Report #12

Report of GARD Consultancy

STRENGTHENING ANIMAL TRACTION RESEARCH AND DEVELOPMENT IN THE GAMBIA THROUGH NETWORKING

Paul Starkey

March, 1986

Gambian Agricultural Research and Diversification Project (GARD)
Consultancy Mission Report

STRENGTHENING ANIMAL TRACTION RESEARCH AND DEVELOPMENT IN THE GAMBIA THROUGH NETWORKING

by

Paul Starkey

Consultant in Animal Traction

March 1986

P. H. Starkey, Specialist in Animal Traction,
2 Wychwood Cresent, Earley, Reading RG6 2RA, U.K.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to everyone who gave up their time to provide the information on which this report is based. Due to the very tight schedule, it was not always possible to make formal appointments, and therefore the help and understanding of the busy professionals who found time to discuss animal traction was particularly appreciated. The names of many who contributed information are given in Section 12, and I would like to thank them all.

GARD, ITC and the Ministry of Agriculture made every effort to make my visit as productive as possible, and provided valuable opportunities for discussions with farmers. I am very grateful for all their help, and hope that this report will assist in planning future research and development initiatives relating to draught animal power in The Gambia.

Paul Starkey
March 1986.

TABLE OF CONTENTS

1. SUMMARY....1

2. OBJECTIVES AND PROGRAMME....3

3. ANIMAL TRACTION PERSPECTIVE....3

4. THE DEVELOPMENT OF ANIMAL TRACTION IN THE GAMBIA....5

5. RESEARCH RELATING TO ANIMAL TRACTION....10

6. PRESENT CONSTRAINTS TO DRAUGHT ANIMAL POWER....19

7. PROPOSED METHODOLOGY FOR FUTURE RESEARCH AND DEVELOPMENT....23

8. POSSIBLE RESEARCH INITIATIVES....26

8.1 5-YEAR PLAN FOR MECHANIZATION OF CROP PRODUCTION....26
8.1.1. General....26
8.1.2. Ridge-planter evaluation....27
8.1.3. Ridging attachment to the Sine Houe....28
8.1.4. Harnessing systems....28
8.1.5. De-linting of cotton seeds for Super Eco Seeder....28
8.1.6. Rice cultivation using animal power....30
8.1.7. Assessment of the Houe Occidentale....31
8.1.8. Evaluation of combined seeder/fertilizer applicator....32
8.2. TIED RIDGES....32
8.3. ANIMAL POWERED SYSTEMS FOR RAISING WATER....35
8.4. THE USE OF DRAUGHT COWS....36
8.5. THE DEVELOPMENT OF THE MAIZE CULTIVATOR....37

9. PROSPECTS FOR NETWORKING ACTIVITIES....38

10. RECOMMENDATIONS FOR FURTHER ACTION....40

10.1. POSSIBLE DIRECT INTERVENTIONS....40
10.2. PREPARATION OF WORK PROGRAMME ON ANIMAL TRACTION....41
10.3. POTENTIAL TECHNICAL ASSISTANCE AND TRAINING ACTIVITIES....43

11. REFERENCES....46

12. LIST OF PERSONS CONTACTED DURING THE MISSION....48

13. APPENDIX A:
NETWORKING CONTACTS ON ANIMAL POWERED WATER PUMPS....49

13.1. ANNOTATED ADDRESS LIST....49
13.2. SOME LITERATURE AVAILABLE....50
13.3. NOTES ON ANIMAL POWERED PUMPS AND MILLS IN SENEGAL....51
13.3.1. Le Sanores....51
13.3.2. Le systém Guéroult....51
13.3.3. Animal powered mills....51
13.3.4. Sites near to The Gambia....51

1. SUMMARY

This is the report of a two-week mission in March 1986 designed to review the progress of animal traction research and development in The Gambia, and to discuss options for combining possible GARD support in this area with regional networking activities.

Animal traction is used by over half the farmers in The Gambia, a high proportion compared with other countries in Africa. Adoption on a large scale is attributed to a major extension effort started in 1955. This was initially based on extension centers where farmers were trained to use N'Dama oxen. However during the past decade, farmer innovation has resulted in the widespread use of donkeys which are now the dominant draught animal in The Gambia. Estimates suggest that there are about 30,000 donkeys, 20,000 oxen and 5,000 horses in use in The Gambia.

From 1955 to 1965 Emcot ridgers were available for primary cultivation. In the late 1960s attempts were made to promote a wheeled toolcarrier, but this was rejected by farmers as being too heavy, complicated, and expensive. Following equipment evaluation trials in the early 1970s, the Department of Agriculture recommended the use of the Sine Houe and Super Eco seeder made in Senegal, and these have been widely adopted. Farm-based trials carried out in 1973 demonstrated that the equipment package being recommended for groundnut production was technically and economically appropriate. Recent long-term on-station trials involving alternative oxen cultivation techniques have been inconclusive but farmers themselves have been moving towards cultivation systems with low draught requirements. A maize cultivator has been developed in the last two years, but it appears heavy, complicated,and expensive.

Three major constraints to the further use of animal traction are the high cost of oxen, mortality among donkeys and difficulties in obtaining appropriate equipment and spare parts. The provision of credit, chemoprophylaxis, and improved equipment supply could alleviate these constraints. The conservation of groundnut hay is a proven solution to the problem of animal nutrition, and is being rapidly adopted.

A methodology for research and development studies is proposed that involves visits to villages by research workers of several disciplines to identify with farmers the priority areas for future adaptive research. Attempts would then be made to build on the experience of neighboring countries in these priority areas, through literature searches, study visits, and collaboration in training and workshops. Comments are provided on some suggested research topics, including the use of draught animals for rice cultivation, the use of cows for work, the development of various implements, the use of animal energy to raise water and the potential for using tied ridges.

Any technical assistance relating to animal traction should be aimed at supporting existing Gambian staff. Further discussions with other interested organizations would be required before specific proposals could be drawn up for combining medium-term technical assistance in this area with other networking initiatives. However strategic short-term assistance designed to stimulate a farming systems and networking approach could be implemented in the near future.

2. OBJECTIVES AND PROGRAM

The mission objectives were to review past animal traction research in The Gambia and future plans; to consult with staff of the International Trypanotolerance Centre (ITC) and the Forage Agronomy Program on possible research areas relating to animal traction; to consult with visiting representatives of the International Livestock Centre for Africa (ILCA) on prospects for regional networking cooperation; and to identify areas for possible GARD support to animal traction research, and possible training and technical support.

The mission started on 26th February 1986, with a briefing by the GARD Chief of Party. Five days were then spent in Banjul during which time available literature was reviewed and discussions were held with staff of the Department of Agriculture, the Department of Animal Health and Production, GARD, ITC, and ILCA. Two days were spent visiting several villages in the Western and Lower River Divisions and holding discussions with farmers. One day was spent visiting Sapu Research Station and the Jahaly Pachar Rice Project in the MacCarthy Island Division, and presenting the initial findings of the mission at a seminar. Following further discussions with the Assistant Director for Agricultural Research, the Mixed Farming Project, GARD, ITC and USAID, the final days of the two-week assignment were spent on further literature reviews and report preparation.

