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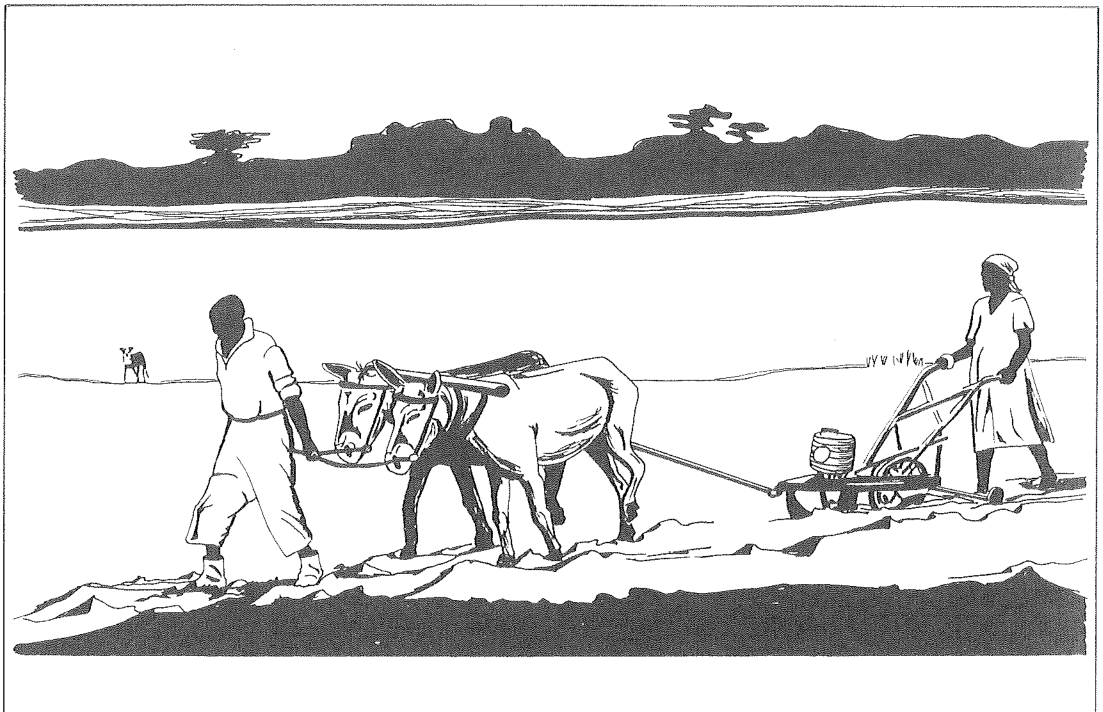
Animal Traction in Rainfed Agriculture in Africa and South America

Aus der Arbeit von gtz



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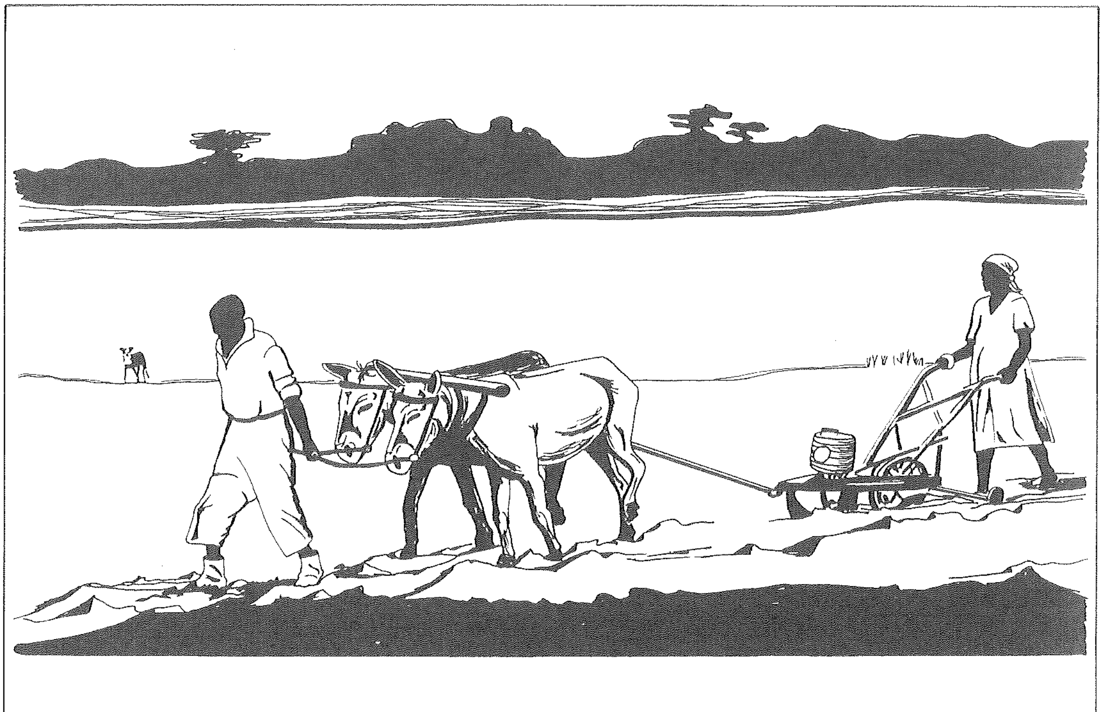

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Deutsches Zentrum für Entwicklungstechnologien – GATE
in: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
P. O. Box 5180
D-6236 Eschborn
Federal Republic of Germany
Telephon: (06196) 79-0 Telex: 41523-0 gtz d Fax: (06196) 794820

Heribert Schmitz, Mathias Sommer, Sabine Walter

Animal Traction in Rainfed Agriculture in Africa and South America

Determinants and Experiences

A Publication of
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The authors
Heribert Schmitz (M.Sc. in Mechanical Engineering) worked as a consultant in the field of urban and traffic planning for four years. He conducted research work in sustainable agriculture and mechanization; at present coordinator of the German Volunteer Service in Brazil.

Mathias Sommer studied Agriculture in Bad Kreuznach and International Agricultural Development at the Technical University of Berlin. He has worked for several years as a Technical Adviser in the field of animal production in Cameroon and Togo.

Sabine Walter studied Agriculture in Göttingen and International Agricultural Development at the Technical University of Berlin.

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Contents

Abbreviations

ACARESC: Associação de Crédito e Assistência Rural de Santa Catarina, Florianópolis, Brazil

ACARPA: Associação de Crédito e Assistência Rural do Paraná, Curitiba; now called: EMATER-PR

APAC: Associação de Produtores Autónomos da Cidade e do Campo; São João de Meriti, Brazil

ASSESOAR: Associação de Estudos, Orientação e Assistência Rural, Francisco Beltrão, Brazil

AT: Animal traction

CEC: Cation exchange capacity

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

CFA: Comunauté Financière Africaine

CIRAD: Département du Centre de Coopération Internationale en Recherche Agronomique pour le Développement, Montpellier, France

CPATSA: Centro de Pesquisa Agropecuária do Trópico Semi-Arido, Petrolina, Brazil

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

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

EMATER – PR: Empresa de Assistência Técnica e Extensão Rural, Curitiba, Brazil

EMBRAPA: Empresa Brasileira de Pesquisa Agropecuária, Brasília, Brazil

EMBRATER: Empresa Brasileira de Assistência Técnica e Extensão Rural, Brasília, Brazil

FAC: Font d'Aide et de Coopération, 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 Agronômico de Campinas, Campinas, Brazil

IAPAR: Fundação Instituto Agronômico do Paraná, Londrina, Brazil

IBGE: Fundação Instituto Brasileiro de Geografia e Estatística, 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 Sénégalais de Recherche Agonomique, Dakar, Senegal

LLCD: Least Developed Countries

MOT: Motorized mechanization

mt: metric ton

ORSTOM: Institut Français de Recherche Scientifique pour le Développement en Coopération, 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: Société Industrielle Sahélienne de Mécaniques, de Matériels Agricoles et de Représentations, Dakar, Senegal

SNLCS: Serviço Nacional de Levantamento e Conservação de Solos, Rio de Janeiro, Brazil

SODEFITEX: Société de Développement des Fibres Textiles, Senegal

SOTOCO: Societé Togolaise de Coton, Togo

STED: Societé Togolaise d'Etude et de Développement, Togo

TIRDEP: Tanga Integrated Rural Development Programme, Tanga, Tanzania

TU Berlin: Technical University of Berlin (West)

UK: United Kingdom

UPROMA: Unité de Production de Matériel 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.

A. Preface

This work, a study jointly funded by GATE/GTZ and IPAT/TU Berlin, is a first attempt to portray the mechanization of farm systems in the countries of the Third World. The investigation is confined to the level of animal traction examining the question of why specific implements are utilized at certain locations.

Our approach was to try to comprehend the conditions of draft-animal use, the selection of animals and the utilization of the implements with regard to the variables of agricultural mechanization, including agroclimatic regions, soil types and farm systems, and subsequently to compile generalized experience with the implements. Our intention was not so directed to represent recent initiatives and prototypes on the level of research or experimental stations, but rather to expose information reflecting the actual animal-traction practices on the farms.

The target group has been selected from the ranks of development workers involved with agricultural techniques and artisanal skills or specialists in the field of crop production, who roll up their sleeves to put the innovativeness of the farmers to the test. Therefore, we have provided a general introduction to the specific, very heterogeneous conditions under which agricultural mechanization occurs, as well as the technical difficulties encountered with the use of farm implements.

In the analysis we were directed by the point of view that there is a rationale behind the actions of the farmers – male or female. These reasons are difficult for outsiders to understand and can only be discovered with a good perception of the entire system. Often one finds oneself revealing the illogical behaviour of the farmers in order to show them the way. A working approach, to first observe, appeared to be the safer path. We are very aware that with this approach placing the farmers at the focus can be deceptive.

My own motivation to collect the experiences from the work at IPAT and my lectures and seminars on appropriate technology (where the authors became acquainted) has found a positive echo with GATE/GTZ to the initiative taken by Klaus Lengefeld suggesting the publication of this subject matter.

We particularly thank the DED and their volunteers and returnees, especially Tassilo von der Decken, coordinator for oxen traction in Togo, IAPAR, Gonçalo S. de Farias and the researchers in the area of mechanization, Ruy Casão Junior and Augusto G. de Araújo, as well as the Brazilian extension service organizations ACARPA/EMATER-PR and ACARESC, especially Claudino Monegat. Energetic support was received from CEEMAT, especially Dominique Bordet, the center for small-farmer research

CPPP/EMPASC, ASSESOAR, ISRA, especially the researchers in Djibelor (Casamance, Senegal). Without the kind hospitality, the information and stimulation of numerous farmers and the institutions and persons mentioned, the study would not have been possible.

We heartily thank Donald Baerg (translation), Kirsten Pfeiffer (graphics), Bernd Hönicke (photographic work), Kurt Nelles (formatting) and Dr. Christian Roth (advisory support) for their participation.

Berlin, 1990 Heribert Schmitz

B. Introduction

1. Preliminary remarks

Smallholder agriculture in the countries of the Third World is generally characterized by poor yields and a low level of mechanization.

In contrast the agrarian sector of industrialized countries has undergone immense changes in recent decades. Yields in the area of crop production have been increased enormously by means of modern breeding methods as well as the application of artificial fertilizers and pesticides. An increasing mechanization of agriculture has led to an increase of labour productivity and a reduction of the typical seasonal labour peaks.

Attempts to transfer capital-intensive Western motor mechanization to the countries of the Third World have as a rule failed, since the transition from the hand hoe to the tractorized plow is only possible in very few regions under special conditions.

In the search for new strategies many people have begun to reflect on elementary technologies; the term appropriate technology has become a buzzword. In this context animal traction has received considerable attention in many countries of the Third World. Numerous institutions are involved with the promotion of animal traction in these regions. It is dependent upon many factors, whether an endeavour to introduce draft animals is successful and draft-animal mechanization is accepted in farming practice above and beyond the experimental stations and projects. Frequently, projects that have failed in this area indicate an insufficient consideration of these limiting factors.

For the further development of animal traction it is necessary to precisely recognize the possibilities and limitations of their utilization. Here it is important to learn from previous experience, both in traditional draft-animal regions as well as in development projects and, thus create the pre-conditions for a constructive improvement or effective introduction of draft-animal mechanization. People concerned directly with animal traction or agriculture in regions having animal traction possess such experience. However as a rule this has not been documented or systematically evaluated.

