has reached a high niveau, such as in Brazil, or where money flows into the farms from earned wages and labour resources are scarce, as in southern Africa. They are also common where the vegetation period is short and the crops must be planted as quickly as possible, such as in Senegal or Mali. Animal traction is widespread in these regions. In the Andes and most African countries draft-animal implements are not employed for seeding, even if the proportion of animal traction is high.

The mechanization of the harvesting process depends directly upon the amount of labour costs and is first an advantage when the wages are high. Often previous work operations are not mechanized due to bottlenecks during harvesting. Soil preparation and transportation are the essential draft-animal tasks in the initial stages of animal traction where low land-use intensity occurs. In one - quarter of

the cases however transportation is not carried out with draft animals, particularly in the Andes countries and Ethiopia, where animal traction has a tradition and the ard is common. Here, draft-animal use appears to have stagnated on the level of own manufacturing by the farmers. The ard is also only partially used for breaking furrows before seeding and weed control. This is partially, for example in Ethiopia, due to soils that are difficult to cultivate (Vertisols) and the crops: teff, the main staple crop is broadcasted. In many regions motor mechanization replaces animal traction initially in regard to soil preparation, followed by seeding, according to our experience.

17. General features of the implements:

Low weight is of particular importance if the fields are not easily accessible, since the implements are carried there in this case. With regard to manoeuvering, especially on slopes, a light construction is an advantage. A lack of adjustable handles leads to the imbalanced load on the farmer. The design and maintenance often presents new problems, e.g. due to bolts which were formerly unknown, the necessity of special tools, assuring spare-part supplies and the difficulty to find distinct names for the parts, especially in regions having several languages. (We also encountered problems in translating the questionnaire into four languages.)

The support wheels, especially on the plows, often cause trouble. The highest demands placed on the manufacturing and maintenance are the rotating parts, which are mostly found on seeders.

18. Field preparation:

In tropical or subtropical humid areas the implements must often work on fields having a great deal of organic matter (growth of fallow, weeds, harvest residues), for which they are poorly suited. To date only the knife roller is utilized, which chops vegetation and leaves a mulch layer.

19. Soil preparation:

The mechanization of soil preparation alone does not bring any quality gain for the work result, in comparison to the hand hoe. Generally, differing points of view are seen regarding the advantages and disadvantages of soil preparation, which are in part attributed to the various natural endowments. Soil preparation, specially plowing, creates coarse pores, which are important for the root growth. The medium and fine pores determining the moisture retention capacity can only be created biologically or physically by means of swelling and shrinking. Loosening the soil makes sense if compaction has occurred, but this does not have a sustainable effect. Disadvantageous is the fact that the decomposition of organic substance is accelerated by intensive soil preparation and moisture loss ensues.

The yield of the individual crops reacts differently to soil preparation. Soil preparation can achieve higher yields and a reduction of erosion by means of an increase of the infiltration rate, wherever weakly structured soils tend to compaction and crusting, as is the case in most of Senegal. However, the farmers here prefer minimal soil tillage with a chisel plow or no-tillage in unprepared soil due to the short vegetation period. On the other hand, in the humid tropics where a constant covering of the soil with mulch would in principle be possible and necessary in view of the erosion effect of the rainfall, the mouldboard plow is used as a soil preparation implement because it achieves better weed control, among

other things. In the transitional zones between semiarid and subhumid climates ridging is frequently used, especially for management of the moisture supply.

20. Ard:

The ard is one of the most widely distributed implements. It is known for its superficial, non-turning operation and is adapted to the conditions in arid areas as well as difficult soils such as Vertisols because of the varying local designs. It does not leave a clean field, so that the use of further implements is problematic. Often the mobilization of subsequent implements is disregarded for economic or cropping reasons.

21. Ridger:

The ridger is used for soil preparation and building up ridges. Frequently, it is the only draft-animal implement used in regions having traditional ridged cropping. It achieves a high area performance.

22. Chisel plow:

The chisel plow is one of a series of soil preparation implements that does not turn the soil. In part, they are utilized in the identical form as the cultivator for weed control. They are preferred in semiarid regions and the dry zones of a semiarid/semihumid climate having light soils. Here they achieve a high area performance. In wetter regions implements with a broader tool are primarily used for weed control (example: bico de pato, fuador).

23. Harrow:

The harrow is only widespread in some areas where a high land-use intensity is found. Where it is frequently used, seeders are also common. It is appropriate for working in seed. Otherwise, it is seldom utilized. Disadvantages are the additional work operation which promotes erosion due to the too fine seedbed preparation, the clogging of organic matter as well as obstacles and sticking of heavy soils.

24. Mouldboard plow:

The mouldboard plow turns the soil and leaves a cleaner seedbed than the ard or chisel plow. Its decisive advantage is the applicability for weed-control purposes. The disadvantage is the intensive soil preparation, especially where the decomposition of organic matter and the moisture loss from evaporation has been accelerated too much. The most common design is the single-wheel plow with the support wheel. The gallows plow and the frame plow have hardly found acceptance. The most usual design is the conventional type, although it can only turn the soil to one side and is therefore inappropriate for slopes. The reversible plow is seldom utilized, despite its advantages on the slope and short plots. Turnwrest plows are the most commonly used reversible plow. According to the survey they are found particularly in Brazil. The conventional plow is generally cheaper and lighter, can achieve greater working width due to the better designed mouldboard shape and is less susceptible to clogging. In the regions investigated it achieved a higher area performance than the reversible plow. Problems are encountered with the rapid abrasion of some parts of the mouldboard plow. The share normally only last for ca. 5 ha equivalent to one working season.

25. Rotary implements:

The disk plow is not utilized in the regions investigated, and the disk harrow only to a limited extent despite its suitability for working in organic matter. It is available from several farm machinery manufacturers in Brazil, the only location where its use was mentioned. Problematic are its considerable weight and the high price.

26. Seeding:

The transition to sowing with draft-animal implements increases the area performance, improves the depositing of seed, facilitates the work where high seed density occurs and serves to maintain seeding correctly in the rows. The precision of depositing seed can also increase the area productivity and thus is considered to be a intensification measure that is particularly advantageous where there is a scarcity of cropland. The saving of seed by means of exact seed depositing is especially economical for expensive seed. It must be qualitatively said though that seeding is generally not a work peak and the increase of labour productivity is mostly achieved with handoperated seeders such as the popular jab planter in Brazil, especially for small cropping areas.

Seeding can in principle take place by broadcasting, dibbling or sowing in rows. In the regions investigated only draft-animal seeders for furrow seeding are being used, usually precision seeders especially developed for the sowing of a particular cash crop. To exploit the capacity of the seeder to the full however the implements must be applied to other crops, which they cannot sow optimally. Many seeders are also designed to spread fertilizer. In Brazil additional fertilizer applicators are utilized in some cases. Multi-row seeders and planters are not employed according to our survey. For the application on ridged crops no implements exist to date.