3. ANIMAL TRACTION PERSPECTIVE

Before reviewing animal traction experience in The Gambia, it may be helpful to provide a perspective of draught animal power use elsewhere. In

the world there are a total of about 400 million draught animals, of which about 16 million are used in Africa. In Egypt and North Africa animal traction has been used for several thousand years, and cattle, donkeys, horses, buffalos, and camels continue to be used for land preparation and transport. In Ethiopia, about 6 million draught oxen are used, mainly with a plough that has changed little during recent centuries, and donkeys are widely used as pack animals. Elsewhere in Sub-Saharan Africa animal traction in agriculture has been introduced during the present century. In Botswana, 80% of farmers use teams of six or more animals (cattle or donkeys) for ploughing. In most other countries in Africa, the majority of farmers still use hand cultivation, and overall only 10-20% of farmers use draught animal power. However such national figures often disguise very large variations in adoption patterns, with 80% of farmers in some localities using animal traction while less than 6% may use it in other areas.

Throughout Africa, the major operation for working animals is primary land cultivation. In Ethiopia a traditional wooden ard (maresha) is used, while in most other countries steel mouldboard ploughs are employed. Ridging is less common, although it is widely used in northern Nigeria. The use of cultivation tines is not widespread, although these are being increasingly employed in some Sahelian countries. With the notable exception of Senegal animal drawn seed planters were seldom widely adopted.

In West Africa, animal traction has been promoted for over fifty years, mainly by cotton and groundnut exporting companies. North of the trypanosomiasis belt zebu cattle are the main draught animals for agricultural operations, with horses and donkeys being mainly used for transport. In the

tsetse areas trypanotolerant taurine cattle, such as the N'Dama, are the dominant draught animals. In southern Mali around 200,000 draught cattle are used mainly for cotton and maize production. In Guinea, Sierra Leone, and parts of Casamance, about 100,000 N'Dama cattle are used primarily for growing sorghum, millet, groundnuts, and rice.

The proximity to The Gambia of Senegal makes the animal traction experience of Senegal of particular interest. The use of draught animals in agriculture in Senegal followed the use of horses for urban transport during the nineteenth century. The active promotion of the use of draught animals for cotton and groundnut promotion started in the early years of this century, and has been maintained in various ways until the present time. Now over 30% of farmers in Senegal use draught animals including 200,000 horses, 130,000 donkeys, and 100,000 cattle (Harvard, 1986). Equines and Zebu cattle are mainly found to the north of The Gambia, while in southern Senegal most draught animals are taurine cattle. The very high proportion of equines is unusual in Sub-Saharan Africa, as is the large number of seeders (150,000) and groundnut lifters (70,000) in use. Senegal has one of the largest manufacturers of draught animal equipment in Africa, known by the acronym SISMAR, formerly SISCOMA.

4. THE DEVELOPMENT OF ANIMAL TRACTION IN THE GAMBIA

In many countries in Africa some innovative agricultural officers, missionaries or farmers experimented with draught animal power prior to the time of the second world war, and it is likely that some small-scale initiatives in this field took place in The Gambia. However the first

systematic attempt at introduction appears to have taken place in 1947, when ex-servicemen were assisted to purchase oxen and "Sutlidge" steel ploughs of a single-mouldboard design (K. M. Banja, personal communication). The initiative that paved the way for a major extension thrust started in 1955, with the establishment by the Department of Agriculture of the first ox-ploughing schools. Credit for the early work is given to Hector Davidson who subsequently became Director of Agriculture. These schools initially trained both young men and oxen for long periods of six to nine months, during which time accommodation and board was provided, and a small allowance paid. The progress of these schools, subsequently known as Mixed Farming Centres and District Extension Centres has been reviewed by Matthews and Pullen (1974), Mettrick (1978) and Cham (1979). By 1960 there were 13 schools with 104 trainees; and by 1965 there were 24 schools with 377 trainees. The period of training was gradually reduced, so that in 1965 it involved two months at the center, the cultivation season on farm, with supervisory visits, and regular refresher training at the center. Cattle were provided by the family or sponsors of the trainee and for the first season ridgers were lent to the trainee. Small financial incentives were given to the trainees and trainers to encourage widespread use of the animal during the first season, and short-term credit was made available for purchase of seeds and fertilizer. Trainees, or their sponsoring farmers, were expected to purchase their own ridger by cash payment after the training period.

The equipment made available during the 1950s and 1960s was the Emcot ridger, which had been successfully employed in northern Nigeria. It had been commercially produced by Ransomes of U.K., and later by John Holt of Nigeria.

The Emcot ridger was heavy, and robust, and relatively easy to use and maintain.

The initial impact of the ox-ploughing schools was considered encouraging and resulted in the numbers of work animals in use increasing rapidly. Prior to 1955 very few farmers in The Gambia used draught animals. However the major extension program based on the ox-ploughing schools undertaken during the late 1950s and the 1960s brought animal traction into the majority of villages in the country. This was clearly illustrated during the farm visits of this present mission, when farmers in fifteen villages all asserted that animal traction had started in their villages 17 to 20 years ago as a direct result of the Department of Agriculture program. Through the training centers and secondary farmer adoption the extension program led directly to about one third of farming families using draught animal power by 1975, which is a high proportion for Africa. Such a major change in just twenty years represents a small agricultural revolution and is indicative of a highly successful extension program.

The success of the extension programme was despite some major errors of judgement concerning appropriate equipment, and this topic was well reviewed by Mettrick (1978). Between 1965 and 1973 the Department of Agriculture, in collaboration with the National Institute of Agricultural Engineering (NIAE) of U.K. promoted the use of "Aplos" and "Xplos" toolcarriers which had pneumatic tyres. These toolcarriers could be converted for use as carts. Although six examples of similar French-manufactured "Polyculteurs" had been used in Mixed Farming Centres prior to the importation of the Aplos, it appears that there was very little consultation with farmers prior to

promotion. A total of 900 units were imported before it was concluded that the toolcarriers were inappropriate being too expensive, too heavy, and insufficiently mobile around stumps (Mettrick, 1978). While the tool carriers could act as carts and implements, their cost was comparable to the combined price of a cart and a more simple toolbar, and farmers did not like the complication of converting, nor the added risk that one breakage could leave the farmer with neither cart nor plough. Some of the toolcarriers remain in service, but only as single purpose carts (Cham, 1979).

Following the problems with the wheeled toolcarriers and the evaluation of implements from several sources, in 1975 it was decided to standardize on a slightly modified version of the Sine Houe and the Super Eco Seeder, both made by SISCOMA in Senegal (Matthews and Pullen, 1976). This provided three cultivation possibilities: direct seeding, tine cultivation, and ploughing. However the ridger attachment was not recommended for primary cultivation.