This problem is also pointed out by Dr. E. G. Norris. He deals with the example of Togo in describing the colonial and post-colonial development approaches to increasing agricultural productivity (by way of introducing the harnessing of oxen):

"Unfortunately, I have never met a development aid expert in the colonial archives of the former European powers or, for that matter, in the colonial archives of the now independent states of Africa; it is also wellnigh impossible for independent scholars to obtain access to reports on failed projects, indeed, some organizations refuse to allow their field workers to write critical reports. In this sense, recent records are not merely inaccessible, they do not even exist.....

....I am less interested here in the various reasons why such projects fail but rather in the extra-ordinary perseverance, with one organization, whether French, German, American, whether colonial or post-colonial, after another perseveres and sets in motion the same solution for African agriculture without casting a glance into European or African archives and, what is worse, without asking their peasant clients whether any such efforts have been undertaken in the past." (Norris, 1988, pp 2 and 9)

The information network lacking here necessarily leads to an enormous waste of resources, aside from the insecurity of planning. Thus, a development input strewn with countless mistakes is perpetrated; the "rediscovery of the wheel" occurs on many occasions.

The aim of this work is to compile experience from practice with animal traction and particularly experience with using draft-animal implements. In addition, some primary determining factors for the utilization of draft animals are presented. The treatise anticipates the closing of information gaps with regard to the following themes:

- conditions for applying animal traction,
- extent of draft-animal use,
- structure of farms keeping draft animals,
- degree of mechanization of the individual work operations,
- regional distribution of draft-animal implements,
- experience with animal-drawn implements.

Our considerations are limited to the use of spans in rainfed cropping in the tropics and subtropics. According to Ruthenberg and Andreae (1982) this is defined as cropping based upon natural precipitation and includes no measures for additional irrigation. Draft-animal use for irrigation cropping, in the post-harvest area as well as water raising is only treated superficially. The use of draft animals for transportation is also a subject of the work, but the techniques are not dealt with individually.

Aside from our own experience obtained from stays overseas and an assessment of the literature, experience with animal traction in practice in rainfed cropping has been drawn upon on the basis of a survey. Two questionnaires were set up for this purpose. A general questionnaire (annex I) was directed to persons and projects working with agriculture in regions having draft animals. Another more detailed questionnaire (annex II) was directed only to persons and projects who are directly involved with animal traction. The questionnaires were distributed in the German, English, French and Portuguese languages.

Contact was made with national and international organizations as well as projects and persons working with animal traction for execution of the survey. In addition, returnees from development agencies were personally written to or interviewed. Since experience has shown that little has been reported on the difficulties encountered with animal-drawn implements, it was important to personally contact as many respondents as possible.

It must be explicitly pointed out that the basis for acquiring data has merely an exemplary character regarding some questions, due to the regional distribution of expertise contacted and the extent of the sampling (88 interpretable questionnaires, see annex III). The comparison of various regions however offers the possibility to obtain general information on the determining factors of draft-animal and implement use. The investigation can only be viewed as a beginning, which will have to be supplemented and completed by further endeavours. Animal traction in Asia would also have to be included in more detail.

This study supplements the publications already issued by GATE/GTZ, especially "Animal traction in Africa" by Peter Munzinger, "Harnessing and Implements" and "Animal-Drawn Wheeled Toolcarriers" by Paul Starkey. In order to complete our study as well as to provide a clearer understanding of the material, some of the themes treated inevitably overlap.

The approach employed is to provide observations going beyond a pure assessment of the techniques involved of the developments in mechanization in complex agricultural farm systems. Therefore, Ruthenberg's farming systems sets the stage for this study and the work by Pingali et al. (1987) is expanded upon, on technical aspects and labour potential. Further knowledge is gained on the comparison between Africa and Latin America. The experience from research and extension service institutions in the countries concerned, which increasingly focus their research on production systems, provides support for our work.

The general factors influencing draft-animal use and the utilization of implements (chapter C) as well as the requirements and experience resulting from this area of draft-animal husbandry (chapter D) is treated first. With this background, the following chapter E presents and interprets experiences with the utilization of animal-drawn implements. The case studies on West Africa (chapter F) and Brazil (chapter G) clarify the variations and difficulties that have resulted from the adaptation to differing given conditions. Important key aspects, which promote or limit the utilization of draft-animal mechanization, are elucidated by means of a comparison of various locations.

2. Procedure and methodology

The study is based upon a survey reflecting the experience gained with animal traction in 32 countries in Latin America, Africa and Asia. The questions in a general section of the questionnaire followed a strict pattern; space was also provided for supplementary answers not covered by the questions and the respondents were requested to include further information in an accompanying letter. Primarily open questions were selected for ascertaining the constraints of implements. (see questionnaire annex I and II)

204 questionnaires (in four languages) were distributed and there were 107 responses, of which 88 were evaluated. The response rate of just over 50 % can mainly be attributed to the fact that we approached contacts personally. These "case studies" were supplied by specialists who are in part functioning as coordinators for animal traction in larger regions, and others who are in part working in a confined project, in which animal traction is not the main objective of the work. The

information overlaps for some regions; in other regions the answers represent an entire country. The figures show estimated values for whole regions, which in some cases approximate the size of a country. The average values, especially in the chapter on labour productivity and distribution should be considered to be more of a tendency than as fixed values. However, they were adjusted to the entirety of the data in order not to show up trends, which were only arranged by the non-representative deviation factor of the questionnaire. In addition, publications as well as personal experience were drawn upon as much as possible.

Exclusively experience from Africa and South America (including the Dominican Republic) was assessed in the section on implements. Experience from Asia was also taken into consideration in the chapter on general influencing factors of draft-animal use and draft animals.

The statistics employed in the case studies, e. g. the FAO production yearbook, the agricultural census of IBGE in Brazil, the proportion of rural population or the cropland in terms of the status of draft-animal use, could not be scrutinized in detail by the study team. Thus, it was not evident as of what size of community the inhabitants were considered to belong to the urban population; also, occasionally the "carré" in West Africa were classified as farms. In these cases we had to base the work merely on the available data.

The original intention to compare the prices of the implements proved to be too expansive within the framework of this study. Of greater importance would have been the collection of more data from farm machinery outlets and artisans. A common basis of comparison, however, would have had to be created, e. g. in relation to a kilogram of maize, for the already compiled data (partially in FCFA in Togo and Senegal, in CZ $, with an inflation rate approaching 1000 % in Brazil and in DM for the answers provided by German experts). This proved to go beyond the framework of our study. Similarly, various investigations on the profitability of draft-animal use could not be taken into consideration.

A clear insufficiency consists in the fact that the survey is based upon the knowledge and opinions of researchers and advisors, but not the farmers themselves. Within the context of the study, however, we have queried farmers directly as much as possible. Also, data on implement performance not based on longer observations on the farms can result in distorted findings. In many cases measurements taken on research stations yield poorer results than with farmers who have command of the techniques.

We were also aware that the assessment of some implements was dependent upon the personal experience of the individual advisor. For this reason, but also because, for example, it does not help the development worker in Zambia to become informed about the special defects of Brazilian makes of machines, the study has been confined to generalizable aspects of design and maintenance.

For our objectives it was important to classify the regions according to climate. Although the average precipitation as well as the duration of the dry season was queried, it was found in the evaluation that the classification in terms of climatic zones was sufficient, for which the temperature (thermic

differentiation) and the number of wet months (hygric differentiation) were adequately considered. It was important that the data could easily be worked out by computer. Thus, we decided upon the climate classifications of Troll and Lauer (Landsberg et al., 1966; Lauer, 1986), which in contrast to the system designed by Köppen (1931) is oriented towards the vegetative conditions. The project locations can also be more easily classified than with the system suggested by Walter (1979).

The selection of the case studies was carried out in such a manner that a comparison could be made between South American and African regions, and that various aspects of draft-animal and implement use could be treated on the basis of various development levels of animal traction (introduction in Togo, longer experience in Senegal, tradition in South Brazil) as well as climatic differences. In the end, the selection was determined by the limited project funding available and personal experience.

C. General factors influencing the use of draft animals

1. Underlying decision-making components in farm-household systems

Various explanations have been put forward for the gap between the technically feasible and the acceptance of technologies put into practice on smallholdings (Strubenhoff, 1988).

– Technology as such is a beneficial thing; the lack of a willingness to accept it must be sought out in the behaviour of the farmers.
– The general given institutional framework necessary for the introduction and dissemination of innovations, for example, extension services and credit facilities, are insufficient.
– The recommended technology does not correspond with the aims of the decision maker of the individual farm-household system.

If they are concerned about cost, yield and risk, farmers are – world wide – rationally thinking people, who undertake enterprising activities in calculated steps within their interactive areas. For observers it is often not obvious how efficiently this occurs (Schulz, 1980, according to Strubenhoff, 1988). Thus, a farm in the tropics and subtropics is a very complex system that concerns both the household as well as the individual operational areas. Economically speaking, both must be combined into one. From the point of view of the farmers there can be good reasons for not applying a technology which experts consider to be useful. It is therefore recommendable to assume that a technology previously not employed will not be adaptable to the special given local conditions of the respective farm-household system.

However, developments ensue, arising from climatic fluctuations, technical innovations or unpredictable agricultural policies, against which the rural population can obviously not react at an opportune moment. This is also the case within the transition to permanent rainfed cropping, as a consequence of rapid population growth. At this juncture the creation of a special infrastructure such as extension and credit services from the outside becomes indispensable. These measures should, however, only be offered the farmers as a possibility.

The first task during the initial phase of development or the introduction of a new technology (in this case animal traction) must therefore be to become acquainted with and to understand the aims and underlying decision-making components of the farmers – male or female. Since the cultivation of soil in rainfed systems depends in the first instance on environmental conditions, the natural endowment of the land plays a decisive role.

2. Natural endowment

The development of natural vegetation in a region is pre-determined by the given ecological conditions, the climate, the soil and the topography, which are adapted to the respective environment in an optimal manner.

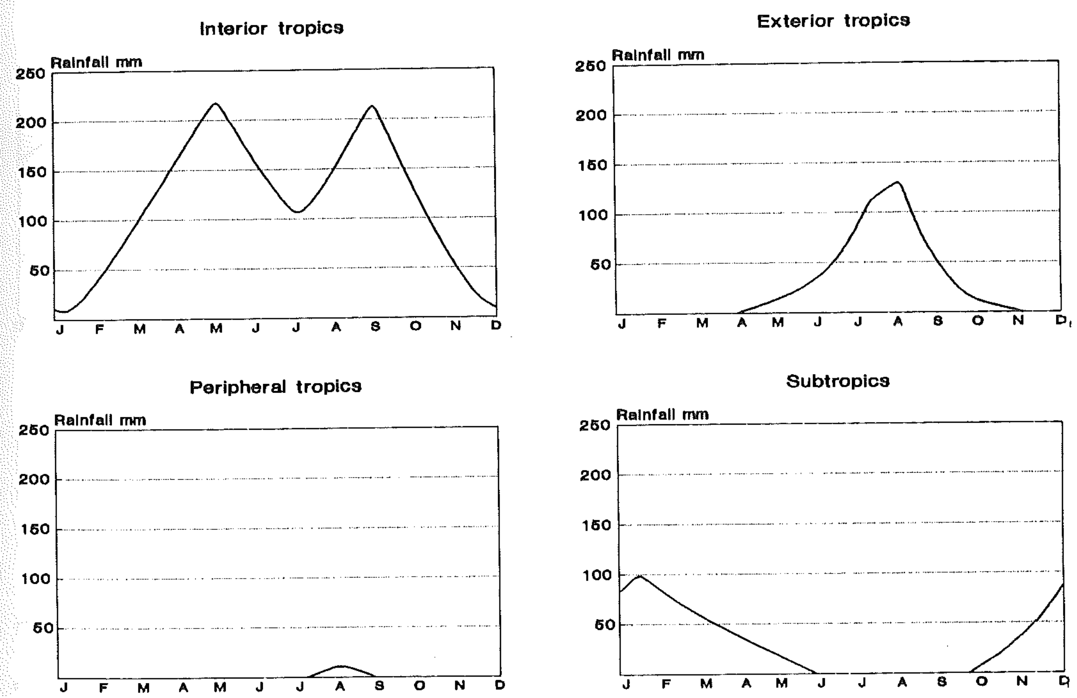
In contrast to agriculture in the western industrial countries, tropical and subtropical agriculture must still today comply with the given environmental conditions, due to a lack of agricultural inputs (fertilizers, pesticides).