High investment costs and a poor functioning due to technical problems with the seeders or inappropriate conditions (unsuitable soil, topography, insufficient seedbed preparation, obstacles) render the acceptance more difficult. Under these conditions furrow breakers facilitate the use of seeders.

27. Weed control:

Depending upon the climate, weed control is one of the most intensive work operations. It should begin as early as possible during the field work season, and should be as superficial as possible. For the farmer at this time the field is still "clean" however. Often it is reported that the farmers carried out the weed control very late in the season. Traditionally this occurred with the hand hoe, and the weeds were often left to grow so that they could simply be pulled by hand during the same operation. This procedure has been retained with work done by cultivators, which then leads to clogging. Especially during the introductory phase the poor training condition of the animals hinders the use of cultivators due to the risk of damage to the plants, which would change if animals were utilized more often. One-to five-share cultivators are employed for weed control. Ideally, the adjustment of the working width is done by a lever with multi-share implements, and bolts must often be loosened in order to alter the hoeing tools.

Single-share implements which are more sturdy than the multi-share types are often utilized inBrazil. They are more efficient for close row spacing and where a great deal of organic matter remains on the fields. On the other hand, the effect is poorer, especially since they can causedamage to the roots of the crops. Five-share cultivators are less widely distributed. Light multipurpose toolbars are more prevalent in the semihumid/semiarid regions of West Africa. Ridgers are utilized

for weed control in regions where ridged cropping is more popular. In ard-plow areas this work operation is normally done by hand, and less often by the ard.

28. Comparison of the case studies Togo, Senegal and Paran (South Brazil):

Animal traction differs in the three case studies with respect to its introduction and dissemination.

In Paran draft-animal techniques accompanied the European settlers; in parallel a close network of artisans was created. Numerous farm machinery manufacturers have a wide array of implements on offer. Due to the already existing tradition animal traction should have already become widespread with a low land-use intensity. The dissemination of soil-preparation implements especially adapted to these conditions, such as the fuador in areas settled by Germans and Italians, leads one to this conclusion. Today, a wide array of implements is utilized in Paran. The reversible plow is primarily used for soil preparation. Draft animals are employed on 56 % of the farms, in 26 % in combination with tractors (mixed mechanization); only 12 % of the farms are equipped with own tractors. Because of the wide distribution of motorization (Paran: 11.76 tractors per 1000 inhabitants) draft-animal techniques in the meantime are manly limited to smallholdings, which work in areas with poor topography or shallow soils in many cases. These facts combined with the limited possibilities for investment reduce the potential for the further development of animal traction and the associated implements.

In spite of the tradition of animal traction in Paran and the high technical level in Brazil the seeder therefore is not commonly found on most of the farms. Tractors

are hardly used in West Africa (0.12 tractors per 1000 inhabitants). The propounded tractorization (which failed in the end) following the second world war was the greatest hindrance for animal traction. It has received a priority position in recent years. The introduction is primarily promoted by development aid schemes; partially it was not recognized that mechanization can only be an advantage after a certain stage of development of the farm system has been reached. In the drier zones of the semihumid/semiarid climate no-tillage or a superficial soil preparation is practised due to the short vegetation period in order to complete the planting as rapidly as possible, as is done in most of Senegal. Here, primarily seeders and chisel plows are utilized. In the bordering wetter zones ridging is frequently found and the use of the ridger, also for soil preparation, as in northern Togo and Casamance in the south of Senegal. In wetter climates the plow is prevalent where animal traction is not widely distributed, as in the Centrale region in Togo.

While the implement offerings in Paran are distributed by private farm machinery manufacturers, state companies are delegated with this task in West Africa. In Togo the implements are delivered by UPROMA, in Senegal by SISMAR, which was first partially privatized in the 1980s. The farmers were forced to purchase implement packages in the context of loan contracts, whereby some e.g. the plow body or the harrow where not even used. While an artisanal system was able to develop in Senegal to ensure the repair of implements despite constraints in spare-part supplies and acquisition of materials, in Togo this was essentially hindered by a centrally managed spare-part system. On the other hand, material procurement is not difficult for the artisans in Paran, but they cannot prefinance it.

29. Prospects:

The progress of animal traction in the countries of the Third World will proceed differently than in Europe or North America because of the developments and world-wide introduction of motor mechanization. While in some regions (e.g. Centrale region in Togo) animal traction is still in the introductory phase, in other areas (e.g. Paran) the transition from draft-animal use to motor mechanization is occurring; in most cases the four-wheel tractor is purchased. Only in certain situations is the two-wheel tractor interesting. The transition to motor mechanization is limited to flat or slightly sloped fields. Thus, draft-animal activities are shifted to the unfavourable steeper sloping terrain. The transition to motor mechanization is generally occurring initially for soil preparation, and according to our experience later also with seeding. Frequently mixed mechanization is found with simultaneous utilization of both animals and tractors. The employment of seeders currently represents the highest stage of development of animal traction in South America and Africa from the technical and economic point of view. Limitations result for the further development of draft-animal implements due to the low volume of investment of non-motorized farms, unfavourable natural spatial conditions such as the topography, the shallow soils and the increasing tendency to conduct soil preparation with implements pulled by tractors.

The design of many implements originated from the colonial period. One approach could be the further development of already introduced implements. For this purpose a close cooperation must take place between the farmers and the artisans in order to incorporate their experience and ideas. This applies especially where the implements are being made by hand, which is however no longer possible in some regions for the ard due to a lack of wood. Considering research, the application of recent design principles and modern materials in closer connection

with the farmers, artisans (who must be able to work with these new innovations) and farm machinery manufacturers could be explored and impulses provided for a further development of the implements. Above all, practice-related tests should be carried out with implements from various countries in order to make the best possible solutions available to the respective regional conditions.

In consideration of these developments it must be ascertained whether manufacturing is interesting at all for the industry, given the expected batch numbers. A significant aspect appears to be the meagre hope of the industry for any future of animal traction. In Brazil, the interest of the farm machinery manufacturers for innovations is also very slight., Moreover, already existing techniques are mainly being copied due to the lack of an effective patent law. Another aspect is the small amount of promotion for artisans. In three of the countries investigated they do not receive the support required for their important task. This applies especially to further training and material procurement. Most of the animals are purchased on credit. Thus, the further development of animal traction is decisively dependent upon the agricultural policies and their impact on prices of agricultural products, the allocation of loans and, in the long term, the distribution of land.