From 1955 to 1976 training had been based at Mixed Farming Centres and involved only N'Dama work oxen. Concerned that the training was only reaching the young men sent for training, in 1977 it was decided to start a program of village based farmer training. At the same time as the shift to village training, it was decided to allow the training of donkeys and horses. Up to this time all reports had referred to "oxenisation" and "ox-drawn implements", and donkeys and horses had not been trained at Mixed Farming Centres. However farmers had been increasingly using equines for work, obtaining the animals and harnessing from Senegal. The 1974/5 Agricultural Census (a sample survey) put the number of oxen or bulls in use at 44,000 and the donkeys and horses at 10,000 and 6,000 respectively. Already by 1974, 25% of compounds were using

donkey power, primarily for seeding, and in the MacCarthy Island Division (MID), there were already more donkeys in use than oxen. Mettrick (1978) noted that in this area, farmers owning suitable cattle were apparently using donkey power in preference to work oxen. Thus, in contrast to the initial introduction of ox power, which was highly innovative, the decision to train donkeys and horses was an example of the extension staff responding belatedly to the farmers' own innovation. In 1977, 1,325 ox pairs, 296 donkeys, and 30 horses were trained in the villages under the supervision of extension workers. By 1980 the numbers of oxen trained had fallen to 1,010 pairs, while the numbers of donkeys had increased to 517 and the horses to 83 (Eyre, 1980). From this time to the present date, the numbers of donkeys and horses in use has been increasing very rapidly. Figures for 1983/4 put the national figures as 38% of compounds using oxen, 44% using donkeys, and 13% using horses (it should be noted that these figures are not exclusive and some farmers will be in more than one category). In MID south 89% of farmers used donkey power. There are major differences between the Divisions in the use of donkeys, and in the western Division oxen are still the main power source. Nevertheless, even in the Western Division, farmers are increasingly using donkeys and the 1983/4 figure of 13% of households using donkeys (while 44% use oxen) would seem too low for the present year. Thus during the period 1965 to 1985, donkeys changed from being of minor importance to their present status of the dominant draught animal of The Gambia. This rapid change,

almost another farming revolution, appears to have come about primarily through farmer innovation rather than extension effort, and illustrates clearly how quickly a technology can spread without government intervention if farmers see it to be profitable.

Exact figures on present numbers of working animals are not available but ITC estimates put the number of working oxen at about 20,000. The number of donkeys in use is likely to be greater than this, perhaps 30,000, while the number of horses would be much lower, perhaps 5,000. The move towards donkey power has been associated with the increased use of seeders and cultivation tines. On many farms, oxen are used for ridging and ploughing while equines are used for the additional operations of seeding and weeding. On other farms there has been a definite move from ploughing or ridging to planting on the flat with tine cultivation, and donkeys and horses working alone are capable of this. Donkeys and horses are being increasingly employed for rural transport.

5. RESEARCH RELATING TO ANIMAL TRACTION

Most research and development work relating to animal traction has been based on equipment. In the period 1955 to 1965, the Emcot ridger was the main implement used, but a need was seen for a more versatile tool capable of weeding. As already mentioned, from 1965 to 1972 the Department of Agriculture, in conjunction with the British NIAE, promoted the use of wheeled toolcarriers. However few experiments were conducted in which these implements were investigated and no programs were undertaken to identify cultivation systems in which they could be employed (Kemp, 1978). This program

seems to represent an antithesis of farming systems methodology. The toolcarriers had been designed in U.K. on the basis of technical excellence, rather than appropriateness to farming systems in The Gambia (Willcocks, 1969). They had not been proven by farmer adoption elsewhere in Africa, but were an entirely innovative technology. The justification for their introduction appears to have been the concept of a "mechanical ladder"' in which they represented a stage between simple animal powered implements and small tractors. However the logic of this was subsequently questioned by Mettrick and his co-authors in their evaluation (Mettrick, 1978). While at the same time a small NIAE designed tractor was tested by the Department of Agriculture and found unsuitable before any promotion was initiated, there appear to have been no systematic attempts to evaluate the Aplos and Xplos either on-station or in conjunction with farmers (Mettrick, 1978). The tool carriers were rejected by farmers as being too expensive, too heavy, too complicated to adjust, and insufficiently mobile. Clearly the expensive "failure" of the Aplos program could have been avoided had farmers been consulted from the outset, and had the innovation been first evaluated by farmers, both technically and economically. However the experience of the toolcarrier promotion has been well documented, and provided the lessons are carried forward into future research and development activities, the program will not have been in vain. This illustrates a major element of development research, that "failures" can be extremely valuable provided they are well documented and publicized.

From 1973 to 1976 a series of replicated trials were carried out at Yundum and at Kerewan, near Sapu, with corroboration demonstrations at five Mixed Farming Centres. The results of these trials were published in detail (Matthews and Pullen, 1974; Matthews and Pullen, 1975). These trials evaluated several designs of implements including the Sine Houe, Arara, Unibar, Houe Occidental, and Super Eco seeder. A total of twelve possible systems of land preparation for groundnut production were compared and the treatments included different combinations of ploughing, ridging, tine cultivation, and hand operations. In addition eleven systems of weeding were compared including tine cultivation and tied-ridging. Work was also carried out on the use of N'Dama for swamp rice cultivation.

Matthews and Pullen (1974, 1975) concluded that the Sine Houe toolbar package was most appropriate for The Gambia, and recommended a few modifications, such as as elongated hake and adjustable handles. The standard attachments to be made available would include a 9-inch plough, a ridger, a groundnut lifter, and either three or five cultivation tines. The ridger was intended for the earthing up of cotton only as it was recommended that groundnuts and cereals be grown on the flat. The SISCOMA Super Eco seeder was recommended, and details of the adjustment and use of the SISCOMA equipment were provided in a technical bulletin (Matthews and Pullen 1976).

The trials of Matthews and Pullen provided much information on the labour requirements for the different operations, and on advantages and disadvantages of different techniques. For example it was concluded that ridging was the fastest method of preparing the soil but it should be performed before there was much weed growth. Ridge erosion could be reduced by tying ridges, but the

implements tested caused severe fatigue to the operator and animals. However as there were not observable yield benefits and as no ridge planter was available, the use of ridging was not recommended. Mouldboard ploughing significantly reduced weed growth compared with other cultivation techniques. In some trials, mouldboard ploughing produced significantly higher yields of groundnuts than direct seeding with the Super Eco seeder, but the benefits were achieved at the cost of much extra work. Spring tines were more effective than rigid tines in controlling weeds. While animal drawn weeders saved much time, no significant differences in yields were obtained for the various cultivation techniques. It was noted that several weeders, particularly the small Houe Occidental tended to clog if the weeds were large, and so frequent weeding was recommended to overcome this problem (Matthews and Pullen, 1974).

During 1974, N'Dama oxen were used in swamp rice cultivation trials at Sapu and Sololor. The trials were not replicated but they established the feasibility of using oxen in irrigation schemes. The recommended procedure was to flood to a depth of 25mm and to commence cultivation about 24 hours later using a 9" mouldboard plough. This was to be followed by reflooding to 75-100mm and leveling after two to three weeks with a wooden board pulled by the oxen. The plough used in the trials was a Unibar, fitted with a wooden skid instead of a depth wheel. The draught requirements for the operations were high at about 110-135kg for the 9" plough. The use of a zig-zag harrow was discontinued as the draught of 200kg could represent up to 50% of the weight of a young pair of oxen. It was noted that the fields had to be well cleared of trash to allow the ploughing and leveling operations to be

successful. Ploughing was undertaken at a rate of 0.030-0.044 ha/hr, which was about ten times faster than hand cultivation although three people were used with the oxen, and the oxen could not work for more than a few hours (Matthews and Pullen, 1974).