Thus, the most sustainable cropping methods are being achieved by means of an adaptation to the natural vegetation. Exceptions to the rule are only found in cropping methods which moderate the effect of the given local conditions (e.g. irrigation farming).

2.1 Climate and vegetation

Generally speaking, the tropical region is defined as the area between the tropics of Can-

Fig. C 1: Model types of temperature fluctuations in the tropics and subtropics. Source: Lauer (1985)



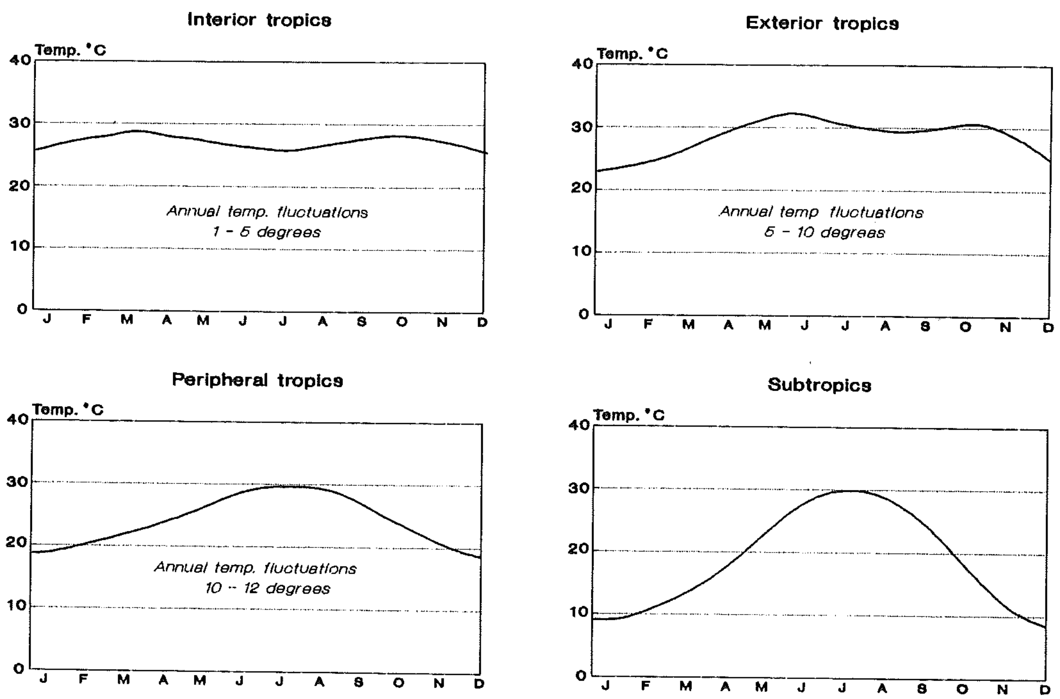
cer and Capricorn. This is subdivided into the permanently humid interior and the seasonal wet and dry exterior tropics. The subtropics border the tropics and extend up to 45° latitude, North and South. (Caesar, 1986; Lauer, 1985)

A high thermic uniformity predominates particularly in the interior tropics; the temperature variations between day and night are more marked than seasonal temperature changes (time-of-day climate: see figure C 1). The temperature decreases with increasing elevation; also in mountainous regions (cold tropics) a time-of-day climate is found. In the wet and dry climates of the tropics both the daytime and nighttime temperature fluctuations and the seasonal temperature changes are greater. The seasons are determined by variations in the distribution of precipitation.

The subtropics are marked by high summer and moderate winter temperatures. The upper high latitudes of the subtropics are often considered to be the upper variants of the temperate climate at the medium latitudes (Lauer, 1985; Müller-Sämann, 1986).

The differences in the rain regime in the various zones of the tropics and subtropics are depicted in figure C 2. The farther one becomes removed from the equator where precipitation occurs throughout the year, the greater is the marked bimodal rainfall distribution. The two peaks in the precipitation curves become equally high with increasing distance from the equator until in the outer tropics a rainy season only occurs in the summer months. The duration and rainfall quantity are increasingly reduced up to the periphery of the tropics. In the subtropics humid and dry regions are distinguished as

Fig. C 2: Model types of precipitation changes in the tropics and subtropics. Source: Lauer (1985)



winter and summer humid seasons, depending upon the duration and time of the rainy season. Overall, the variability of precipitation and thus the uncertainty of rainfall supply both in quantity and with time increases with a reduction of average rainfall amounts.

The temperatures as well as the total amount of rainfall – with a constant year-round moisture availability – decreases with higher elevation levels, in contrast to the temperate zones. (Weischet, 1984)

In practice an actual demarcation between the tropical and subtropical zones is difficult to establish. Frost may be an approximate borderline for the tropics where balanced temperatures manifest themselves (Lauer, 1985). Independent of the geographic location, however, the immediate local conditions must be taken into consideration. These are largely determined by rainfall characteristics and the temperature; further factors playing a role are elevation, air movements and the landscape. The requirements of agriculture and the mobilization of technology may be completely different in closely neighbouring regions.

Various systems exist to design exact climatic classifications. Here, a delineation according to characteristic vegetation units appears useful, as it provides information on the agro-ecological zones. The classification according to Troll (Landsberg et al., 1966) and Lauer (Müller-Sämann, 1986) are employed below. The number of humid months is the criterion for a demarcation of the various forms of vegetation, in which the humid period is defined as the time of a water supply surplus. Then, rainfall is greater than potential evaporation.

Table C 1: Explanations for climatic classification (see figure C 3 and C 4). Source: Landsberg et al. (1966)

Abbrevisation	Designation	Humid months	Characteristic vegetation
SUBTROPICS			
IV1	Dry-summer, humid-winter climates	> 5	Hard-leaved and coniferous wood
IV2	Dry-summer, humid-winter steppe	< 5	Grass and shrub-steppe
IV3	Steppe climates with short summer humidity and dry winters	< 5	Thorn and succulents-steppe
IV4	Dry-winter, long humid-summer climates	6 – 9	Monsoon wood and wooded-steppe
IV5	Semi-desert and desert climates	< 2	Semi-deserts and deserts
IV6	Permanently humid grassland-climates	10 – 12	High-grassland
IV7	Permanently humid, hot-summer climates	10 – 12	Humid forest (laurel, coniferous)
TROPICS			
V1	Rainy climates	12 – 9.5	Evergreen rain forest
V2	Humid-summer climates	9.5 – 7	Humid forest and grass-savannah
V3	Wet and dry climates	7 – 4.5	Dry wood and dry savannah
V4	Dry climates	4.5 – 2	Thorn-succulent wood and savannah
V5	Semi-desert and desert climates	< 2	Semideserts and deserts

- **arid zones**: 0 – 2 humid months
- **semiarid zones**: 2 – 4.5 humid months
- **semihumid/semiarid zones**: 4.5 – 7 humid months
- **subhumid zones**: 7 – 9.5 humid months
- **humid zones**: 9.5 – 12 humid months

Furthermore, **highland areas** above 1000 m altitude are considered separately because of the particular agro-ecological conditions.

Fig. C 3: Climatic classifications of Africa. Source: Landsberg et al. (1966)

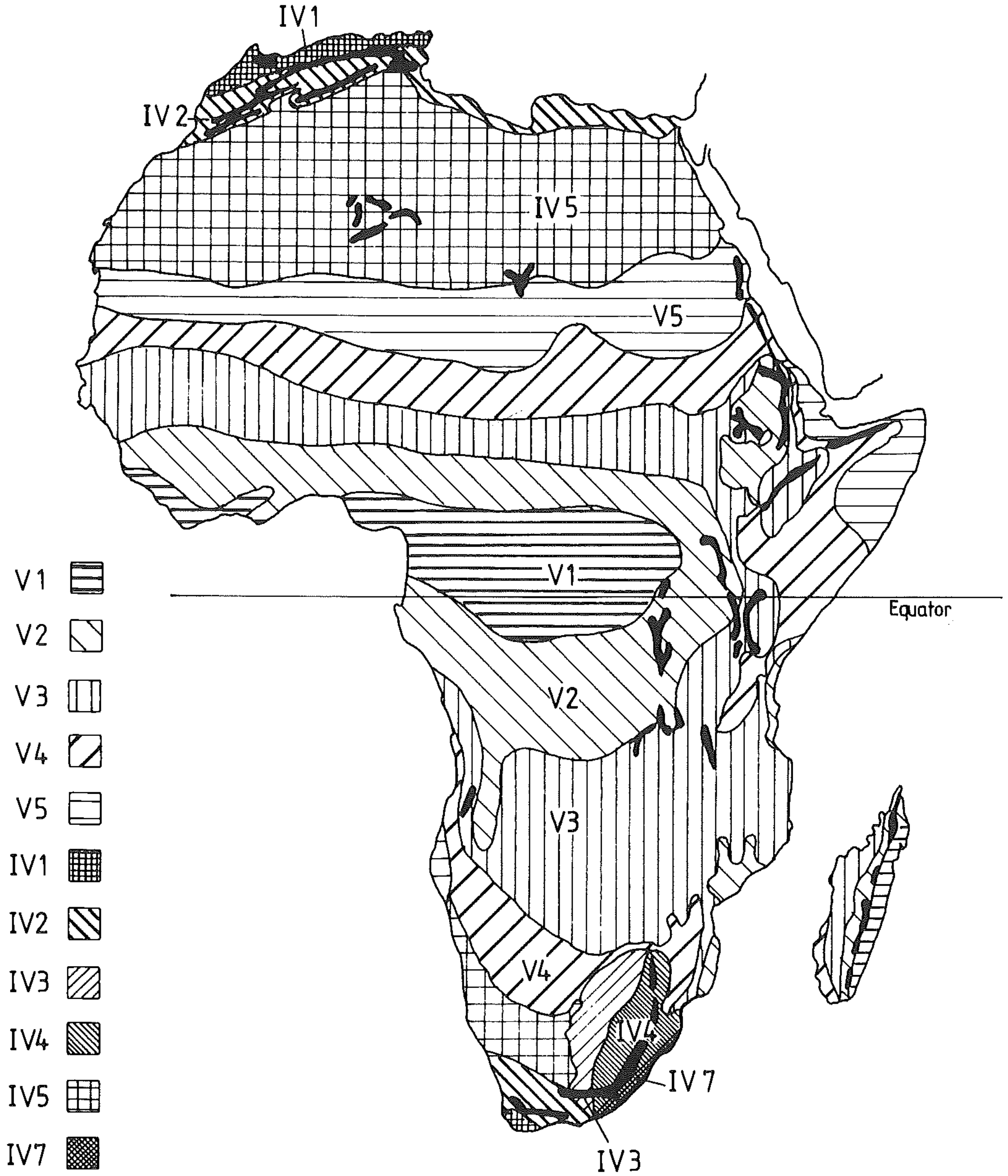
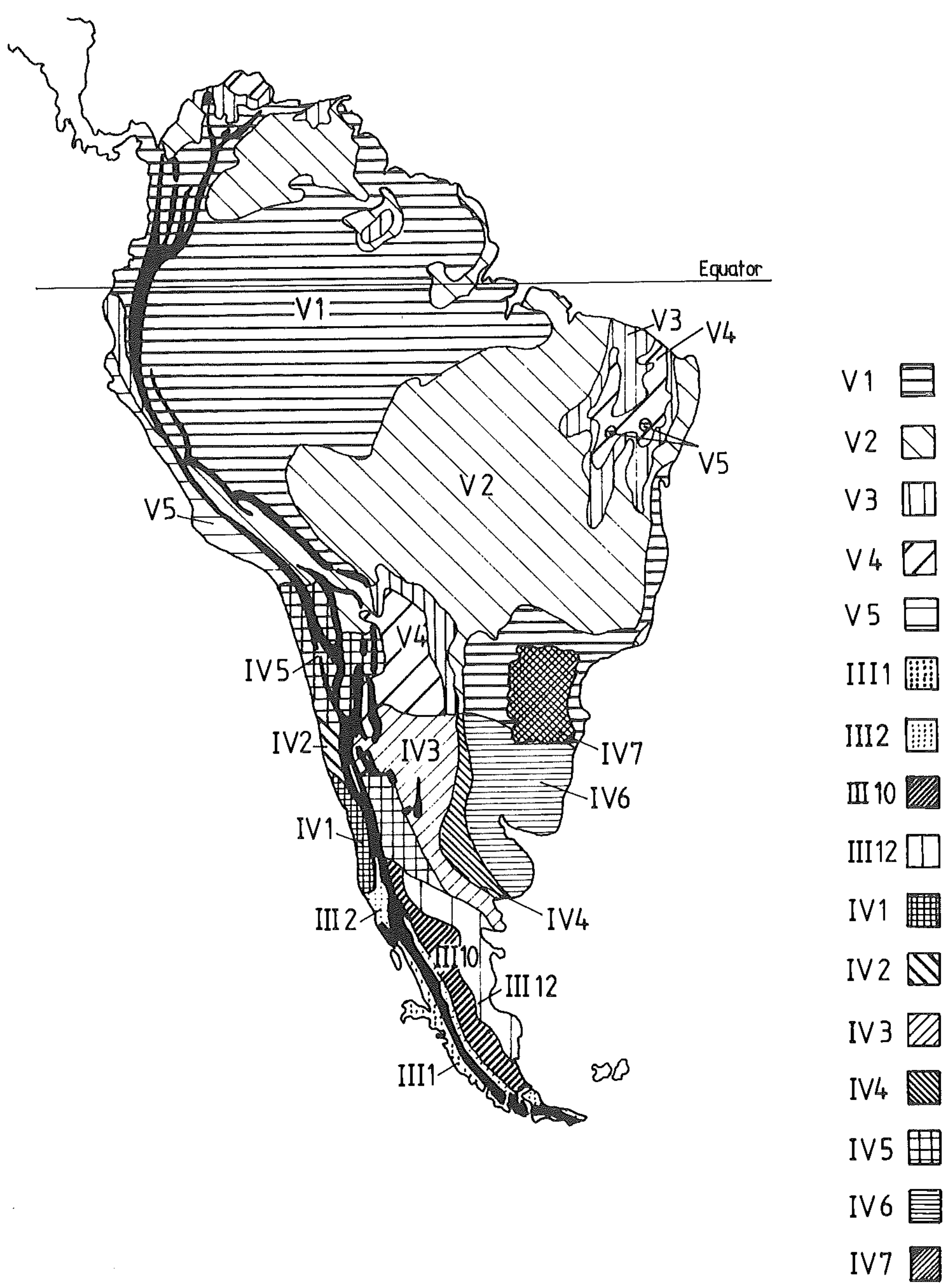


