

Many farmers using 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 prob-

lems 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.

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 calendar 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 intens-

ity 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 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 there 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 limi-

ting 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) was 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 such 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 that of 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, in 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 manoeuvring, 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 of finding 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, especially 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 sub-humid 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, fuçador).
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 hand-operated 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 in Brazil. 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 cause damage 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 Paraná 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 fuçador in areas settled by Germans and Italians, leads one to this conclusion. Today, a wide array of im-

plements is utilized in Paraná. 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 (Paraná: 11.76 tractors per 1000 inhabitants) draft-animal techniques in the meantime are mainly 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 Paraná and the high technical level in Brazil the seeder 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 to 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 Paraná are distributed by private farm machinery manufacturers, state companies are delegated with this task in West Africa. In Togo the implements are delivered by UPRAMA, 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, were 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 Paraná, 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 worldwide 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. Paraná) 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 transi-

tion 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 for the ard in some regions 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 in 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.