Matthews and Pullen (1974, 1975, 1976) also carried out trials with the use of single oxen, and concluded that single animals were particularly suitable for light operations such as seeding and inter-row cultivation. For use in pairs they recommended that the existing simple neck yokes be used, with different lengths for ploughing and weeding.

In general the research carried out by Matthews and Pullen on equipment evaluation appears to have been useful and comprehensively reported. However the on-station data relating to the labour requirements for operations was markedly lower than that obtained through on-farm trials by the Land Resources Division (Dunsmore et al., 1976), and the lack of farmer involvement in the studies makes it advisable to treat some of the conclusions with caution. The study involved only agricultural engineers, and recommendations that farmers should feed supplements of ground cereals to their oxen was based on on-station work at IRAT in Senegal rather than on any studies in The Gambia involving animal nutritionists or farmers. The figures quoted for average animal weight losses of 25kg following three hours of ploughing are very high and do not appear to have been controlled. Such statistics should not be considered as being authoritative.

An extensive randomized and stratified series of on-farm trials designed to evaluate the recommended groundnut packages using either draught oxen or hand labour were carried out in 1973 and these were reported in the Land

Resources Division (LRD) study (Dunsmore et al., 1976). The trials involved a total of 81 compounds in the Lower River, North Bank, and MacCarthy Island Divisions. Traditional techniques were compared with the ox-cultivation package and a similar package that used only hand labour. The work involved fields of about one hectare rather than experimental plots, and socio-economic data was collected on labour required to complete the various operations and yield information was recorded. Both "improved" treatments which involved monocropping with new varieties, fertilizer application, and up to three weedings gave significantly higher yields than the traditional controls. While there was no significant yield difference between ox cultivation and manual cultivation using the package, there were consistently higher yields recorded by the manual techniques and these were attributed to the higher density of groundnut plants achieved through hand planting (Dunsmore et al., 1976)

The LRD survey noted that the higher yields were associated with larger variations, suggesting the new techniques increased the uncertainty of the production system. The ox cultivation involved almost the same labour as the traditional system, with the greater time spent in land preparation with oxen being offset by a reduction in the requirement for weeding. Using the improved package without oxen required much more work, particularly during the crucial July peak period, although the traditional system required least work at this time. Economic analyses showed that gross margins were highest in the improved manual package, but that returns to labour were lowest in this system. Ox cultivation had significantly higher returns to land and labour than the traditional system. The social analyses did not identify any

significant deleterious effects of the ox-cultivation system. The SISCOMA equipment found to be very satisfactory.

The LRD trials appear to have been thoughtfully planned and implemented combining close farmer contact with technical, economic, and social analyses. They provided useful information on the various costs and benefits of growing groundnuts using work oxen and confirmed that the recommended package using draught animals was technically and economically sound. The authors went on to develop alternative economic models that took note of the different implications of cultivation systems on both male and female members of compounds. Although similar field studies on cotton and rice did not involve draught animals, models were prepared. In which their use was postulated, and it was envisaged that oxen could be profitably employed for both crops. From the trials and the economic models it was concluded that technology "packages" were appropriate in The Gambia, and that packages involving ox cultivation should be developed for both cotton and irrigated rice (Lowe, 1976).

The LRD study did not make reference to the use of donkeys for crop cultivation. In this respect it is similar to other documents relating to animal traction in The Gambia. During the present mission, a review of available documents combined with discussions with research and extension staff suggests that no systematic research studies have been carried out on the use of donkeys in The Gambia.

In the late 1970s a prototype fertilizer applicator modification to the Super Eco seeder was developed at Yundum, but to date this has not been further developed.

From 1981 to the present year, a series of trials have been undertaken at Sapu Agricultural Station in which hand, oxen, and tractor cultivation are being compared. The trials are carried out on 9m x 9m plots with six treatments and three replications. The upland crops of maize and groundnuts are grown using traditional manual minimum tillage techniques, using herbicide-based minimum tillage and using tractor ploughing. The tractor ploughed system uses the animal drawn Sine Houe package for planting and weeding. Three treatments employ oxen in different techniques for primary cultivation. These involve the use of the Sine Houe in the system adopted by the farmers in the area, the use of cross cultivation with two passes of the Sine Houe tines, and the use of the Emcot ridger. The same plots have been used each year, and data is now available for four years. While the treatments have not shown differences that have been statistically significant, the minimum tillage techniques have led to the stunting of maize, associated with drought and the tractor ploughing seems to have been beneficial (T. Senghore, personal communication).

A maize cultivator and planter was designed by the Mixed Farming Project in 1984, and was tested by farmers in both 1984 and 1985. The double toolbar can be used to plant two rows of seeds at a time, and the cultivation tines allow over-the-plant weeding, on both sides of the row. The toolbar was developed in cooperation with the SISMAR factory which made the two discs that can be used both for weeding close to the row and for ridging. The frame uses the same steel as the Sine Houe and most components are compatible with the standard Sine Houe toolbars, although an articulation wheel has had to be specially made. Eight units were evaluated by farmers in 1984 and these were

then lent to other farmers in 1985. Following various problems experienced by farmers, extension workers, and the supervisors in 1984, greater emphasis was put on farmer and extension worker training prior to the 1985 evaluation. Although there were some breakages and technical problems, the toolbar was successfully employed by some of the farmers, particularly those with well trained animals. However it was generally agreed that the toolbar was heavy, difficult to maneuver and complicated to set up. It was also very expensive (about $400). Although it was designed for maize production, one of the farmers successfully used it for cotton weeding and groundnut lifting. The Mixed Farming Project feels it has designed a potentially useful toolbar that is worth developing further (Shuman, 1986); but elsewhere in the Department of Agriculture, serious doubts have been expressed concerning its applicability. In particular it is felt that the heavy draught requirement, the problem of maneuverability, the complexity and the high cost of the toolbar makes it unlikely to be adopted by farmers.

In addition to the research and development work of the Department of Agriculture, there have been initiatives relating to animal traction carried out by other development agencies. These have included local modifications to equipment and management systems and the development of artisanal production of equipment and spare parts. For example in 1980 in villages in Kiang West, Action Aid carried out demonstrations involving the use of teams of two donkeys and the Houe Occidentale with the mouldboard plough attachment, with the aim of assisting women's groups involved in rainfed rice production (Senela, 1981).

Finally it should be noted that the farmers themselves have been carrying out much adaptive research and development work on animal traction. All development work, to date, on the use of donkeys has been carried out by farmers, based on ideas and experience brought in from Senegal. Other farmers have been adapting equipment and cultivation techniques, and some have started evaluating the use of animals for rice cultivation. Many farmers have been assessing the use of groundnut hay supplementation and some farmers are trying the use of cows for light work. Farmers have been making informal technical and economic comparisons between the use of horses, donkeys, and oxen for different operations. This ongoing adaptive research is extremely valuable, and the rapid spread of innovations resulting from the farmers' own development initiatives illustrates the importance of this work.