Fig. C 4: Climatic classifications of South America. Source: Landsberg et al. (1966)



2.2 Soils and topography

Tropical and subtropical soils are, as all soils, a product of parent rock, age, climate relief of the landscape and vegetation. These vary substantially in type and application.

Generally, the tropical and subtropical regions have possessed a stable soil surface for millions of years, where the soil could develop untouched and unharmed. Due to the warm and partially moist conditions the soils are fragmentarily weathered very deeply. Various levels of erosion have occurred depending upon the topography, so that different horizons can be found in close proximity in the soil. (Caesar, 1986) In spite of the variations of soil types some generally valid statements may be made, whereby it appears to be more meaningful to consider soils in humid and arid climates separately.

2.2.1 Soils in humid climatic zones

The humus content of soils in humid regions hardly varies from that found in the temperate zones. The high temperatures in conjunction with sufficient soil moisture however lead to a rapid depletion of organic matter as soon as an insufficient replenishment of organic material occurs (Sanchez, 1976). Also, the weathering of soil minerals is considerable under these conditions. These areas have a water supply surplus, i.e. rainfall exceeds the evaporation rate, leading to a downstream direction of water movement. In conjunction with the high mineralization rate and the intensive rainfall there occurs a high nutrient leaching process. As a result the soils have a nutrient deficit (especially P and N). The pH values are low as a rule and plants are subject to Al or Mn toxicity. The cation exchange capacity (CEC), i.e. the ability to store nutrients, is low due to low-absorption clay minerals (especially kaolinite). The biomass production occurring nevertheless is assured by an efficient nutrient exploitation (deep and intensive root penetration, rapid nutrient decomposition) (Caesar, 1986).

In the humid tropics only a few favourable regions exist which do not manifest these soil quality deficiencies. These are regions with neolithic weathered and volcanic parent rock as well as flood plains carrying fertile alluvial soil (Scholz, 1984).

The residual mineral content is also higher (Dehn, 1981) in mountainous regions as a result of constant removal of weathering products from water erosion and soil flow (solifluction). Here, weathering as well as the decomposition of organic material is checked, being a positive factor for natural soil fertility. This advantage for soil quality, as opposed to that in humid lowland soils, becomes however a limitation for agricultural utilization, usually due to the rolling relief of the landscape (Scholz, 1984).

2.2.2 Soils in arid climatic zones

In arid and semiarid zones chemical weathering hardly occurs; if so only to a limited extent, since the products are only slightly leached out due to the small amount of precipitation, and thus they retard further weathering processes. For this reason the soils occurring here basically possess a greater residual mineral content and are richer in bases. Thereby, the pH values lie predominantly in the neutral to alkaline level (Caesar, 1986). A calcium carbonate or gypsum accumulation, and thus crusting, can occur in the soil, depending on the soil crumb structure and rainfall quantities. This may hinder soil drainage as well as the root rowth. Furthermore, the rising and evaporation of groundwater in some areas leads to salt accumulation in upper horizons of the soil. Thus, surface sealing can rapidly ensue due to the high content of Na^+ and K^+ in some soils.

In regions having marked seasons for rainfall the humus depletion is limited to the rainy season. However, the mineralization beginning with the first rains leads to a sudden liberation of nutrients (MacArthur, 1980). The proportion of humus is all the lower, depending on the quantity of precipitation and accumulation of litter which appears in reduced quantity due to a lack of vegetation (Caesar, 1986). Low humus content is also evident in regions e.g. savannas, where it is common to burn off vegetation (Sanchez, 1976). Life in the soil also diminishes, thus yielding a nitrogen deficit.

3. Conditions for agriculture and animal traction in rainfed cropping

3.1 General background

Since no large ecologically homogeneous space exists in the tropics and subtropics it is very difficult to make generalized statements regarding the conditions under which agriculture in the lower latitudes (it is understood that this refers to the land area between the equator and 40 degrees latitude) is performed. Nevertheless, an attempt will be undertaken to summarize some of the characteristics of agriculture in this zone.

The average daily amount of sunshine in the tropics has an intensity approximately double that of the temperate zones. Calculations have shown that also the potential to convert solar energy into useful plant mass is substantially greater in tropical and subtropical regions. Individual yields of harvest have also confirmed this (Sanchez, 1976). That the yield per average farm however is low in relation lies in some extent in the limitations set by the natural endowment of a particular area of land. No adapted methods are available for the solution to these problems in most cases.

One primary limiting factor for agricultural development in the equatorial regions is the widespread low residual mineral content of the soil and the rapidly diminishing humus content due to the normally-occurring forms of cultivation affecting soil fertility. On the other hand, the limited water supply in the more arid areas of the tropics and subtropics restricts in the first instance the amount of agricultural activity.

Moreover, the share of water available to the plants compared to the total precipitation in the tropics and subtropics is often lower than in the temperate climates. This is because the drainage and evapotranspiration rates are considerably higher due to the extreme temperatures and deficient water absorption and storage capacity. Thus, crop production is tied to the period when the rains fall. Even short dry periods can cause plant stocks to dry out. Generally, one can say that the certainty of rain decreases with a decline in annual rainfall and therefore increases the risk for crop cultivation. Also hot winds blowing out from desert areas cause a rapid drying within a very short time which leads to wind erosion. (MacArther, 1980)

Rainfall often occurs as cloudbursts, bringing about severe surface drainage and thus water erosion if a protective crop cover is absent. This promotes a rapid depletion of an otherwise good soil structure, evident in tropical soils after removal of vegetation. In addition, intensive rainfall produces serious surface sealing; subsequent dry periods cause compaction of the soil which then cannot be worked.

Infestation by disease, pests and weeds is especially high in more humid regions, and epidemics and pest plagues can develop with-

Fig. C 5: Plot in South Cameroon (humid tropics) (Photo: Sommer)

in a very short time period leading to calamities. In the humid and subhumid regions rapid growth of weeds is as a rule the most significant yield-limiting factor (figure C 5). Thus, weed control requires a progressively increasing investment with higher land-use intensity; meaning a reduction of fallow land.

3.2 Selected zones

Because of the diversity of the tropical and subtropical climatic zones the various conditions of four different climatic regions are presented here in relation to their agricultural use and the mentioned conditions under which draft animals are mobilized in the respective regions.

3.2.1 Humid zones (permanently green rainforest)

These areas are normally sparsely settled. Exceptions to the rule are island-type centres of population, which are usually limited to advantaged areas (volcanic parent rock, flood plains).

The high temperatures and rainfall promote rapid plant growth and require a high time and labour investment for clearance in preparation for soil cultivation. Following the removal of natural vegetation a rapid depletion of organic material occurs, allowing merely a short-term cropping (1 – 3 years) of annual plants.

Nutrient losses due to leaching also become apparent in this case due to the low cation

Fig. C 6: Yam cropping in the Central region of Togo (Photo: Sommer)

exchange capacity of the soil, rendering storage in the soil impossible. Fertilizer is only given in small dosages, depending upon uptake capacity of the plants ("dressing by the spoonful"). Fertilizing with organic material increases the water as well as the nutrient storage capacity and improves the soil structure. However, since depletion is rapid larger quantities of nutrients must be applied.

Shifting cultivation systems are ecologically and ergonomically adapted for the reasons mentioned, as long as the necessary fallow periods are maintained to regenerate the soil. In rainfed agriculture, predominantly mixed cropping, tuberous plants are grown such as cassava, yam and taro; also maize, beans, vegetables, bananas and rice can be cultivated here. Cotton, soybean, sweet potato and groundnut is produced with increasing distance from the equator, particularly in the more heavily populated humid savanna.

Cropping with trees (oilpalm, coconut, cocoa, rubber), shrubs (coffee, tea) and perennial crops (sugarcane, bananas) as well as irrigation systems (especially for rice) have been the only forms of successful permanent land use of duration to date.

Conditions for animal traction in the humid zones

In contrast to the work accomplished with the hoe, where tree stumps and larger trees can remain on the field following slash-and-burn clearance, mechanization even on the niveau of draft animals requires a more intensive clearance; and animals can hardly be employed in this process.

Soil tillage is generally not required for perennial cropping. Thus, the possibility of mobilizing draft animals is limited to the transportation sector. Also, the important cultivation of tubers in this region, whose cultivation normally occurs on mounds (yams) and ridges, can only be done to a limited extent with the aid of animal traction (see figure C 6).

The near year-round humidity and the cultivation of crops lead to a relatively balanced workload without greater peaks. The primary argument for mechanization at all, the reduction of labour peaks, possesses no validity in this case.

Animal husbandry is connected with a severe disease pressure (e. g. trypanosomiasis in Africa). Traditionally, only small ruminants, swine and poultry are extensively kept. Cattle husbandry seldom exists; here a lack of draft animals can initially occur. Those adapted to these regions usually have a small frame and can therefore only develop a small amount of traction power.

The lush vegetation provides sufficient fodder for the animals so that they are available year-round; however local pastures in humid regions possess lower fodder quality, and often forest must be cleared for the purpose of keeping larger animals.

3.2.2 Semihumid/semiarid zones (arid forest and savanna)

In relation to the more humid savanna regions this area is relatively heavily populated and the pressure on the land is correspondingly high.

Due to the small amount of cloud the optimal prerequisites are given for plant growth in terms of the intensity of sunshine.

Moisture is the limiting factor for plant growth. Thereby, the vegetation period and cropping is restricted to the rainy season. The natural soil fertility is better here than in the humid tropics, an advantage for agriculture. The humus content is as a rule low, due to the small accumulation of litter and widespread burning. Therefore, the yields could be increased substantially by means of a well regulated organic or mineral fertilization.

Serious competition often prevails in these regions between animal production and crop production. However, the two areas of production can be complementary if plant residues are used as a fodder resource for keeping animals and the animals provide the dung for the fields. Particular exploitation of this fertilizer is normally only carried out in or near farmyards and in horticulture.

Because of the time limitation for crop cultivation there is a higher demand for labour at the beginning of the rainy season. Outside the vegetation period the people are sometimes underemployed. Due to the low amount of precipitation drought-resistant crops are grown that have a short vegetation period (e. g. sorghum, millet, cotton, groundnut).

Conditions for animal traction in the semi-humid/semiarid zones

The investment for clearance requires little mechanization, as the natural vegetation is less abundant. Weed invasion becomes less due to low rainfall (figure C 7). The cultivation of local crops can easily be mechanized.