Abreviations

ACARESC: Associaao de Crdito e Assistncia Rural de Santa Catarina, Florianpolis, Brazil

ACARPA: Associaao de Crdito e Assistncia Rural do Paran, Curitiba; now called: EMATERPR

APAC: Associaao de Produtores Autnomos da Cidade e do Campo; Sao Joao de Meriti, Brazil

ASSESOAR: Associaao de Estudos, Orientaao e Assistncia Rural, Francisco Beltrao, Brazil

AT: Animal traction

CEC: Cation exchange capacity

CEEMAT: Centre d'Etudes et d'Exprimentation du Machinisme Agricole Tropical, Montpellier, France

CFA: Comunaut Financire Africaine

CIRAD: Dpartement du Centre de Coopration Internationale en Recherche Agronomique pour le Dveloppement,Montpellier, France

CPATSA: Centro de Pesquisa Agropecuria do Trpico Semi-Arido, Petrolina, Brazil

CPPP/EMPASC: Centro de Pesquisas para Pequenas Propriedades (Empresa Catarinense de Pesquisa Agropecuria),Chapec, Brazil

DED: Deutscher Entwicklungsdienst, Berlin (West); German Volunteer Service

EMATER -PR: Empresa de Assistncia Tcnica e Extensao Rural, Curitiba, Brazil

EMBRAPA: Empresa Brasileira de Pesquisa Agropecuria, Braslia, Brazil

EMBRATER: Empresa Brasileira de Assistncia Tcnica e Extensao Rural, Braslia, Brazil

FAC: Font d'Aide et de Coopration, France

FAO: Food and Agriculture Organization of the United Nations, Rome, Italy

FRG: Federal Republic of Germany

FS: French Soil Classification System
ha: Hectare

IAC: Instituto Agronmico de Campinas, Campinas, Brazil

IAPAR: Fundaao Instituto Agronmico do Paran, Londrina, Brazil

IBGE: Fundaao Instituto Brasileiro de Geografia e Estatstica, Rio de Janeiro, Brazil

ICRISAT: International Crops Research Institute for the Semi-Arid Tropics, Niamey, Niger

IITA: International Institute of Tropical Agriculture, Ibadan, Nigeria

IPAT: Interdiciplinary Group for Appropriate Technology, Technical University of Berlin (West)

ISRA: Institut Sngalais de Recherche Agonomique, Dakar, Senegal

LLCD: Least Developed Countries

MOT: Motorized mechanization

mt: metric ton

IORSTOM: Institut Franais de Recherche Scientifique pour le Dveloppement en Coopration, Paris, France

PES: Division de la Programmation, de l'Evaluations et des Statistiques du PROPTA, Togo

PROPTA: Projet pour la Promotion de la Traction Animale, Togo

R Value: Measurement for land-use intensity, directly proportional to time of fallow and utilization of the field

SEMA: Secteur de Modernisation Agricole, Senegal

SISMAR: Socit Industrielle Sahlienne de Mcaniques, de Matriels Agricoles et de Reprsentations, Dakar,Senegal

SNLCS: Servio Nacional de Levantamento e Conservaao de Solos, Rio de Janeiro, Brazil

SODEFITEX: Socit de Dveloppement des Fibres Textiles, Senegal

SOTOCO: Societ Togolaise de Coton, Togo

STED: Societ Togolaise d'Etude et de Dveloppement, Togo

TIRDEP: Tanga Integrated Rural Development Programme, Tanga, Tanzania

TU Berlin: Technical University of Berlin (West)

UK: United Kingdom

UPROMA: Unit de Production de Matriel Agricole, Kara, Togo

USST: U.S. Soil Taxonomy: U.S. American Soil Classification System

The brand names of the draft animal implements are generally not listed here.

References

ACARPA (1986): Diagnstico da situaao dos ferreiros. (1-2), Ponta Grossa, Brazil (unpublished)

ALEXANDRATOS, N.; BRUINSMA, J., et al. (1982): Power inputs from labour, draught animals and machines in the agriculture of the developing countries. In: European Review of Agricultural Economics. Vol. 9 (2): 127-155

ALMANAQUE ABRIL '87 (1986): Editora Abril, Sao Paulo, Brazil

ALMANAQUE ABRIL '89 (1988): Editora Abril, Sao Paulo, Brazil

ALMEIDA, F.S.; RODRIGUES, B.N.; OLIVEIRA, V.F. (1983): Contrle de plantas daninhas na cultura do feijao no Estado do Paran. Circular No.32, IAPAR, Londrina, Brazil

AMEGBETO, K. N. (1988): Etude Comparative de Rentabilit de la Culture Manuelle et de la Culture Attele en Milieu Rurale dans les Zones de Broukou et de Kambole au Togo. Third Regional Workshop Animal Traction forAgricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

ARMON, M.; LAL, R. (1979): Soil conditions and tillage systems in the tropics. Proceedings of the 8th Conference of the International Tillage Research Organization, Hohenheim, FRG

ANDREWS, D.J.; KASSAM, A.H. (1977): The importance of multiple cropping in increasing world food supplies. In:Multiple Cropping. ASA Special Publication Number 27, Madison, USA

APO (1983): Farm Mechanization in Asia. Asian Productivity Organization (APO), Tokyo, Japan

ARAUJO, A.G. (1988a): Personal information

ARAUJO, A.G. (1988b): Preparo do solo com traao animal. Curso de mecanizaao e manejo de solos de baixa aptidao agrcola no Paran. Ponta Grossa, Brazil (unpublished)

ASHBURNER, J.; YABILAN, M. (1988): The Development of Animal Traction Equipment adapted to the Agricultural Production practised in the Rainfed Areas of the Republic of Niger. Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

BECKER, H. (1987): Entwicklung und Erprobung einer Unkrautwalze.

Abschlubericht an die GTZ, Gieen, FRG (unpublished)

BERTOL, O; WAGNER, O. (1987): A knife roller or chopping roller. ILEIA-Newsletter, Vol.3 No.1, Leusden, The Netherlands

BERTONI, J.; PASTANA, F.I.; LOMBARDI NETO, F.; BENATTI JR., R. (1972): Conclusoes gerais das pesquisas sobre conservaao do solo no Instituto Agronmico. Circular No. 20, 56p., Instituto Agronmico do Estado de Sao Paulo, Campinas, Brazil

BONNET, B.; GUIBERT, B.; et al. (1988): Conduite, gestion des carrires et valorisation des boeufs de trait en zones cotonire. Economie de la Mcanisation en Rgion Chaude. CIRAD/MESRU, 12-16 Sep. 1988, Montpellier, France

BORDET, D.; LHOSTE, P.; LE MOIGNE, M.; LE THIEC, G. (1988): La Traction Animale en Afrique Francophone. Rapport Final. CEEMAT, Antony, France