6. PRESENT CONSTRAINTS TO DRAUGHT ANIMAL POWER

The high cost of cattle is cited as one of the major constraints to the adoption of work oxen. While cattle ownership has increased greatly in recent years (with the national herd expanding eightfold in fifty years), many farmers do not own two male animals, and cannot afford to buy them. The rapid adoption of donkey power is mainly attributable to their low cost. Donkeys can be bought for D80-150 ($15-25), while oxen are likely to cost D600-1000 ($100-170). Farmers accept that donkeys are likely to die within a few years, with no income from sale, while oxen are likely to be sold at a profit after their working life. Thus while farmers are aware of the potential profit involved in investing in oxen, lack of capital or credit prevents many farmers from adopting work oxen.

Disease is not considered to be a major constraint to ox owners, as the trypanotolerant N'Dama are very hardy. However it is the major constraint to the utilization of horses and donkeys which are highly susceptible to trypanosomiasis. Donkeys experience very high mortality rates, and the population is maintained by continued importation from Senegal. Farmers buy donkeys in the knowledge that they may well die within two years, but the low price justifies this risk. In most of the villages visited, donkeys had only been used for about ten years, and during this period many had died within two years and few animals had survived for more than five years. Farmers considered that reproduction in donkeys was improving, in that in recent years more foals had been born and had survived, but in most villages the reproduction did not keep pace with mortality. Farmers acknowledge that horses are more susceptible than donkeys, and this, combined with their cost (between three and six times that of a donkey) restricts the use of horses. While the main disease problem appears to be trypanosomiasis, an unpleasant skin infection with the appearance of yoking sores can prevert donkeys from being harnessed.

All farmers contacted cited problems in obtaining equipment and spare parts, with limited availability being emphasized much more than high cost. Many farmers in the Western Division are still using Emcot ridgers bought 17-20 years ago, and replacements for these are not presently available. Local artisans are able to make some spare parts, such as the wearing parts of tines, but farmers complained of the quality and lack of durability of more ambitious repairs and implement manufacture by blacksmiths. In the past, lorries from SISCOMA/SISMAR would visit villages to sell implements and parts,

but farmers had not had this service in recent years. Many farmers appeared to overcome the problem of high cost equipment by buying used implements derived from Senegal.

All farmers contacted indicated that the initiative to start to use work oxen in their villages had come from the Agriculture Department and there were no indications that training or technical advice were lacking. Inevitably some farmers are completely unaware of novel techniques; for example, several farmers indicated that they had never thought of using draught animals for rice cultivation. However in several areas innovative farmers have started to try new techniques such as rice cultivation using oxen, horses, and donkeys, and the use of draught cows. One farmer contacted had only one ox, but when he had tried to yoke a cow with it for work, he had been threatened with legal action by the local extension worker who assumed from his training that only oxen were to be used for draught operations. In a few other villages farmers have successfully experimented with the use of females, and the word has spread to neighboring areas that this is feasible. The rapid spread of donkey technology illustrates how quickly knowledge can diffuse through informal channels. Thus it is concluded that lack of technical knowledge is not a major constraint to draught animal power in The Gambia. However the standard of training of oxen is often poor, and it is not unusual for three people to be used to control them. While there may be very valid reasons why farmers do not invest more time in the training of their animals, few farmers seemed aware that it is quite possible for oxen to be worked with one person, as is the norm in Ethiopia and Asia. As farmers cited that the move towards the use of donkeys was related to the perceived requirement for several people to work with oxen, past training standards may be implicated in this change.

It has already been noted that there have been major changes in recent years relating to cattle and donkey ownership. In some areas men have become involved in the cultivation of rice, which has traditionally been the responsibility of women. With such examples of rapid changes in agricultural traditions, it is unlikely that socio-cultural factors act as a major constraint to draught animal power in The Gambia. However many farmers cited the fear of theft of animals as a major constraint to the use of oxen, as opposed to donkeys. In one village, farmers argued that donkeys were preferred to oxen as it took fewer people to control them. When it was suggested that if oxen were better trained they would require fewer handlers, it was pointed out that well trained, docile oxen were not desirable, as they would be easier to steal. In this particular village, oxen availability was not a problem and it was the strong fear of theft that had persuaded many cattle owners to take up the use of donkeys rather than oxen.

While the nutrition of cattle in the dry season is a major problem, many farmers now conserve groundnut hay for their draught animals. The effectiveness of this system of improving the nutritional status of draught animals can be seen in the better body condition of working animals and in recent years there has been a marked and rapid spread of the systematic conservation of groundnut residues. A significant market in groundnut hay has recently developed, and owners of draught horses in particular appear willing to purchase feed for their animals if their own stocks run out. Thus while inadequate nutrition may be a problem for some working animals, particularly those oxen that rejoin herds in the dry season, there appears to be an effective, proven solution available that is increasingly being adopted.

In conclusion it would appear that most of the preconditions for successful animal traction are already found in The Gambia. Thus there is sufficient land, there are suitable animals and proven, socially acceptable systems of crop cultivation, animal nutrition, and management. Knowledge of appropriate techniques and equipment is widespread, and the farming population has recent traditions of innovation. The crucial constraints to the greater adoption and more efficient utilization of animal power appear to be lack of capital or credit, difficulties in obtaining equipment, and mortality among the donkeys and horses. It is of interest to note that these key limiting factors have known solutions, and so the current low level of government research in animal traction does not appear to represent a major constraint at present.

7. PROPOSED METHODOLOGY FOR FUTURE RESEARCH AND DEVELOPMENT

The Gambia, being a small country, has limited manpower and financial resources that it can devote to new government sponsored animal traction research and development initiatives. It is therefore unrealistic to contemplate large, fundamental research programs. Rather, the limited resources available should be allocated to adapting proven technology and the experience gained from research and development programs elsewhere to the specific ecological, agricultural, and socio-economic conditions found within The Gambia. Such research and development initiatives should be carefully prioritized so that they address the crucial limiting factors affecting the profitable and productive use of animal energy.

A five-point strategy is proposed for the orientation and implementation of future research and development initiatives relating to draught animal power. This involves a multi-disciplinary, farming systems approach, and a networking system of operation. As such, it appears completely in line with the approaches already proposed by GARD, ITC, and staff of the Department of Agriculture (Cham et al., 1982).

Firstly, through discussions with farmers, extension workers, and research specialists, a list of priority areas for possible action should be drawn up. This list should include the main constraints perceived by the farmers, and farmer suggestions for possible solutions. It might also include innovative technologies, known by research workers, that have received favorable farmer reaction. Farmers should be asked to provide an indication of the maximum cost that they would be prepared to pay themselves for solutions to particular problems, and this information should be carefully born in mind in all subsequent activities designed to find appropriate solutions.

Secondly, a review should be undertaken of previous work in these priority areas. This review should involve local reports and a study of relevant international literature. Approaches should be made to appropriate aid agencies, international, and national research centers and national programs in other African countries. This should result in an appreciation of existing knowledge in the various fields and the major centers of experience.

Thirdly, where proven solutions to problems appear to exist elsewhere, contact should be made with the relevant authorities, and a program for building on existing experience should be drawn up. This may include study visits to other countries, invitations for information exchange/training

visits from appropriate experts from other countries, and the importation of proven technology (equipment, designs, techniques, or systems). Farmers should be consulted at all stages of the exercise, to ensure that the technology being investigated is likely to be considered technically, socially and economically appropriate to the local conditions.