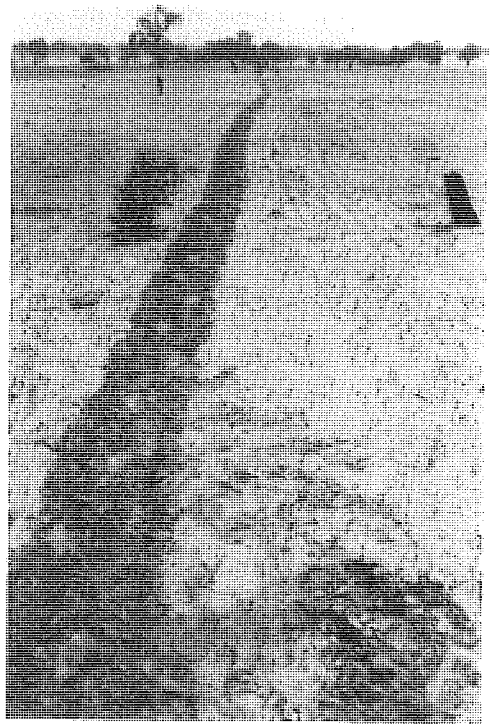


Fig. C 7: Plot in Senegal (semihumid/semiarid climate) (Photo: Schmitz)

Low yields are harvested due to the dryness. Therefore, large areas must be cultivated to assure food supplies. Workload peaks occur during the short vegetation period. The increase of power forces due to mechanization has great advantages. On the other hand, under a certain duration of the vegetation period the given work timespan can be so short that the introduction of draft-animal mechanization no longer is worthwhile since the animals and implements are not used to capacity (Pingali et al., 1987).

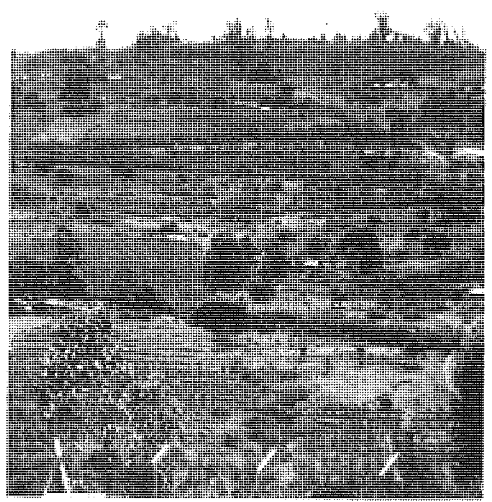
Animal husbandry is widespread and in many areas a tradition of employing draft animals exists. During periods when there is a great deal of work at the beginning of the rainy season the animals are often in such poor condition, due to the lack of fodder in the dry season, that their performance is severely hampered.

3.2.3 Highlands of the humid tropics (approx. 1000 – 3000 m)

The tropical highlands at these elevations are often densely populated (e. g. Ethiopia, Kenya, the Andes). Since the soil fertility is generally good and growth periods are long the transition to permanent rainfed cropping is possible. However, due to the various altitudes different conditions can be observed within a short range.

Often there is intensive cultivation of crops (figure C 8) and animal husbandry (e. g. highlands of Kenya). Also, regulated fallow systems up to intensive ley systems or permanent land use are found here. In higher regions the cool moderate temperatures allow cropping of plants from temperate latitudes (wheat, barley, potatoes). In some areas shrub crops (tea, coffee) are cultivated.

Fig. C 8: More intensive cropping in the highlands of Kenya (Photo: Neunhäuser)



Conditions for animal traction in the highlands of the humid tropics

Climate and often the types of crops cultivated offer suitable prerequisites for the use of draft animals. Frequently, they have been traditionally employed in these regions (Ethiopia, Andes highlands). Limitations can often occur in these areas due to the rolling landscape, which can reduce the possibilities of mechanization of soil tillage or transportation.

3.2.4 Semiarid zones with winter rains

These zones can normally be found in the subtropics (e. g. Mediterranean region). Precipitation occurs during the cooler seasons and in contrast to areas having summer rains the rainfall intensity is less marked so that the risk of erosion is lower here (Wieneke and Friedrich, 1983).

As opposed to the tropical soils, which often possess a lower water storage capacity, the soils in these areas of the subtropics are more able to save water for subsequent crops, due to the lower evaporation rate during the cool winters. This has led to a cropping system known as dry farming in the semiarid regions of the subtropics. Dry farming is already found at locations having precipitation levels down to 250 mm per annum. Complete fallow is employed in this case. The soil surface is periodically tilled in order to destroy soil capillaries and to remove all plant growth. The function of this full fallow is in the first instance for water storage, since less water evaporates than with growing crops. The precipitation collected in the soil is beneficial to subsequent crops, especially grains (e. g. wheat, barley and millet). The proportion of fallow is found to increase with a decrease in rainfall quantities (Wieneke and Friedrich, 1983; Ruthenberg and Andreae, 1982).

Conditions for animal traction in semiarid winter rainy zones

Keeping livestock is common here as in the semiarid regions having summer rains. The natural plant growth is minimal and crops are very suited to mechanization.

The practice of full fallow requires frequent working of the soil; traditionally draft animals are employed for this purpose. In spite of the low supply of fodder and water as well as the high temperatures in these regions the mobilization of adapted draft animals (camel, donkey) has been proven useful. A transition to motorized mechanization has in many cases already taken place in these areas (e.g. Maghreb).

4. Dynamics of farming systems and mechanization

4.1 Land-use intensity

In smallholdings located in the tropics and subtropics very complex farm systems have developed on the basis of the close link between the farm and the household. Even if the management of the individual farms varies, still farms subject to similar environmental, economic and social conditions tendencially possess similarly organized farm systems. Ruthenberg (1980) consolidates such similarly structured farm systems under the heading of farming systems, which can be classified on the basis of varied factors (e. g. according to water supply for irrigation and rainfed cropping, or according to intensity of cycles in shifting cultivation, fallow and permanent cropping).

The various farming systems undergo constant change, produced by

- increasing population pressure due to population growth or migration (e. g. to fertile areas or near towns),
- better market access because of improved infrastructure or higher product demand,
- technical advancement,
- land-tenure structures (land distribution),
- intervention of the government etc.

Most of these reasons have one thing in common: that as a rule they lead to a greater intensity of land use. The land-use intensity, expressed by the so-called R value, is thereby defined by the relationship of cropping years to the sum of the cropping plus fallow years, which is effectively the intensity of rotation (Ruthenberg, 1980).

$$R\ value = \frac{cropping\ years}{cropping\ years + fallow\ years} \times 100$$

According to Boserup (1965 in: Strubenhoff, 1988) an increase of the population is the most important single factor influencing the land-use intensity.

Table C 2 shows the relationship existing between the population density and the intensity of land use in the tropics, as well as the most frequently used agricultural implements. The figures here merely represent approximate values, since also other factors naturally influence land-use intensity, such as soil fertility or a profitable marketable crop.

With a low population density the predominant land-use form is therefore the forest-fallow system. After clearance and the usual burning of the natural vegetation, there follows a 1-2 year timespan of cultivation. There after, fallow must occur for a duration of up to several decades. With the slash-and-burn method planting can be carried out immediately without further soil tillage. The main reasons for short-term use of a field prepared in this manner are:

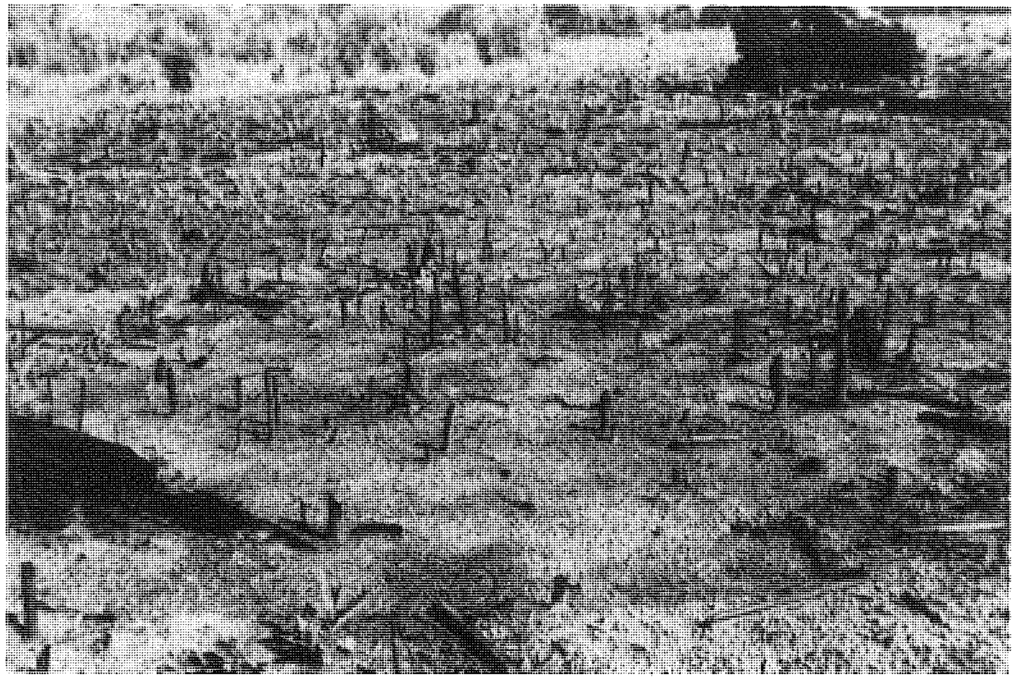
- the low capacity of the soil to produce good yields, which rapidly declines; the farmer is forced to shift to regenerated and more fertile soils.
- the soil is loose and free of weeds following slash and burn. Thus, the labour input on recently cleared fields is less than for loosening used soils and particularly for weed control, which progressively increases with longer use.

Tree stumps and roots remain on the field with this system and thereby check erosion; following the cropping period they can resprout. In conjunction with the subsequent long period of dormancy in forest fallow a development of the original vegetation is possible, also the regeneration of soil fertility.

Table C 2: Population density, land-use intensity and predominantly used agricultural implements. Source: Pingali et al. (1987)

Farming Systems	Land-use intensity (R value)	Population density (inh./km^2)	Typical implements
Forest fallow	0 – 10	0 – 4	digging stick, machete, ax
Bush fallow	10 – 40	4 – 64	digging stick, machete, ax, hoe
Short fallow	40 – 80	16 – 64	hoe, animal drawn implements
Annual cropping	> 80	< 64	animal drawn implements, hoe

Fig. C 9: Cleared plot after bush fallow in Brazil (Photo: Schmitz)

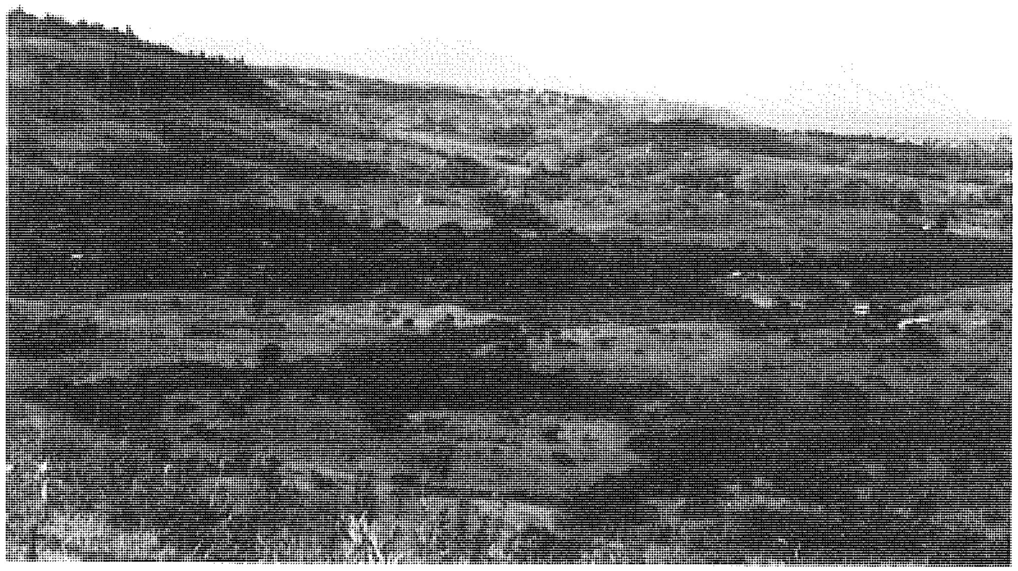


Increasing population density leads to a decrease in the duration of the fallow period. If the population pressure on the soil further continues, a constant land use results without fallow periods. Continued adherence to the previous production technique without a regulated fertilizer management leads to declining soil fertility. The vegetation that develops on the fallow areas, depending upon the climatic zone, indicates an approximation of the length of the former fallow duration. Increasing R values progressively lead from forest to bush fallow, and finally to grass fallow (short fallow) in the humid zones (figure C 9 and C 10). In savanna zones of more arid areas this development becomes less obvious due to reducing tree density, however the plant associations also become modified here. (Strubenhoff, 1988)

At the stage of short fallow the problem arises that the fire does not destroy the grass roots and a mechanical removal becomes necessary prior to planting. Perennial grasses then cause weed invasion (Pingali et al. 1987). The declining yield and increasing input of the handhoe to till the soil and control weeds effects a reduction in labour productivity with increasing land-use intensity. According to Strubenhoff (1988) the acceptance of animal traction, with increasing land-use intensity, serves to moderate the drop in labour productivity in hand-hoe cropping systems.