BOSSI, M. T. (1982): Evaluation Couts/Avantages de la Culture Attele dans les Zones d'Action du Projet Nord-Togo. Ministre du Plan et de la Rforme Administrative, Programme d'Amenagement dans le Nord-Togo; Kara, Togo

BRUCHHAUS, E.M. (1984): Von der Buerin zur Hilfskraft? In: Entwicklung und Zusammenarbeit, No. 6/84, FRG

CAESAR, K. (1986): Einfhrung in den tropischen und subtropischen Pflanzenbau. DLG-Verlag, Frankfurt a.M., FRG

Calcagnotto, G. (1985): Agrarpolitik und Internationalisierung des brasilianischen

**Agrarsektors. In:
Lateinamerika. Analysen -Daten -Dokumentation. Inst. f. Iberoamerika-Kunde, Hamburg, FRG**

CASAO JUNIOR, R. (1987): Uso da traao animal na agricultura. 3°. Encontro Brasileiro de Agricultura Alternativa, 12-17 April, Cuiab, Brazil (unpublished)

CASAO JUNIOR, R. (1988a): Personal information

CASAO JUNIOR, R. (1988b): Estudos sobre manejo de solos de baixa aptidao agrcola no Paran. Curso de mecanizaao e manejo de solos de baixa aptidao agrcola no Paran. Londrina, Brazil (unpublished)

CASAO JUNIOR, R.; SIQUEIRA, R.; YAMAOKA, R.S.; ARAUJO, A.G.; FIGUEIREDO, P.R.A. (1987): Estudo e caracteri zaao de semeadoras-adubadoras traao animal no Paran. Inf. da pesq. No.77, IAPAR, Londrina, Brazil

CASAO JUNIOR, R.; SIQUEIRA, R.; YAMAOKA, R.S.; ARAUJO, A.G.; FIGUEIREDO, P.R.A. (1988): Adaptaao e desenvolvimento do arado traao animal "Tamandu-IAPAR". Circular No.54, IAPAR, Londrina, Brazil

CHARREAU, C. (1972): Problmes poss par l'utilisation agricole des sols tropicaux par des cultures annuelles.Agron. Tropicale 27: 905-929

CHARREAU, C. (1974): Soils of Tropical Dry and Dry-Wet Climatic Areas of West Africa and their Use and Management. A series of lectures presented at Cornell University, Ithaca, USA

CHOPART, J.L. (1981): Le travail du sol au Sngal. Analyse des contraintes techniques et propositions actuelles de la recherche. IRAT, 36p, Nogent sur Marne, France

CIRAD (1988): Economie Rurale en Zone de Savane. Actes du 7. sminaire d'conomie et sociologies rurales, 15-19 Sep. 1986, Montpellier, France

CNEEMA (1981): Les matriels de labour et de prparation du sol. Antony, France

COELHO, W. (1988): Personal information

COPESTAKE, P.G.; TINKER, D.; ZUNIGA, A (1988): A simple jab-planter for sowing maize and beans. In:Appropriate Technology, Vol.15, No.3

DAVID, A. (1988): Personal information

DECKEN, T.v.d. (1989): Personal information

DECKEN, T.v.d.; PANA (1987): Compte Rendu de la Tourne Effectue dans la Rgion Centrale du 24 au 28 aot 1987. PROPTA; Atakpame, Togo

DEHN, C.J. (1981): Der Einflu von Bodenbearbeitungsmanahmen auf die Bodenfruchtbarkeit in den Tropen.Diplomarbeit, Inst. f. Trop. u. Subtrop. Pflanzenb., Universitt Gttingen, FRG

DENCKER, (1961): Handbuch der Landwirtschaft. Parey Verlag, Hamburg, FRG und Berlin (West)

DERAL (1986): Prognstico Agrcola - Safra 1986/87. Secretaria de Estado da Agricultura, Curitiba, Brazil

DERPSCH, R.; ROTH, C.H.; SIDIRAS, N.; KPKE, U (1988): Erosionsbekmpfung in Paran, Brasilien: Mulchsysteme,Direktsaat und konservierende Bodenbearbeitung. GTZ, Eschborn, FRG

DOHRMANN, R. (1988): Der Esel -Nutzung und Bedeutung in den Tropen und Subtropen. TU Berlin, Inst. f.Tierproduktion, Diplomarbeit, Berlin (West), (unpublished)
DOSSA, D. (1988): Personal information

EICHHORN, H. (1985): Landtechnik. Ulmer-Verlag, Stuttgart, FRG

ELHIMDY, B.; CHICHE, J. (1988): Traction animale au Maroc. Approche a la rentabilit dans les petites exploitations (Cas de Tadla). Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

EMBRATER (1985): Projeto mecanizaao traao animal na regiao Sul. Reuniao tcnica de avaliaao.Braslia, Brazil (unpublished)

EMBRATER (1986a): Traao animal nas regioes Sudeste e Centro-Oeste. Braslia, Brazil

EMBRATER (1986b): Catlogo de fabricantes. Mquinas e implementos agrcolas. Braslia, Brazil

ERBACH, D.C.; LOVELY, W.G. (1977): Machinery Adaptions for Multiple Cropping. In: Multiple Cropping. ASA, Special Publication Number 27, Madison, USA

ESTLER, M.; KNITTEL, H.; ZELTNER, E. (1984): Bodenbearbeitung aktuell. DLG-Verlag, Frankfurt a.M., FRG

FABRY, R. (1989): Personal information

FABRY, R. 1990): Mechanisierung der kleinbuerlichen Weizenproduktion. Einsatzmglichkeit und Grenzen der Zugtieranspannung in Paran/Brasilien. Diplomarbeit, Inst. fr Betriebs-und Standortkonomie, TU Berlin, Berlin (West)

FALL, A. (1985): Situation actuelle sur l'environnement et l'utilisation du parc de matriels de culture attele en Basse Casamance. ISRA, Dakar, Senegal

FALL, A.; NDIAME, F. (1988a): La mcanisation de la riziculture en Basse-Casamance. Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

FALL, A.; NDIAME, F. (1988b): Roles actuels et potentiels des forgerons traditionnels dans la maintenance du matriel agricole en Basse-Casamance. Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

FAO (1977): Farming with animal power. Economic and Social Development Series No. 3/14, Rome, Italy

FAO (1988): Production Yearbook 1987. Vol. 41, Rome, Italy

**FASOLO, P.J.; HOCHMLLER, D.P.; CARVALHO, A.P.; CARDOSO, A.; RAUEN, M.; POTTER,
R.O. (1986): Guia para identificaao dos principais solos do Estado do Paran. Documentos 10, EMBRAPA-SNLCS, Rio de Janeiro, Brazil**