Fourthly, the knowledge from elsewhere should be evaluated by local farmers. The early screening processes should have removed the necessity for comprehensive on-station evaluation, and in most cases the technology could be tested by cooperating farmers from the outset. At this stage, overall farmer assessment is the main objective. Thus, while detailed records would be valuable, comprehensive data collection is not a prerequisite, for the conclusions of several farmers may well be more significant than any parameters recorded by enumerators. Farmers should be free to modify the innovation as they see fit.

Finally research and development workers (in conjunction with farmers) should evaluate the innovations and jointly plan any follow-up programs of modification, re-testing and further research or incorporating well-proven techniques into the extension and training systems.

While listed as five separate components, the various processes would be part of an integrated, continuous, and adaptive program with feedback from farmers, extension staff, researchers, and policy makers allowing constructive modification at all stages. While a holistic approach would be maintained, individual networking searches might well be component orientated, and could be undertaken at different times. For example while farmers evaluate apparently suitable implements, further liaison could be taking place to identify proven techniques for diversifying operations or enhancing animal condition.

The starting point for such a program should be a series of multi-disciplinary village visits and farmer consultations by the staff of the different departments and organizations who would be responsible for undertaking any research and development work. Such a group visit is strongly recommended, to allow as much of the program as possible to develop from close contact between the farmers and the research workers of different disciplines. However, as several ideas for research studies have already been raised in formal proposals and during conversations, these will be briefly discussed in the light of the methodology proposed.

8. POSSIBLE RESEARCH INITIATIVES

8.1. 5-YEAR PLAN FOR MECHANIZATION OF CROP PRODUCTION.

8.1.1. General.

A five-year plan for research, much of it relating to animal traction, was prepared by Cham et al. in 1982. The proposals were discussed during the present mission with the senior author who is Head of the Agricultural Engineering Unit at Yundum. Although the proposals were first prepared in 1982, most of the proposed research remains to be undertaken. While significant funding would have been required for some of the proposals, the primary constraint to their implementation has been lack of available time of professional staff of the agricultural engineering unit. This is jointly attributed to a small cadre of staff, and other diverse responsibilities such as maintenance work. However the Unit anticipates that this will be less of a constraint in future.

It has been, and continues to be, the aim of the Agricultural Engineering Unit to undertake its research using a multi-disciplinary approach, drawing on expertise from soil scientists, agronomists, animal production specialists, economists, and social scientists as appropriate. It is also policy to endeavor to liaise with external organizations and so benefit from experience elsewhere. In this respect, the aspirations of the Unit are completely in accord with the philosophy underlying this present report.

8.1.2. Ridge-planter evaluation.

For a number of reasons, some farmers prefer ridge-cultivation, although most Department of Agriculture advice is now aimed at encouraging planting on the flat. While ridging with animals is quicker than comparable ploughing techniques, animal powered ridge planting is more difficult than flat planting, and so generally involves more expensive equipment, or less reliable results. At present no ridge-planters are available in The Gambia, and during the equipment evaluation of the 1970's ridge-planters were not widely tested due to their high cost and poor availability. The present proposal involves the testing of well-proven designs from elsewhere in Africa, including Senegal. Information will be required on some additional sources of supply. While it is known that some farmers have been requesting ridge-planters, little reliable data exists on the extent of this demand, nor on the ability of farmers to pay for them. Economic considerations should be an essential part of this study, and information on how much farmers would pay for a ridge-seeder would be valuable from the outset in order to assess the priority that should be given to this potentially useful proposal.

8.1.3. Ridging attachment to the Sine Houe.

The "Emcot" ridger body has been found effective by very many farmers in The Gambia, and it is generally considered preferable to the "SISCOMA" ridger supplied with the Sine Houe package. SISMAR has therefore agreed to make a ridger attachment for the Sine Houe based on the Emcot design. This collaboration between the Agricultural Engineering Unit and SISMAR is in an advanced stage, and appears a useful arrangement that, subject to adequate engineering and testing, should allow a well-known design to become commercially available again.

8.1.4. Harnessing systems.

It has been proposed that information on harnessing systems used elsewhere, including Senegal, should be studied, with a view to assessing designs for multiple hitching of donkeys and horses. At present both neck yokes and withers yokes are used for oxen, and the same farmers often use withers yokes with their carts and neck yokes for ploughing. Yokes are of a very simple pole design and they can be easily made and repaired in the villages. The yokes used with ox carts seem longer than necessary, and it might be useful to ascertain if there are sound reasons for this. During discussions it was agreed that research on harnessing systems was not an area of great priority at present. However reports of comparable research elsewhere would be of value in planning any future initiatives in this field.

8.1.5. De-linting of cotton seeds for Super Eco Seeder.

Lint on cotton seeds reduces the efficiency of the Super Eco Seeder. The Agricultural Engineering Unit has proposed that acid treatment could be an industrial process to overcome this problem in The Gambia, and has undertaken

some initial trials to identify appropriate dilution rate. A more extensive research program in this area is now envisaged. It is recognized that such a treatment would have to be cost effective, and associated with an efficient system for distributing treated seeds.

As many commercial cotton marketing companies have invested heavily in many aspects of cotton production using animal traction, it is likely that the problem of planting cotton seed using animal power has already been investigated in neighboring countries including Senegal, Mali, Cameroun and Ivory Coast. For example a large number of Super Eco seeders are used for planting cotton in southern Mali, and some farmers rub the cotton seeds in cow dung to overcome the problem of lint clogging the seeders. It thus seems very likely that contact with the large French cotton companies, and their African collaborators would be productive. If, as suggested by the Agricultural Engineering Unit, the proposed research on acid de-linting is found to be of a pioneering nature, the contacts could lead eventually to a commercially supported program. However it is likely that such contacts would lead to some additional information being found on previous work on this subject, and on alternative solutions, and this would also be of great value. In either case, The Gambia has much to gain from the many years of animal traction research, development, training and extension undertaken in West Africa by the francophone cotton companies.

The priority given to research relating to cotton should be determined by discussions within the Ministry. If this is considered a priority area, contacts should be made with the cotton companies and an early overland study visit to cotton growing projects in Senegal and southern Mali should be

undertaken. Such information gathering should precede any major research and development work relating to cotton production using animal traction in The Gambia.

8.1.6. Rice cultivation using animal power.

Proposals have been submitted for the on-station assessment of the animal drawn rice cultivation equipment imported by the Chinese Agro-Technical Team but not used. Certainly the use of draught animals for rice production would seem to be an important area for research. Such research should build on present farmer innovation in this area and of the experience of other countries in the sub-region.

Research in the 1970s, and some farmer experience, suggests that rice cultivation using N'Dama is technically feasible in The Gambia, and the constraints to this should be investigated through farmer discussion and on-farm trials. Limited on-station testing may be desirable to screen unproven equipment designs, and prevent the farmer from being asked to evaluate technically unsuitable systems. However the program should be heavily farmer orientated. Given the complex interaction of social, technical, ecological, and economic factors, the multi-disciplinary nature of this research is of particular importance.

Although some farmers have already started trying to use horses and donkeys in rice fields, there are few, if any, countries where donkeys and horses are regularly used in swamp conditions. Thus the proposal of the Agricultural Engineering Unit that it should give emphasis to work with cattle appears well founded.