In order to facilitate tillage with an animal-drawn plow, a great deal of labour input for clearance must be invested in the forest fallow stage to remove roots and tree stumps

Fig. C 10: Short fallow system in west Cameroon (Photo: Reichardt)



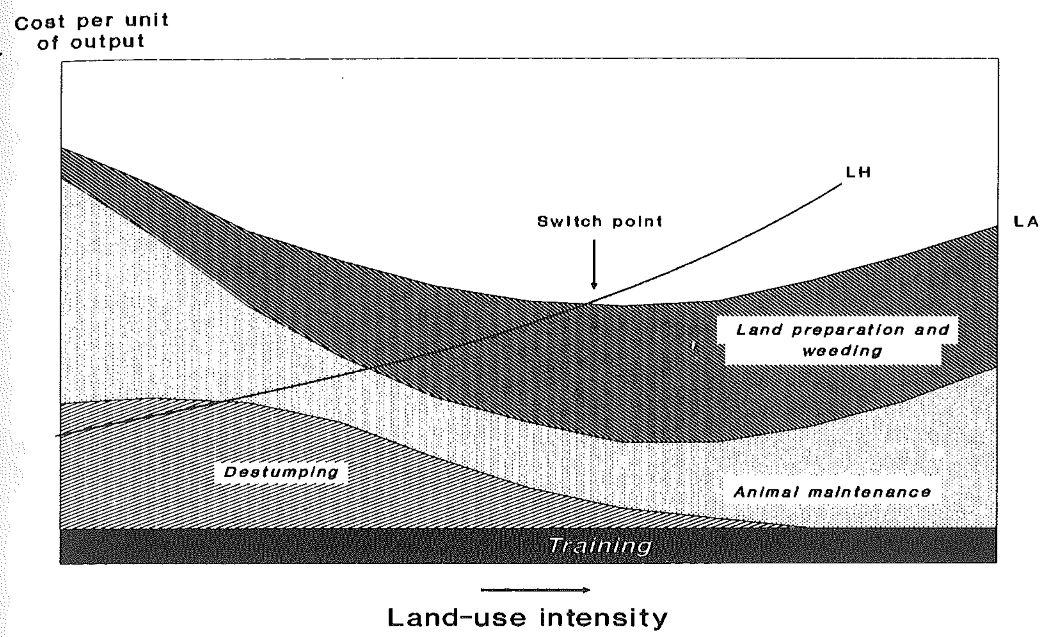


Fig. C 11: Comparison of labor costs with the practice of hand cultivation and animal-powered cultivation. LH = Labour costs per unit of output, using the hand hoe; LA = Labour costs per unit of output, using animal traction. Source: Pingali et al. (1987)

(figure C 11). This decreases with a reduction of the fallow and lapses completely with regular annual cropping. Furthermore, with a lower land-use intensity the year round, inputs for keeping draft animals and feeding are high, since for example cleared pastures are often not available for the animals. Within the stage of grass fallow the inputs for keeping animals increases due to better fodder availability. With permanent land use, however, the amount of inputs required increases again due to scarce pasture resources. The number of work operations for soil tillage and weed control that can be carried out with the mobilization of draft animals increases considerably with higher R values. The expenditures for training animals, for costs of teaching the farmers and the direct investment for purchasing animals and implements remains essentially independent of the land-use intensity.

With hoe cultivation the overall labour input constantly increases with greater intensity of land use due to an increasing investment for soil tillage and weed control; this cannot be compensated for by a reduction in the amount of clearance. The introduction of draft-animal mechanization is only beneficial at a point at which the labour investment per unit of production in handhoe systems (LH) is greater than the investment in the system with animal traction (LA) (figure C 11).

Pingali et al. (1987) think that a more work-effective acceptance of animal traction is generally only given beyond the stage of

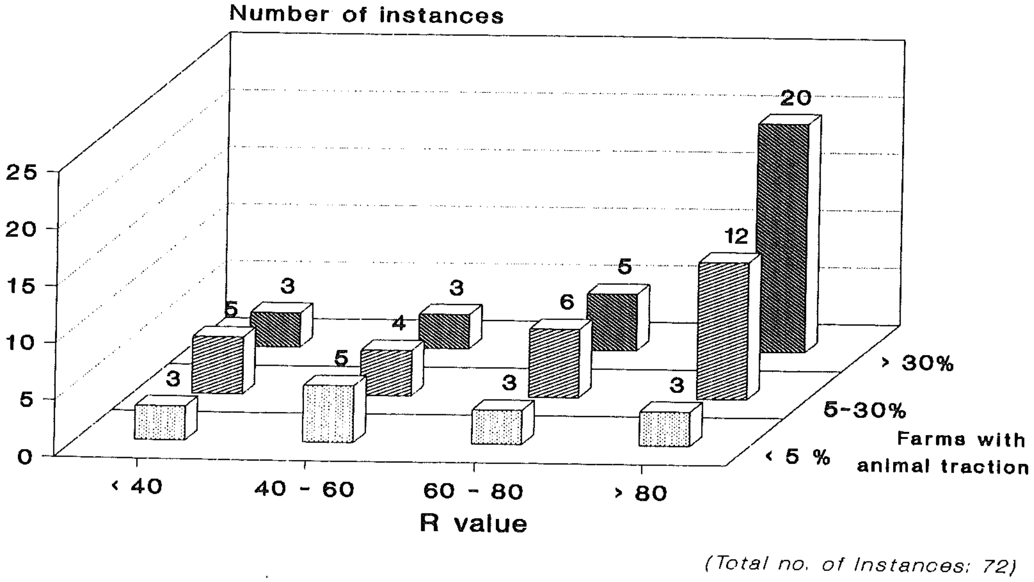


Fig. C 12: Distribution of animal traction with increasing land-use intensity

short or grass fallow (R value 40). This is confirmed by our survey.

As shown in figure C 12, 85% of the regions having animal traction (61 instances) show an R value of more than 40. It is also evident that with a transition to permanent land use the degree of animal traction increases significantly, i. e. the number of farms with draft-animal mechanization (P<5%).

In the 11 regions in which animal traction is also employed with low land-use intensity, two are situated in higher locations and a further six in semihumid/semiarid locations; here clearance does not present a problem for using animal traction in cultivation because of the climate and vegetation. The remaining three cases are in regions having a semihumid climate. Noteworthy is, however, that here the degree of draft-animal distribution is low with less than 5% of the farms, and in two cases draft-animal mechanization is propagated under the auspices of technical cooperation programmes (Togo, Tanzania). In all three regions problems are encountered in poorly cleared fields. As a result the farmers use their draft animals chiefly for transportation; with 50 – 70% this represents the main share of the work done by the animals.

In summary, the following factors could render the use of draft animals attractive to the farmers, also for those with low land-use intensity:

- the existence of heavy soils, as tillage with the hoe is very hard work,
- cropping in areas where the investment for clearance is low, e. g. in grass savanna or flood plains,
- a high value estimation or demand for by-products from draft animals (e. g. dung, meat),
- the existence of suitable draft animal types and knowledge of animal husbandry,
- already existing experience and knowledge (e. g. for migrants) of animal traction methods.

This stands opposed to the fact that in intensive systems applying permanent land use without fallow the transition to the plough has not been realized. Thus, mechanization with draft animals can be ruled out because of severe risk of disease on the animals (e. g. widespread occurrence of the tsetse fly as a carrier of trypanosomiasis), inaccessibility to the fields, steep slopes and increased risk of erosion. The hand hoe remains the most important tool for soil tillage in these areas.

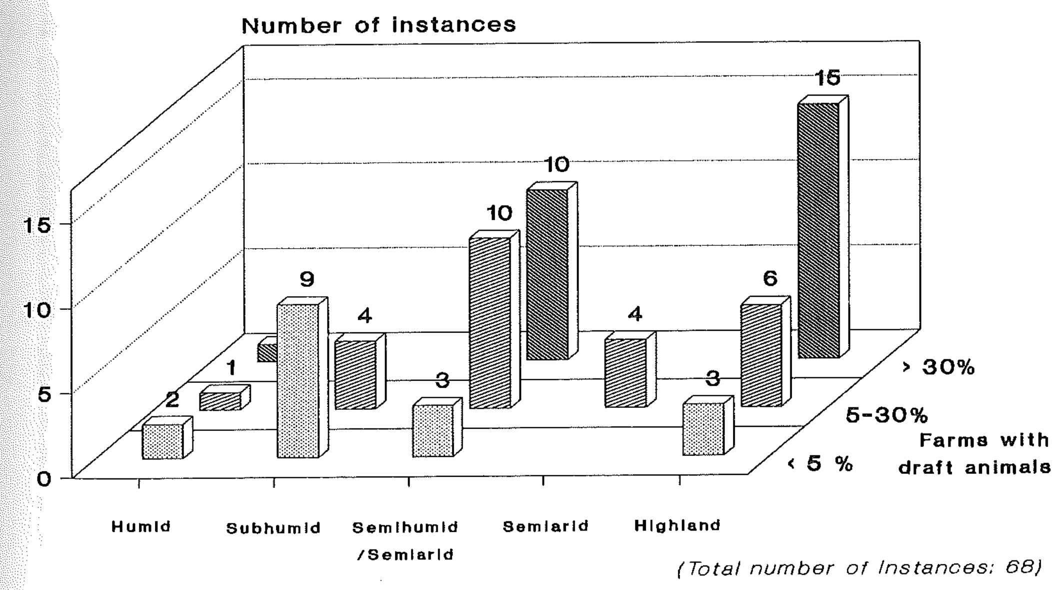
4.2 Agro-ecological zones

In general, the investment for keeping draft animals increases with higher humidity. Here, especially in tropical lowlands, the risk of disease for the animals (in Africa particularly due to the occurrence of the tsetse fly) as well as the natural vegetation, and thus the time investment for clearance. As illustrated in figure C 13 this strongly influences the distribution of draft-animal mechanization. Therefore, according to the survey the areas in the tropics where animal traction has found greater distribution are predominantly in the semihumid/semiarid zones and in the highlands.

The conditions for using draft animals are also suitable in semihumid areas. The low number of only four instances in this climatic zone is, in the first instance, due to the small amount of data available from the questionnaire.

The four regions having draft animals in a humid climatic zone (Cameroon, Dominican Republic, Brazil) lie exclusively in locations

Fig. C 13: Distribution of animal traction in relation to climate in the tropics



where high land-use intensity prevails, and only in one case is the degree of engaging draft animals of relatively greater importance. In this exception in the coastal region of the state of Santa Catarina in Brazil animal traction is found in 30 – 50% of the farms, with an R value of 100. In addition, the transition to motor mechanization has already taken place to a large extent. Thus, in humid regions having a high land-use intensity the use of draft animals can achieve greater importance due to the absence of investment for clearance and less risk of disease as a result of the reduction of the natural vegetation. The state of São Paulo can also be mentioned as an example: in 1975 over 50% of the farms worked with draft animals, representing one of the most significant regions where animal traction is distributed in Brazil (Casão, 1987). Many industrial centres are found in this tropical humid area. The population density and the land-use intensity are also both very high.

In the subtropics, especially in the warm and summer dry areas, the preconditions for animal traction are suitable. Thus, the investment for clearance and risk of disease is low because of the climate and less lush vegetation. Furthermore, the less rapidly decreasing soil fertility in comparison with the tropics allows a more permanent land use. Also, the greater risk of erosion caused by draft-animal mechanization is highly moderated due to the less intensive rainfalls. In these areas many centres have developed with high distribution of draft animals and century-long tradition of animal traction (e.g. the entire Mediterranean region, Afghanistan, Pakistan).