FAURE, G.; DJANGI, K. (1988a): Study of Village Land and Monitoring of Farms in Togo. In: CIRAD, 1988: Economie Rurale en Zone de Savane. Actes du 7. sminaire d'conomie et sociologies rurales, 15-19 Sep. 1986, Montpellier, France

FAURE, G.; DJANGI, K. (1988b): L'Expansion de la Culture Attele dans la Rgion des Savanes au Togo. Facteur de Progrs Social sans Progrs Economique. Economie de la Mcanisation en Rgion Chaude. CIRAD/MESRU, 12-16 Sep. 1988, Montpellier, France

FAURE, P. (1976/77): Occupation du Sol, d'aprs photos ariennes. In: CIRAD, 1988: Economie Rurale en Zone de Savane. Actes du 7. sminaire d'conomie et sociologies rurales, 15-19 Sep. 1986, Montpellier, France

FAYE, A.; NIANG, L.; SARR, D.Y.; THIAM, A. (1986). Etude monographique de la communaut rurale de Kaymor. Doc. de Travail 86-4, ISRA, Dakar, Senegal

FIGUEIREDO, P.R.A. (1988): Personal information

FIGUEIREDO, P.R.A.; ARAUJO, A.G.; CASA ~O JUNIOR, R.; YAMAOKA, R.S.; SIQUEIRA, R. (1986): Estudo e caracteri zaao de implementos de preparo primrio traao animal em solo Litlico Eutrfico, com baixa aptidao agrcola. XV Congresso Brasileiro de Engenharia Agrcola 8-12/7/1986, Sao Paulo, Brazil

FRANZ, G. (1969): Die Geschichte der Landtechnik im 20. Jahrhundert. DLG-Verlag, Frankfurt a.M., FRG

FREIRE, C. (1988): Personal information

FRYREAR, D.W. (1984): Soil cover and wind erosion. TRANSACTIONS of the ASAE 27 (2): 445-448

FUENTES, R.L. (1984): Caracterizaao da estrutura de produao agropecuria do Estado do Paran. Dissertaao de mestrado, ESALQ/USP, Piracicaba, Brazil

FUENTES, R.L. (1988): Personal information

GILL, W.R.; VANDEN BERG, G.E. (1968): Soil Dynamics in Tillage and Traction. Agriculture Handbook No.316; US Dept. of Agric., Washington D.C., USA

GOE, M.R. (1987): Animal traction on smallholder farms in the Ethiopian Highlands. Dissertation Abstracts International, Vol. 48, No 2

GROSSMANN, M. (1986): Lesothos Agrarmechanisierung am Scheideweg? Probleme und Perspektiven der Ochsenanspan nung in Lesotho. Diplomarbeit, Universitt Hohenheim, Stuttgart, FRG

GRUBBE, P. (1987): Dritte Welt, was ist das? Peter Hammer Verlag, Wuppertal, FRG

GRYSEELS, G.; ABIYE ASTATKE; ANDERSON, F.M.; GETACHEW ASSEMENEW (1984): The Use of single Oxen for Crop Cultivation in Ethiopia. In: ILCA Bulletin

No.18, April 1984

GUTSCHE, K. (1989): Personal information

HADLICH, E. (1988): Personal information

HAEFS, H. (ed.) (1988): Der Fischer Weltalmanach 1989. Fischer Taschenbuch Verlag, Frankfurt a.M., FRG

HARRIS, M. (1988): Wohlgeschmack und Widerwillen -Die Rtsel der Nahrungstabus. Klett-Cotta, Stuttgart, FRG

HARTMANS; E.H.; KUILE, C.H.H.t. (1983): IITA's views on current and future trends in tillage in the humid and subhumid tropics. Fifth Session of the FAO Panel of Experts on Agricultural Mechanization, 20-22.4.83, Rome, Italy.

HAVARD, M. (1985): Principales caractristiques et contraintes de gestion du parc matriels de culture attele au Sngal. Machinisme Agricole Tropical, N° 91, S. 19-24, CEEMAT, Antony, France
HAVARD, M. (1987a): Le parc de matriels de culture attele et les possibilits de sa maintenance dans le dpartement de Fatick. Doc. de Travail 87-6, ISRA, Dakar, Senegal

HAVARD, M. (1987b): Le parc de matriels de culture attele et les possibilits de sa maintenance dans le dpartement de Nioro. Doc. de Travail 87-3, ISRA, Dakar, Senegal

HAVARD, M. (1988a): Les conclusions des exprimentations (1950 -1985) sur le

semis en culture attele des principales espces cultives. In: Machinisme Agricole Tropical, No.101, CEEMAT, Antony, France

HAVARD, M. (1988b): L'application au bassin arachidier d'une mthode simple de suivi et d'valuation de la culture attele. ISRA, Dakar, Senegal

HERLEMANN, H. (1961): Grundlagen der Agrarpolitik. Verlag Franz Vahlen GmbH, Berlin (West) und Frankfurt a.M., FRG

HOPFEN, H.J. (1969): Farm implements for Arid and Tropical Regions. FAO, Rome, Italy

HURTIENNE, T.; RAMALHO, L. (1989): Die Wirtschaftsentwicklung. In: HART, K.; RAMALHO, L. (eds.): Brasilien. VSA-Verlag, Hamburg, FRG

IAPAR (1978): Cartas climticas bsicas do Estado do Paran. Londrina, Brazil

IAPAR (1988): Adaptaao e desenvolvimento do arado de aiveca a traao animal. Circular No 54, Londrina, Brazil

IBGE (1975): Censo Agropecuario Brasil, VII Recenseamento Geral 1970, Nacional. Vol. III, Rio de Janeiro,Brazil

IBGE (1984): Censo Agropecuario Brasil, IX Recenseamento Geral do Brasil 1980. Rio de Janeiro, Brazil

IBGE (1986): Sinopse preliminar do censo agropecurio -Paran. Censos econmicos -1985. Brazil (unpublished)

IPARDES (1985): A sobrevivncia da pequena produao e a oferta de alimentos no Paran -uma anlise integrada. Vol.1, Curitiba, Brazil

ISRA; CIRAD; FAC (1986): Recherche et Developpement Agricole. Les Units Exprimentales du Sngal.Montpellier, France

JACOBEIT, W. (1969): Tierische Anspannung. In: FRANZ, G. (1969): Die Geschichte der Landtechnik im 20.Jahrhundert. DLG -Verlag, Frankfurt a.M., FRG

JAEGER, R. (1988): Le Dveloppment Rcent de la Traction Bovine au Burundi. Economie de la Mcanisation en Rgion Chaude. CIRAD/MESRU, 12-16 Sep. 1988, Montpellier, France