As N'Dama cattle are successfully employed for swamp rice cultivation in several neighboring areas, including Guinea, Sierra Leone, and Casamance, study visits to projects and villages in one or more of these countries would seem desirable. Following such visits priority should be given to working with farmers to evaluate those management systems and implements that have already been shown to be appropriate for use with N'Dama cattle. It could also prove useful if an agricultural officer or instructor from one of these countries (for example anglophone Sierra Leone) be invited to visit The Gambia to provide some initial practical training for Ministry staff involved in this program.

8.1.7. Assessment of the Houe Occidentale.

It has been suggested by the Agricultural Engineering Unit that it carry out trials with the small Houe Occidentale, a simple cultivator used for donkeys. The advantage of this implement is its low draught and low cost, but its small size makes clogging common and it is not a full toolbar. Many farmers have started buying these implements from Senegal, and while most use it as a weeder, some farmers have started using the mouldboard plough attachment. Thus the implement has passed the primary test of farmer adoption, and farmers often regard it as a complementary tool to the Sine Houe. Therefore fundamental research on the Houe Occidentale does not appear a priority, but the relative advantages and disadvantages of these implements could be discussed with farmers during the proposed multi-disciplinary village visits, in order to ascertain areas of farmer dissatisfaction that require investigation.

8.1.8. Evaluation of combined seeder and fertilizer applicator.

The Fertilizer Project, sponsored by FAO, is currently evaluating two commercially available designs of seeder that incorporate a fertilizer applicator. This on-farm evaluation is being carried out in cooperation with farmers. If the technology proves appropriate and profitable, the project will endeavour to make further units available for wider scale testing. The system adopted whereby farmers test proven and commercially available designs of equipment is fully in accord with the methodology proposed, and the trials should be continued, making sure that economic realism is maintained at all times. Such research should not preclude additional studies involving fertilizer placement at times other than at seeding.

8.2. TIED RIDGES

In certain circumstances, the use of tied ridges (that is ridges joined at regular intervals by small mounds) can improve yields through improved water conservation and reduced erosion. A proposal has recently been prepared for a program of on-station trials and on-farm testing of a new design of animal drawn ridge-tier in The Gambia (Wright et al., 1986). The proposal envisages that three prototype implements would be designed and constructed in USA. These ridge-tiers would be fitted to Sine Houe toolbars and would aim to be improved versions of models tested by IITA/SAFGRAD in Burkina Faso. The research protocol would involve two research stations, four replications, three crops (maize, sorghum and millet) and five treatments. On-farm testing would involve ten farmers, in cooperation with the Farming Systems Research/Extension Unit.

Previous trials with different designs of ridge-tiers in The Gambia were not encouraging, as the operation was very tiring for both the operator and the N'Dama cattle (Matthews and Pullen, 1974). However recent trials in Burkina Faso have involved a rotating tying blade, controlled by a bicycle brake cable, designed to reduce operator and animal fatigue (Wright and Rodriquez, 1986). The work in Burkina Faso involves IITA/SAFGRAD and ICRISAT, and 1986 will be the second year of on-farm trials with animal drawn ridge-tiers. The results have been very variable, but have generally led to yield increases of 25-80%. The ridge tier designed for donkeys has been found much too heavy for the animals, but the version designed for oxen has been found to have acceptable draught requirements for the Zebu animals. Operator fatigue is not a major problem although moving the implement at the end of rows is very difficult. There have been breakages in the mechanism for releasing the rotating blade, and design problems still have to be solved. As the ties are not compacted at all, they have a tendency to wash away, particularly if the ridge is slightly off the contour. To overcome this problem, and the breakages of the rotating mechanism new designs will be evaluated by IITA and ICRISAT in 1986. The ICRISAT protopye animal drawn tied ridger has a very large and eccentric depth wheel that causes the ridger body to rise and fall, and so produces more gradual and compacted ties. Initial results from the IITA/SAFGRAD and ICRISAT studies suggest that the tied-ridge technology is likely to be most appropriate in the 400-700 mm rainfall areas (P. Matlon, personal communication, 1986).

Thus the work in Burkina Faso suggests that construction of tied ridges using animal power may well be a useful means of improving crop yields,

provided the technical problems with equipment can be solved and provided the farmers perceive that the overall benefits justify both the additional work and the investment in equipment. However the Burkina Faso research is still continuing and the technology is not yet ready to be translated into extension recommendations. For this reason the IITA research worker Dr. M. Rodriguez has applied for a grant to develop further prototypes, and IDRC is likely to provide funds which will allow the implements and appropriate systems to be tested in more than one country in West Africa (A. Ker, IDRC, personal communication, 1986).

According to the methodology proposed, future animal traction research in The Gambia should be based on farmer-identified problems and technologies proven by farmer adoption in other countries. The proposal for work on tied-ridges falls into neither of these categories, and therefore should not be given priority in the allocation of scarce financial and manpower resources. It would seem very likely that if the proposed research were delayed for a few seasons, The Gambia would be able to benefit much more from the research and development experience of Burkina Faso and elsewhere, and by building on further experience, returns to research efforts would be much greater.

However the area appears to be one of sub-regional research interest and if, <u>for reasons not connected with national priorities</u>, it is decided to go ahead with pioneering research on tied ridges in The Gambia, this should be carried out in very close liaison with ICRISAT, IITA, and any IDRC-supported research programs in this area. In any project involving regional cooperation, it should be remembered that N'Dama cattle are smaller than the

Zebus, and that donkeys are increasingly becoming the draught animals of choice in The Gambia. Future research should also follow a detailed review of previous experience on tied ridges in northern Nigeria and in Eastern and Central Africa. Given the wide variations in the quality and sizes of steel, all prototypes for use in West Africa should be constructed within the sub-region, preferably in conjunction with SISMAR or similar workshops.

8.3. ANIMAL POWERED SYSTEMS FOR RAISING WATER

The potential for using animal energy for raising water from wells or rivers in The Gambia has been discussed on several occasions, and at least two expatriate workers employed by non-governmental organizations have recently been working on possible designs. Although time was not available to study the various proposals in detail, the impression given was that the research and development methodology envisaged by these people would probably be very time consuming, and would run the risk that insufficient progress would be made before the departure of the expatriates to justify the longer-term continuation of the programs. As much development work in this area has been carried out elsewhere in Africa, it would seem that this is a particularly suitable case for proceeding with a networking approach to research and development. Thus it is envisaged that those responsible for implementing development work relating to animal powered water systems should be aware of the progress made in this field in Senegal, Mali, and Botswana, and that they should visit selected installations in Senegal, some of which are only a few kilometers from the frontier with The Gambia. The first prototypes to be constructed in The Gambia would then be based on several years of joint researcher and villager experience in neighboring countries, and the time thus

gained could be considerable. Details of possible contacts and information sources for this program are given in Appendix A, as an example of the networking approach being proposed.

Most of the information given in Appendix A relates to raising water from wells. However in view of past problems experienced in maintaining motorized water pumps, the use of animal power for irrigating rice fields using river water has been suggested. Therefore it is recommended that experience from elsewhere be assessed, prior to initiating a specific research program, and in addition to monitoring the work in Mali, information could be gathered on irrigation systems used in Egypt and Asia.