With increasing humidity in the subtropics there is a corresponding increase of investment necessary for clearance in order to use draft animals, and in the constantly wet areas of the subtropics this investment is very high. Plant growth, due to the occurrence of

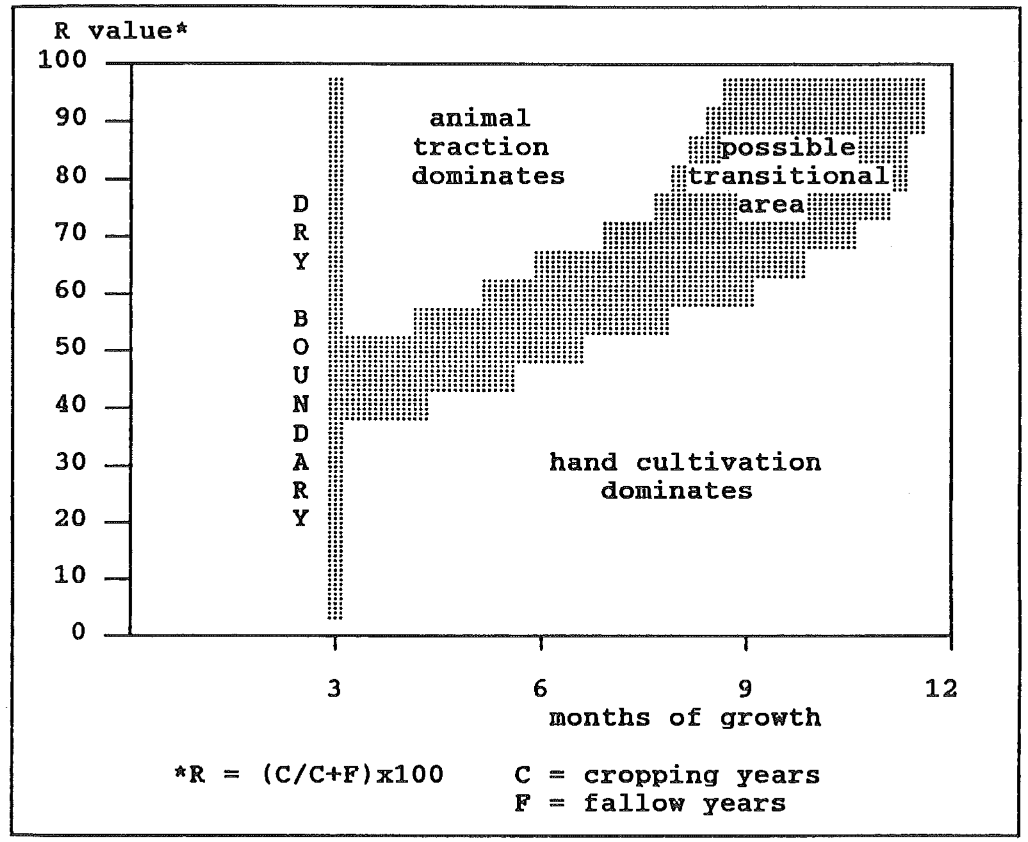
Fig. C 14: Animal traction in the state of Paraná, Brazil (subtropical, constantly wet climate) (Photo: Schmitz)

cooler seasons, as well as the risk of animal diseases is less in the humid tropics and thus the preconditions for draft-animal mechanization are somewhat more reasonable. 10 out of 14 respondents from subtropical, constantly wet regions in Brazil reported a high degree of draft-animal use on their farms (more than 30% with draft animals). Also in the remaining four cases draft animals were used on 10 – 30% of the farms. The introduction of draft- animal mechanization occurred through immigrants to these regions who have experience with animal traction in their tradition (e.g. Poles, Germans, Italians). Noteworthy is however that in all regions there is a high land-use intensity; in 50% of the cases the land is used every year (R value = 100). Nevertheless, in five regions difficulties with using draft animals arose due to root residues and poorly cleared fields. (figure C 14)

4.3 Criteria for the transition

Strubenhoff (1988) has derived a transitional area for the use of draft animals in cropping considering the land-use intensity and the

Fig. C 15: Competitive force of animal traction in relation to land-use intensity and agro-climatic zone. Source: Strubenhoff (1988)



agroclimatic zone in terms of the growing season (figure C 15). The values given here relate in the first instance to the conditions in tropical lowlands. The switching point must be defined for the particular location on the basis of further local endowment factors.

According to Herlemann (1961) mechanization occurred in the development of the agricultural sector of a western industrialized country when the production factor of labour in comparison to land became scarce and the labour productivity had to be increased. This was achieved by a substitution of labour with capital. On the other hand, an intensification took place when the land represented the most scarce factor and the productivity per area was expanded with the aid of inputs such as fertilizer or improved seed. In this case land was replaced by capital. For this reason an intensification of agriculture occurred in heavily populated countries, e. g. Germany and Japan, and an increased mechanization could only happen when the labour force migrated from agriculture to the industry. The development in thinly populated agricultural areas in the USA, with its large area, underwent the exact opposite – the intensification followed mechanization.

As a result, western experts in many development projects in the Third World have attempted to increase the labour productivity of the farmers by means of draft-animal mechanization where low population densities and minimal land-use intensity are present. These projects have collapsed as a rule, since, for the reasons mentioned, the use of draft animals in stages of low land-use intensity is not able to facilitate the labour productivity of the hoe farmers, especially in humid regions.

Whether technology can improve labour productivity is soon recognized by the farmers, for labour is the main input factor for agricultural production in most of the regions near the equator. As a consequence the farmers rapidly search out and accept new production techniques which increase the labour productivity with not too great a risk. Other ineffective techniques for them, on the other hand, are not adopted. The assessment of the farmers regarding labour productivity increase of any technique is particularly infallible since the execution of work on the fields, in contrast to that of many development experts, is the object of their immediate personal experience. (MacArther, 1980)

5. Status of animal traction

Most of the data referring to the distribution of draft animals in the tropics and subtropics are merely based upon rough estimations. Often no distinction is made between draft animals and work animals (to which group e. g. pack animals belong). Exact figures are normally only available for individual countries or regions.

On the basis of an assessment of recent literature an attempt has been made in the following illustrations to represent the status of animal traction in the individual countries in Africa, South America and Asia (figure C16, C17, C18). The figures are taken from various sources published from 1979 to 1988 (see annex IV). Since information on the numbers of farms are only available for a few of the countries portrayed, the number of animals per 100 ha of arable land was selected as a point of reference. A representation of the number of draft animals in relation to the rural population was not practical because of the diverse levels of mechanization. The figures of the countries showing a higher technical level, having a lower proportion of rural population, would have been overestimated.

The majority of draft animals are used for cultivation of agricultural areas. However, animals contributing to post-harvest and transportation functions must also be taken into consideration in the following treatise. In addition, draft animals are frequently employed to dispatch or further process agricultural products and inputs.

The greatest density of draft animals is evidenced in the countries of Asia; these are precisely the "strongholds" of animal traction (Nepal, Bangladesh) coinciding with a high population density. In Africa the figures for draft animals are generally low. However, in the Sub-Saharan countries there exists a vast potential for an increase of draft-animal use. In contrast, traditional animal traction in the Mediterranean countries of Africa is already being replaced with tractor mechanization. This trend is also being observed in many of the Latin American countries.

Since general data on the countries was used for the illustrations in the text, they possess little weight in terms of their significance for singular regions in these countries. Thus, in an extreme case the entire draft-animal population of a country could be concentrated in a small area and hold a significant position there. In order to clarify this point the example of Togo is used to show the distribution of draft animals in the individual regions of a country (figure C 19).

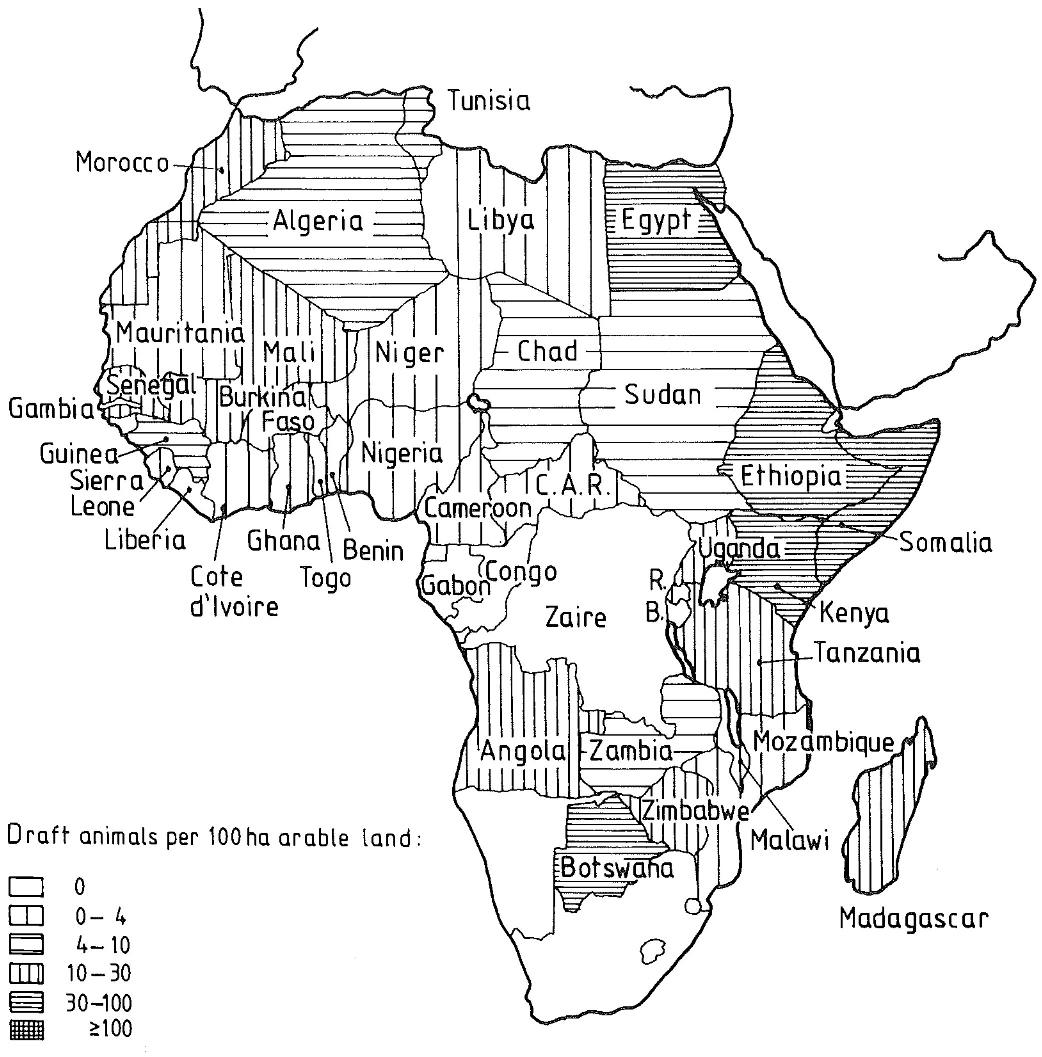


Fig. C 16: Status of animal traction in Africa (countries without name no data available)

Fig. C 17: Status of animal traction in South America (countries without name no data available)