KIRK, M. (1987): Technologiewahl in der Landwirtschaft Kameruns. Probleme der Ausbreitung von Ochsenanspannung in kleinbuerlichen Betriebssystemen. Alano Verlag, Aachen, FRG

KLAIJ, M.C.; SERAFINI, P.G. (1988): The potential impact of the use of animal traction on millet-based cropping systems in the sahel. Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

KLAPP, E. (1967): Lehrbuch des Acker-und Pflanzenbaues. Verlag Paul Parey, Berlin (West), Hamburg, FRG

KLINGENSTEINER, P. (1987): Personal information

KPPEN, W. (1931): Grundri der Klimakunde. Berlin, Deutschland

KRAUSE, R.; KNICHEL, W. (1986): Entwicklung, Bau und Verbreitung eines Universal-Ackergertes (UAG) -

MULTITRAC (berregional). Marktstudie Brasilien. GTZ, Eschborn, FRG (unpublished)

KRAUSE, R.; LORENZ, F. (1984): Bodenbearbeitung in den Tropen und Subtropen. GTZ, Eschborn, FRG

KRAUSE, R.; LORENZ, F.; HOOGMOED, W.B. (1984): Soil Tillage in the Tropics and Subtropics. GTZ, Eschborn, FRG

KURBJUWEIT, D. (1989): "Ihr bildet Kapitalisten heran". Die Zeit, Nr.22-26.5.1989, FRG

KHNE, G. (1930): Handbuch der Landmaschinentechnik. Springer-Verlag, Berlin, Deutschland

LAL, R. (1975): Role of Mulching techniques in Tropical Soil and Water Management. Technical Bull., IITA, Ibadan, Nigeria

LANDSBERG, H.E.; LIPPMANN, H.; PAFFEN, K.H.; TROLL, C. (1966): Weltkarten zur Klimakunde. Dritte Auflage, Springer Verlag, Berlin (West), Heidelberg, FRG, New York, USA

LARACH, J.O.; CARDOSO, A.; CARVALHO, A.P.; HOCHMLLER, D.P.; FASOLO, P.J.; RAUEN, M.J. (1984): Levantamento de Reconhecimentos dos Solos do Estado do Paran. EMBRAPA-SNLCS, SUDESUL, IAPAR, Curitiba, Brazil

LAUER, W. (1985): Das Klima der Tropen und Subtropen. In: REHM, S. (ed.) (1986): Grundlagen des Pflanzenbaues in den Tropen und Subtropen. Verlag Eugen Ulmer, Stuttgart, FRG

LAURENTI, A.C. (1985): Estrutura agrria do municpio de Rio Azul, diagnstico preliminar voltado ao direcionamento das aoes de pesquisa agrcola no PRORURAL. IAPAR, Boletim Tcnico, 77p., Londrina, Brazil

LAWSON, L. T. (1988): Les Contraintes de la Culture Attelee Observee par la Societe Togolaise de Coton (SOTOCO). Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

LE THIEC, G.; BORDET, D. (1988): Etude de deux outils de traction animale visant rduire les contraintes de travail du sol en zones seches. Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 - 12 July, 1988, Saly, Senegal

LHOSTE, P. (1986): L'utilisation de l'nergie animale en Afrique intertropical. Atelier: Mthodes de la rcherche sur les systmes d'levage en Afrique intertropical. 2-9 Fev. 1986, Mbour, Senegal, IEMVT-CIRAD, Etudes et Synthses, No. 20, Maison-Alfort, France

LHOSTE, P. (1987): L'association agriculture -levage. IEMVT-CIRAD, Etudes et Synthses, No 21, Maison-Alfort, France

LHOSTE, P. (1988): Les projets de developpement de la traction animale: Les contraintes lies l'animal et les voies d'intervention prioritaires. Economie de la Mcanisation en Rgion Chaude. CIRAD/MESRU, 12-16 Sep.1988, Montpellier, France

LINDSAY, F.J. (1986): An introduction to working animals. MPW Australia, Melbourne, Australia LO, M. (1988): Personal information

MAC ARTHUR, J. D. (1980): Some characteristics of farming in a tropical environment. In: Ruthenberg, H. (1980): Farming Systems in the Tropics. 3. Auflage, Clerendon Press, Oxford, UK

MACK, R.P. (1985): Untersuchungen zur Bestimmung der Arbeitseignung von Zugochsen der Lokalrasse und F1-Kreuzungstieren am tropischen Standort Bangladesh. TU Berlin, Inst. f. Tierproduktion, Dissertationsarbeit, Berlin (West)

MACK, R.P.; WENIGER, J.H.; et al. (1987): Untersuchungen ber die Arbeitseignung von Zugochsen der lokalen Rasse und F1-Kreuzungstieren in Bangladesh. Sonderdruck: Zeitschrift fr Tierzchtung und Zchtungsbiologie Bd. 104 (1-2): 96112, Verlag Paul Parey, Hamburg, FRG

MANTOVANI, E.C. (1986): Implementos agrcolas desenvolvidos pelo Centro Nacional de Pesquisa de Milho e Sorgo. In: Traao animal nas regioes Sudeste e Centro-Oeste. EMBRATER, Brasilia, Brazil

MARQUES, J.Q.A.; BERTONI, J. (1961): Sistemas de preparo do solo em relaao produao e erosao.Bragantia 20: 1144-1181

MARZOUK-SCHMITZ, Y. (1984): Instruments aratoires, systmes de cultures et diffrenciation intra-ethnique. In:Les instruments aratoires en Afrique tropicale. Orstom, Paris, France

MATTHIES, H.J. (ed.) (1987): Die Entwicklung des landwirtschaftlichen

Maschinenwesens in Deutschland. Reprint der Ausgabe von 1910. VDI-Verlag, Dsseldorf, FRG

MEIER, H. (1987): Personal information

METZGER, M. (1988): Personal information

MIDHOE, K.; HECHT, H. (1982): Technologietransfer im Bereich Agrartechnik. Teilprojekt Anpassung von Agrartechnologien. Arbeitszeitstudien und Mechanisierungsmodelle in kleinbuerlichen Betrieben in To go/Westafrika. Inst. f. Landtechnik, Justus-Liebig-Universitt, Gieen; GTZ, Eschborn, FRG

MINISTERE DE LA COOPERATION (1975): Manuel de culture avec traction animale. France

MINISTERE DE LA COOPERATION (1984): Memento de l'agronome. Troisime dition, France

MONEGAT, C. (1985): O plantio direto no Estado de Santa Catarina. Anais do 3. encontro nacional de plantio direto. Ponta Grossa, Brazil

MONEGAT, C. (1988): Personal information

MORRISON, B. (1951): Feeds and feeding. A handbook for the students and stockman. 21. edition, Morrison Publishing Company, New York, USA

MUNGROOP, R. (1988): Personal information

MUNZINGER, P. (ed.) (1981): Handbuch der Zugtiernutzung in Afrika. GTZ, Eschborn, FRG

MLLER-SMANN, K.M. (1986): Bodenfruchtbarkeit und standortgerechte Landwirtschaft. Manahmen und Methoden im Tropischen Pflanzenbau. GTZ, Eschborn, FRG

NELLES, K. (1988): Mglichkeiten und Probleme der Zugtiernutzung in der Zentralregion Malawis. Bericht anllich einer Hospitation im Projekt "Frderung der Viehzucht in Malawi". GTZ, Eschborn, FRG (unpublished)

NELLES, K. (1989): Mglichkeiten und Probleme der Zugtiernutzung in der Zentralregion Malawis. Diplomarbeit, Institut fr Tierproduktion, TU Berlin, Berlin (West) (unpublished)

NEUNHUSER, P. (1984): Personal information

NICOU, R. (1972): Synthse des tudes de physique du sol realis par l'IRAT en Afrique Tropicale Sche. Seminar on Tropical Soil Research. 19pp, IITA, Ibadan, Nigeria

NOHLEN, D. (1989): Lexikon Dritte Welt. Rowohl Taschenbuchverlag, Reinbek bei Hamburg, FRG
NOHLEN, D.; NUSCHELER, F. (1982): Handbuch der Dritten Welt. Bd. 4 Westafrika und Zentralafrika, Verlag Hoffmann und Campe, Hamburg, FRG

NORRIS, E.G. (1987): Sisyphean Labours -Ahistoricity and the failure of development aid -A case history from Togo. Vortrag im Inst. f. Ethnologie, FU

Berlin 1987, Vortragsmanuskript, Mnster, FRG (unpublished)

NSING, J. (1989): Personal information

ORSTOM (1984): Les Instruments Aratoire en Afrique Tropicale. Vol.10, No.3-4, dition de l'ORSTOM, Paris, France

PERSOONS, C. (1988): Problmatique d'une tude sur la motorisation intermdiaire au Mali et premires observations. Economie de la Mcanisation en Rgion Chaude. CIRAD/MESRU, 12-16 Sep. 1988, Montpellier, France

PES (1988): L'Emploi de la Culture Attele dans la Rgion Centrale. Atakpame, Togo

PHILLIPS, R.E., PHILLIPS, S.H. (1984): No-tillage agriculture, principles and practices. 306pp., Van Nostrand Reinhold Company, New York, USA

PINGALI, P.; BIGOT, Y.; BINSWANGER, H.P. (1987): Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa. A World Bank Publication, The John Hopkins University Press, Baltimore, USA

POCTHIER, G. (1988): Personal information

PREUSCHEN, G. (1951): Die Technik im landwirtschaftlichen Betrieb. Ulmer Verlag, Stuttgart, FRG

PROPTA (1985): Situation actuelle de la Traction Animale au Togo. Atakpame, Togo

PROPTA (1987): Force Animal No.1 Juli 1987; Bulletin Technique; Fiche Technique No.1, 2, 3, 9, 11, 12, 13, 14. Atakpame, Togo

RAMASWAMY, N.S. (1981): Report on Draught Animal Power as a Source of Renewable Energy. FAO, Rome, Italy (unpublished)

RAMASWAMY, N.S. (1986): Draught animal power in the Third World. In: LINDSAY, F.J. (1986): An introduction to working animals. MPW Australia, Melbourne, Australia

RAMOS, M.C.F. (1987): Personal information

REH, I. (1981): Tierhaltung und Veterinrwesen. In: MUNZINGER, P. (ed.) (1981): Handbuch der Zugtiernutzung in Afrika. GTZ, Eschborn, FRG

REH, I. (1982): Zur Bedeutung der Rindfleischerzeugung als Nebenprodukt der Zugrinderhaltung in kleinbuer lichen Betrieben Westafrikas, dargestellt am Beispiel der Region Sine-Saloum in Senegal. TU Berlin, Inst. f. Tierproduktion, Dissertationsarbeit, Berlin (West)

REIS, O.G.; BARON, V. (1986): A mecanizaa ~o agrcola traa ~o animal no Brasil. In: EMBRATER (1986b): Catlogo de fabricantes. Mquinas e implementos agrcolas. Braslia, Brazil

ROCKENBACH, O.C. (1987): Personal information
ROCKWOOD, W.G.; LAL, R. (1974): Mulch tillage: a technique for soil and water conservation in the tropics. Span 17 (2): 77-79
ROTH, C.H. (1986-1989): Personal information

RUTHENBERG, H. (1980): Farming Systems in the Tropics. 3. Auflage, Clarendon Press, Oxford, UK

RUTHENBERG, H.; ANDREAE, B. (1982): Landwirtschaftliche Betriebssysteme in den Tropen und Subtropen. In: von Blankenburg, P. (ed.) (1982): Handbuch der Landwirtschaft und Ernhrung in Entwicklungslnder. Band 1, 2. Auflage, pp125-173, Stuttgart, FRG

SANCHEZ, P.A. (1976): Properties and Management of Soils in the Tropics. Wiley, New York, USA

SCHMITZ, H.: Mulchsaat in Klein-und Mittelbetrieben. Anstze in Sdbrasilien. Entwicklung und lndlicher Raum, 22 (5), 14-17, 1988

SCHOLZ, U. (1984): Ist die Agrarproduktion der Tropen kologisch benachteiligt? Geographische Rundschau 36, No. 7: 361-366

SCHULTZ-KLINKEN, K.-R. (1981): Haken, Pflug und Ackerbau. August Lax Verlagsbuchhandlung, Hildesheim, FRG

SCHWARTZ, H.J. (1987a): Personal information

SCHWARTZ, H.J. (1987b): Nutzungsformen spezieller Tierarten -Kameliden. TU Berlin, Inst. f Tierproduktion, Verlesungsskript, Berlin (West)

SEGLER, G. (1956): Maschinen in der Landwirtschaft. Parey Verlag, Hamburg, FRG und Berlin (West)

SENE, M. (1988): Le travail la dent en traction bovine pour une meilleure infiltration des eaux des premires pluies sur sols grvillonnaires en bordure de plateaux: C.R. de Kaymor. Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

SHAW, L.N.; KROMER, K.H. (1987): Revolving spade planter soil opener. ASAE, 1987 Summer Meeting, Baltimore,USA

SIQUEIRA, R.; YAMAOKA, R.; CASAO JUNIOR, R.; ARAUJO, A.G.; FIGUEIREDO, P.R.A. (1986): Projeto de desenvolvimento de equipamentos traao animal para o Estado do Paran. XV Congresso Brasileiro de Engenharia Agrcola 8-12/7/1986, Sao Paulo, Brazil

SORRENSON, W.J.; Montoya, L.J. (1984): Economic implications of soil erosion and soil conservation practices in Paran, Brasil. Convnio IAPAR/GTZ. IAPAR, Londrina, Brazil

SOTOCO (1987): La Culture Attele dans les Savanes, Situation, Structure des Exploitations, Fonctionnement.