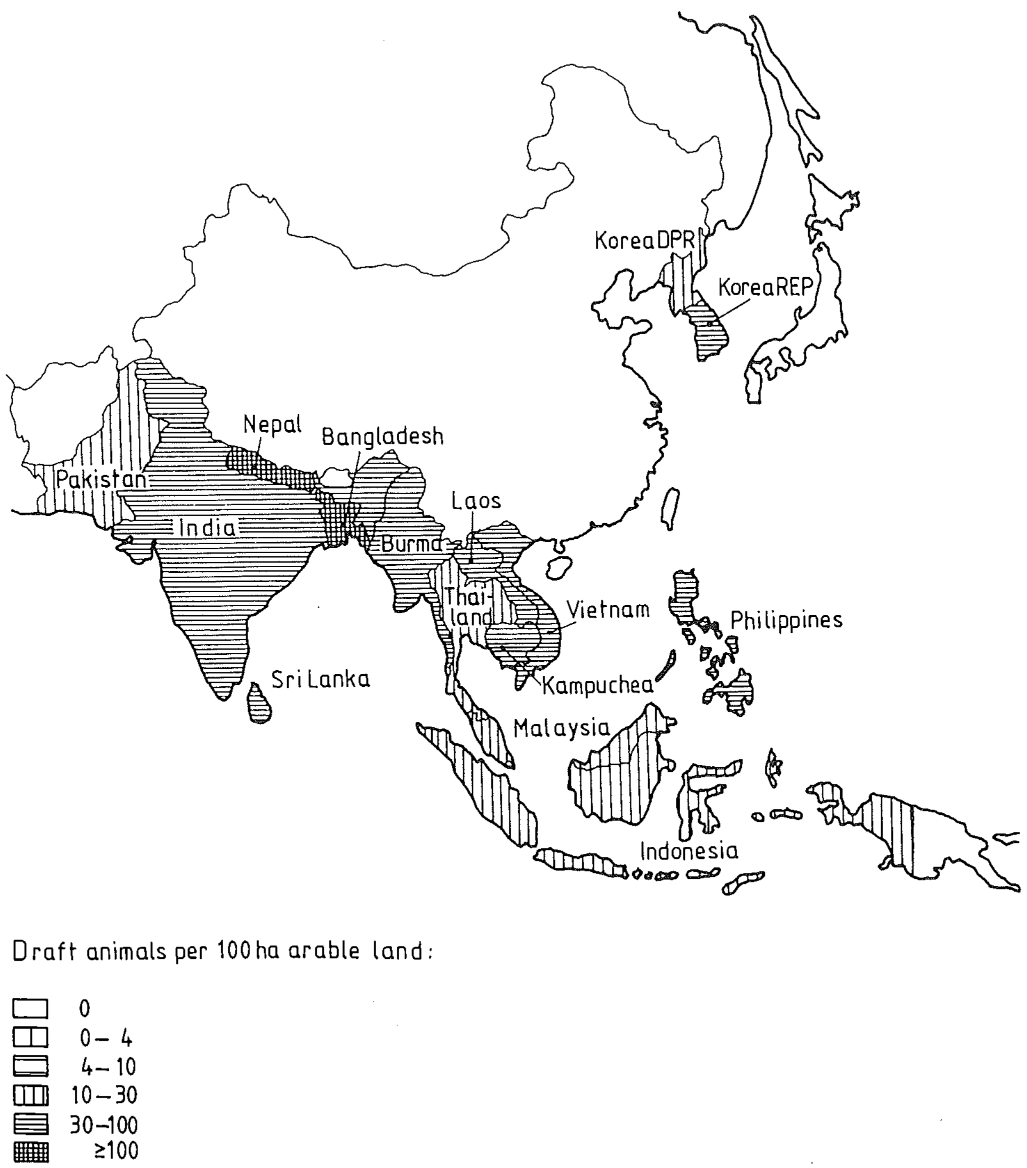


Fig. C 18: Status of animal traction in Asia (countries without name no data available)

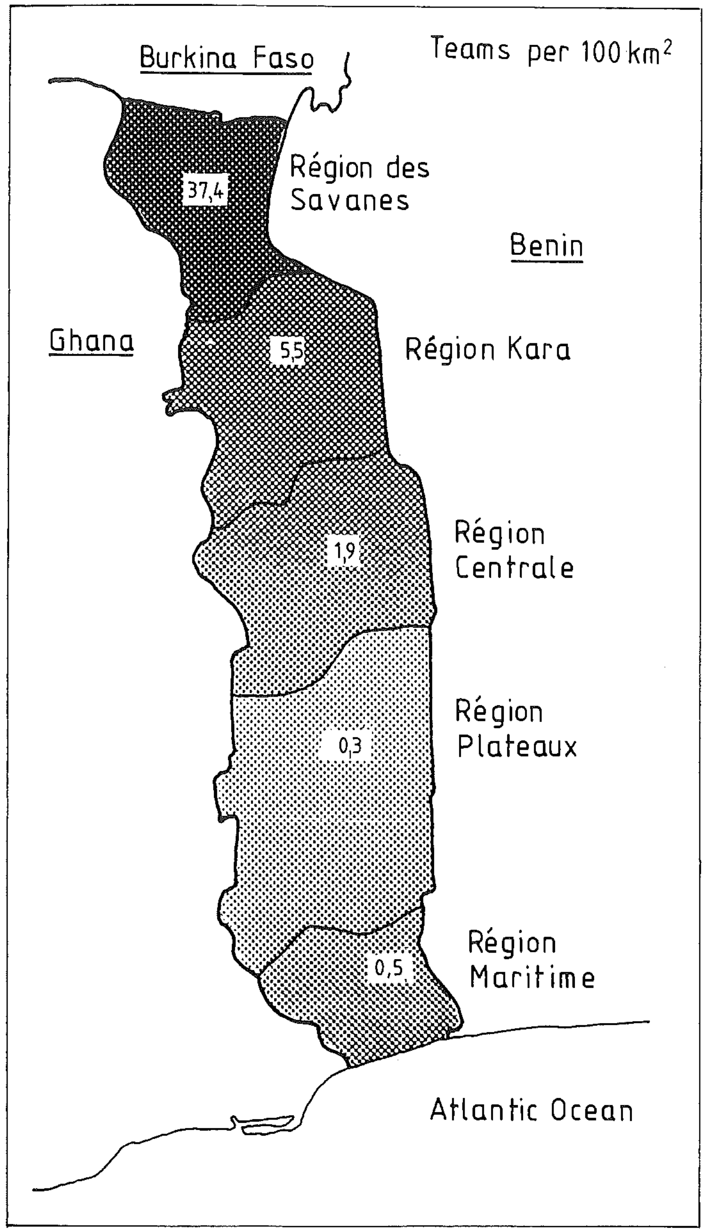


Fig. C 19: Importance of draft-animal use in the individual regions of Togo. Source: according to Strubenhoff (1988)

6. Constraints of animal traction

The limiting factors of draft-animal mechanization can be sub-divided according to the degree of manipulation and/or in terms of their dynamics within a given time sequence:

– Non variable factors arising in the first instance from the natural endowment (climate, soils, topography).

– Long to medium-term variable endowment factors such as farming systems or land-use intensity, which possess a certain internal dynamics, e. g. triggered by population growth or increased product demand (see section C 4.1). Direct possibilities of influencing the promotion of animal traction do not have any or are of secondary importance. In the framework of such changes the limiting effects of disadvantageous natural endowment factors for draft-animal mechanization could be eliminated by melioration measures such as clearance, terracing, contour cropping or irrigation.

– Short-term variable factors: primarily the problems of draft-animal use fall in this category, resulting from poor infrastructure, specifically transportation and communications systems, marketing conditions, credit systems, training and extension services for farmers and artisans, material supplies (animals, spare parts, raw materials) veterinary services, etc. Here, direct action could be taken to promote animal traction, assuming that conditions are appropriate for draft-animal mechanization in regard to the above-mentioned less manipulatable limitation factors.

According to Pingali et al. (1987) the tasks of promotion facilities of draft-animal mechanization lie clearly in the recognition and elimination of these short-term limiting factors.

In our survey the respondents were able to select the following answers under the section "constraints of animal traction" (see questionnaire in annex I, point 4): unpopularity of draft-animal mechanization, lack of draft animals, high prices for animals, animal diseases, soil characteristics and unsuitable cropping system. Multiple selection was possible; also, space for further comments was provided. In additional questions on the nutritional condition of the animals as well as the possibilities of repair and maintenance of the implements were included. The results of the various aspects are depicted in figure C 20.

It is evident that limiting factors are more prevalent in the area of infrastructure, while less importance is attached to problems that have no immediate short-term solution, as for example unsuitable cropping systems or poor soil conditions for animal traction. This is also understandable, since a certain compatibility with the latter for an effective use of draft animals is frequently an absolute precondition for access to the introduction of draft-animal mechanization at a specific location with rainfed cropping. In that development organizations and institutions initi-

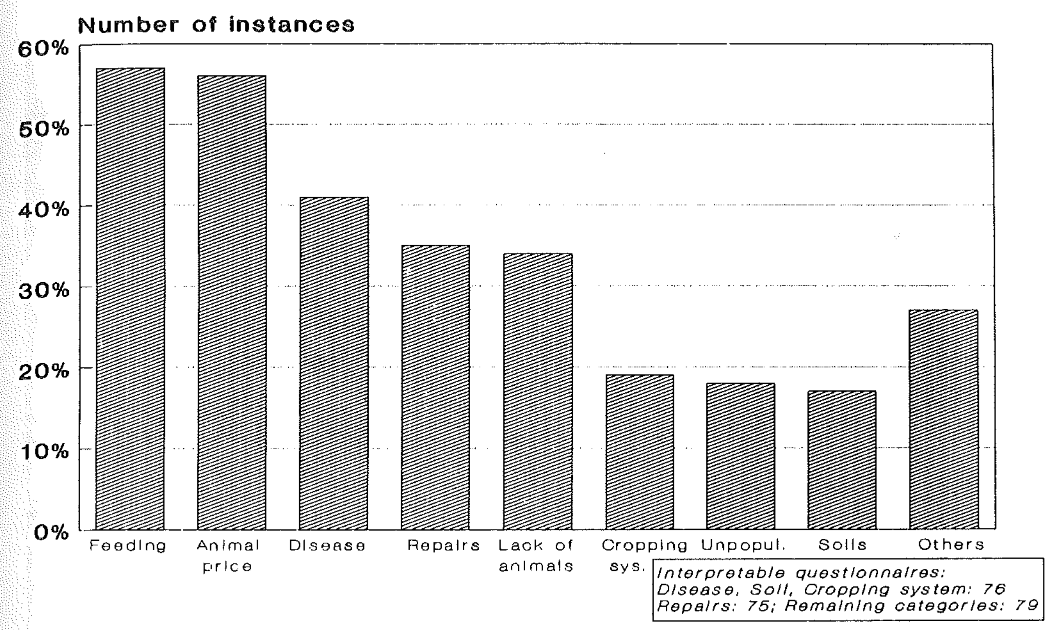


Fig. C 20: Constraints of animal traction

ate projects to introduce draft animals in regions that do not show or have not yet proven compatibility in regard to the local given conditions, these problems have often arisen within the framework of the projects and therefore are not recognized or are simply ignored.

Thus, of the 15 regions, in which the cropping system is mentioned as a constraint for animal traction, over half are located in a humid or subhumid climatic zone (Tanzania, Benin, Togo, Cameroon, Brazil) primary crops mentioned are those considered unsuitable to draft-animal mechanization (tubers, perennials). In another case in the semiarid climatic zone of Niger the use of draft animals for seedbed preparation is limited by the short vegetation period. In the majority of all these regions having suitable cropping systems draft animals, if they at all become widespread, are primarily employed for transportation purposes.

One of the least mentioned problems for animal traction was unsuitable soil conditions (17%). Interestingly, of these, 85% (11 of 13 cases) are in regions in Latin America (Peru, Ecuador, Brazil, Dominican Republic). Nevertheless, animal traction possesses a certain tradition in all these regions with one exception and is in part widely found. Here, the poor soil conditions have not led to the exclusion of draft-animal mechanization. Due to the hilly and very steep topography (with one exception) and the partially existing heavy soil it is a question of implements and cropping techniques, in finding an appropriate solution for the long-term soil cultivation for this location. Obstacles in the fields, such as stones (figure C 21), and as a result unadapted tillage methods, finally causing erosion gullies, were mentioned.

For 18% of the respondents (14 instances) the unpopularity of animal traction was suggested as a limiting factor, whereby in 11

Fig. C 21: Plowing on stony soils in the highland of Peru (Photo: Schmitt)

cases harnessing of animals was not part of the tradition in the region, and for half the distribution in the region is relatively low, with less than 5% of the farms. In the majority of cases it already stood in competition with motor mechanization; at least 5% of the agricultural work was already being done by tractor (in 3 cases more than 20%). Unpopularity as such does not suffice as an explanation for the limitation of animal traction in a region. It is rather based upon influencing factors caused by local conditions, often the natural endowment. Furthermore, favouring motor mechanization can lead to a degrading of animal traction to a "backward technology". For example, after World War II the introduction of tractors in West Africa was one of the chief limiting factors of draft-animal use (Pingali et al., 1987).

Other constraints not listed in the questionnaire were given by 27% (21 responses) of the respondents. The most significant in order of importance are: lack of know-how of the farmers (5 instances), unadapted draft-animal implements (4 instances), theft of draft animals and increasing rural exodus (both 2 instances).

The most often mentioned constraints in the survey, purchase of teams of animals, the keeping and foddering of draft animals and the maintenance and repair of the implements belong, as already mentioned, to the short-term variable limiting factors. The first three constraints are now dealt with in more detail in the following chapter.

D. Features of draft animal husbandry