SOTOCO, Atakpame, Togo

STARKEY, P. (1981): Farming with Work Oxen in Sierra Leone. Ministry of Agriculture and Forestry, Tower Hill, Freetown, Sierra Leone

STARKEY, P. (1986a): The introduction, intensification and diversification of the use of animal power in West African farming systems. Implications at farm level. In: STARKEY, P, NDIAME, F. (1988) Animal Power in Farming Systems. GATE/GTZ,

Eschborn, FRG

STARKEY, P. (1986b): Draught animal power in Africa. Priorities for development, research and liaison. Farming Systems Support Project (FSSP), Networking Paper No. 14, Washington, USA

STARKEY, P. (1988a): Animal-Drawn Wheeled Toolcarriers: Perfected yet rejected. GATE/GTZ, Eschborn, FRG

STARKEY, P. (1988b): Animal Traction Directory: Africa. GATE/GTZ, Eschborn, FRG

STARKEY, P. (1989): Harnessing and Implements for Animal Traction. GATE/GTZ, Eschborn, FRG (im Druck)

STARKEY, P.; APETOFIA, K. (1986): Integrated livestock systems in Nepal and Indonesia. Implications for animal traction programs in West Africa. Farming Systems Support Project (FSSP), Network Report No. 3, Washington,USA

STARKEY, P.; NDIAME, F. (eds.) (1988): Animal Power in Farming Systems. GATE/GTZ, Vieweg Verlag, Braunschweig/Wiesbaden

STATISTISCHES BUNDESAMT (1985): Lnderbericht Senegal 1985. Verlag W. Kohlhammer, Stuttgart und Mainz, FRG

STATISTISCHES BUNDESAMT (1987): Lnderbericht Senegal 1987. Verlag W. Kohlhammer, Stuttgart und Mainz, FRG

STATISTISCHES BUNDESAMT (1988): Lnderbericht Brasilien. Verlag W. Kohlhammer, Stuttgart, Mainz, FRG

STATISTISCHES BUNDESAMT (1981): Lnderbericht Togo. Verlag W. Kohlhammer, Stuttgart, Mainz, FRG

STED (1988): Usure du Matriel de Culture Attele. Togo

STEINER, K.G. (1984): Intercropping in Tropical Smallholder Agriculture with Special Reference to West Africa. GTZ, Eschborn, FRG

STRUBENHOFF, H.-W. (1988): Probleme des bergangs von der Handhacke zum Pflug. Eine konomische Analyse der Einfhrung der tierischen Anspannung in Ackerbausysteme Togos. Wissenschaftsverlag Vauk, Kiel, FRG

TCHOUGOUNE, M. (1988): Les Contraintes dans l'Utilisation de la Traction Animal. Third Regional Workshop Animal Traction for Agricultural Development in West Africa, 7 -12 July, 1988, Saly, Senegal

TROUSE, A.C. (1979): Soil physical characteristics and root growth. In: LAL, R.; GREENLAND, D.J. (eds.): Soil Physical Properties and Crop Production in the Tropics. Wiley, pp319-325, Chichester
UPROMA (1986): Catalogue et Tarif. Kara, Togo

VALENTIN, P.; SPITTLER, G. (1976): Mglichkeiten der Ochsenanspannung unter den Gesichtspunkten einer integrierten Viehhaltung in Westafrika. AFC Agriculture and Food, Duisburg, FRG

VICENTE-CHANDLER, J. et al. (1966): High crop yields produced wih or without tillage on three typical soils of the humid mountains of Puerto Rico. J.Agr.Univ.Puerto Rico 50: 146-150

VIEBIG, U. (1981): Grundlagen der Anspannungs-und Gertetechnik. In: MUNZINGER, P.: Handbuch der Zugtiernut zung in Afrika. GTZ, Eschborn, FRG

VIEBIG, U. (1982): Grundlagen der Anspannungs-und Gertetechnik. (English Text) In: MUNZINGER, P.: Animal Traction in Africa. GTZ, Eschborn, FRG

VIEBIG, U. (1988): Personal information

VIEIRA, C. (1985): O feijao em cultivos consorciados. Universidade Federal de Viosa, Viosa, Brazil

VIEIRA, M.J. (1987): Solos de baixa aptidao agrcola. Opoes de uso e tcnicas de manejo e conservaao.

IAPAR, Circular No.51, Londrina, Brazil

WALTER, H. (1979): Vegetation und Klimazonen. Stuttgart, FRG

WALTER, S. (1990): Nicht-chemische Unkrautregulierung. Stiftung kologischer Landbau (SL), Bad Drkheim, FRG

WEISCHET, W. (1984): Agrarwirtschaft in den feuchten Tropen. Geografische Rundschau 36, No. 7, pp. 344-351

WENIGER, J.H.; SCHNEICHEL, M. (1986): Rinder-und Bffelhaltung auf dem indischen Subkontinent. TU Berlin, Inst. f. Tierproduktion, Vorlesungsskript, Berlin (West)

WERTH, M. (1987): Prokektfortschrittskontrolle 1987 zum Projekt "Entwicklung der Zentralregion Togo". Institut fr Entwicklungsforschung, Wirtschafts-und Sozialplanung, Saarbrcken und Bonn, FRG

WESTNEAT, A.S.; KLUTSE, A., AMEGBETO, K.N. (1988): Features of Animal Traction Adoption in Togo. In: Starkey, P. und Ndiame, F. (eds.): Animal Power in Farming Systems. GATE/GTZ, Vieweg Verlag, Braunschweig/Wiesbaden, FRG

WIENEKE, F., FRIEDRICH, T. (1983): Agrartechnik in den Tropen. DLG-Verlag, Frankfurt a.M., FRG

WIJEWARDENE, R.; WAIDYANATHA, P. (1984): Conservation Farming. For small farmers in the humid tropics. Dept. of Agric., Peradenia, Sri Lanka

YU, C.M. (1988): Sistema Faxinal. Uma forma de organizaao camponesa em desagregaao no Centro-Sul do Paran. IAPAR, Bol. Tc. No.22, Londrina, Brazil

YU, C.M.; SEREIA, V.J. (1989): Tipificaao e caracterizaao dos produtores do Estado do Paran. Londrina, Brazil (unpublished)

ZWEIER, K. (1986): Women can handle draught oxen, too. In: Draught animal power. GATE/GTZ, Eschborn, FRG