The use of animal power for grinding cereals may also be appropriate in The Gambia, and the success of animal powered mills in Senegal should be monitored. At present the village installations in Senegal have only been used for eight months and so it is too early to judge their reliability and long-term profitability.

8.4. THE USE OF DRAUGHT COWS

In some parts of the world, cows are used for work, and the combining of work with milk production and calf raising can be highly efficient and profitable, provided husbandry standards are high. Just to the north of The Gambia, in Sine Saloum, the use of cows for work has increased rapidly over the past decade, expanding from 325 pairs in 1974 to 8,000 pairs in 1981, and about 20% of working cattle in that area are now females (Lhoste, 1983). In The Gambia, female equines are commonly used for work and a few innovative farmers have started using draught cows. It is accepted by farmers that cows

are weaker than oxen, and there are suggestions that they may be less resistant to disease if they are made to work. While it is known that the use of cows is technically feasible, it would certainly not seem appropriate to actively promote their use without more evidence of the various advantages and disadvantages, and so a modest research program investigating the potential for using N'Dama cows for work appears to be appropriate. Such a program should be carried out with the ITC and should be based on cooperation with innovative farmers who may be interested in trying to use cows themselves on their own farms. While regular monitoring would be very desirable in order to obtain quantified data relating to the use of cows, the ultimate assessment must be whether the practise is adopted in the long term by these and other farmers.

8.5. THE DEVELOPMENT OF THE MAIZE CULTIVATOR

Following two years of research and development, ten prototype maize cultivators exist which have been shown to be capable of useful operations, but which are expensive, heavy, and difficult to set up and maneuver. To date they have been used in farmer trials supervised by extension staff. Two important questions that remain unanswered relate to the extent to which the implements would be used if farmers were left entirely by themselves, and whether the farmers would be prepared to pay a realistic price to purchase them. These questions should be answered before significant additional research time is devoted to this program. It is therefore recommended that some of the toolbars be lent out to interested farmers for another season, but with only limited monitoring. While technical advice should be available if

required, there should be no active promotion of the implements. Farmers should be allowed to modify both the toolbars and the methods of their utilization, as they feel appropriate. At the end of the season, farmers should be given the opportunity to purchase the cultivators at a realistic price (perhaps 75% of their replacement cost), with any credit being provided through existing institutions. Should farmer reaction be encouraging, a larger batch of the implements could be prepared for test marketing.

9. PROSPECTS FOR NETWORKING ACTIVITIES

When the dates for the present mission were set, it was envisaged that it would be possible to hold talks with the Director General of ILCA, who was due to be in The Gambia for an ITC meeting. In the event ILCA was represented at the meeting by the Head of ILCA's Livestock Productivity and Trypanotolerance Group. He relayed the information that while ILCA was extremely interested in developing animal traction networking activities in Africa, proposals on the most appropriate mechanism to implement this were still under discussion. Following three joint missions with FAO to fifteen African countries the need for some form of networking arrangement had been clearly established, but funding for such a network had yet to be obtained. Thus while ILCA would be interested in discussing ways in which animal traction work in The Gambia could be combined with African networking, it was not in a position to make financial commitments relating to this. The Head of the Livestock Productivity and Trypanotolerance Group was interested in the potential for including work with draught animals within the Trypanotolerance Network that is coordinated by his group, and felt that it might be possible to combine

such networking activities with an ITC-based position. It was agreed that a concrete proposal would be required prior to any formal negotiations on possible links between ILCA and the GARD/ITC animal traction initiatives, but that some less formal contacts might be appropriate before such a document was prepared.

FAO is also interested in the formation of a network concerned with draught animal power, and in the stimulation of cooperation between developing countries. FAO has been cooperating with ILCA in preparing joint plans for this. While it is unlikely that there would be scope for any formal relationship between GARD and FAO in this area, there could be opportunities for The Gambia to participate in networking activities that may be initiated by FAO in the coming years.

The Farming Systems Support Project (FSSP) will be sponsoring a networkshop in Sierra Leone in September on "The introduction, intensification and diversification of the use of animal power is West African farming systems: implications at farm level." This will be held under the auspices of the Integrated Livestock Systems group associated with the West African Farming Systems Research Network. It is envisaged that animal traction specialists from many West African countries will attend, in addition to representatives of international organizations and research centers. The networkshop will provide a useful opportunity to learn from the experiences of others in the region and to see field demonstrations involving the use of N'Dama cattle for rice production. It is therefore recommended that GARD sponsor the participation of one or more Gambian at this networkshop. While FSSP has financed several networking activities in the sub-region, it does not

have future funding guarantees and may not be able to continue its present level of support to networking in West Africa.

IDRC may start supporting some animal traction networking activities in the region, particularly in relation to research on tied ridges. It is possible that there would be scope for cooperation between the activities recommended in this report and the IDRC program, and it is suggested that this possibility be investigated.

While awaiting more formal network initiatives from ILCA, FAO, and other agencies, The Gambia should endeavour to make networking contacts of its own, and GARD could assist this by obtaining relevant research reports from other African countries and by sponsoring Gambians to undertake study visits. In addition national experts from other countries could be invited to give advice on Gambian research programs. One way to achieve this would be by hosting small workshops with one or two of the neighboring countries. This might be found useful after the first season of research, when progress on research topics (such as irrigated rice production using draught animals) could be evaluated.

10. RECOMMENDATIONS FOR FURTHER ACTION

10.1. POSSIBLE DIRECT INTERVENTIONS

As farmers cited the mortality of donkeys and horses as a major problem, prophylaxis against trypanosomiasis could be given to donkeys and horses. This would be relatively inexpensive, and farmers would generally be prepared to pay for this if it proved effective. This intervention would tend to increase the numbers of farmers using donkeys for draught, and might lead to

some farmers changing from oxen to donkeys, with a resulting decrease in animal powered ridging, and an increase in direct planting with the Super Eco seeder.

As capital is a major constraint to the adoption of draught animal power, schemes to provide medium-term credit could lead to an increase in the use of animal power. As some cattle owners do not have available funds to purchase oxen, loans for the purchase of oxen might well be secured against the collateral of cows or calves maintained in village herds.

As all farmers contacted complained about the availability of implements and spare parts, schemes to improve equipment supply might well lead to increased or enhanced use of animal power. Blacksmith programs might help alleviate spare part constraints, and the supply of a ridger to replace the Emcots, would allow the continuation of farming systems based on oxen power for ridge farming.

10.2. PREPARATION OF WORK PROGRAMME ON ANIMAL TRACTION.

If the proposed methodology of strengthening animal traction research and development through networking is to be adopted, there are some essential preconditions. Firstly liaison has to be assured at a national level. International networking would be of limited value if it were not linked to good information exchange between individuals and organizations in The Gambia. Thus some form of national liaison system should be defined. One possible mechanism would be the establishment of a coordinating committee (or animal traction group), with its secretary responsible for disseminating incoming reports to all relevant individuals and organizations. Its secretary

should also be charged with circulating reports within the country and to external organizations. It is the view of the author that a specific animal traction committee would be highly desirable. Nevertheless it is recognized that some persons may feel that a special committee is not justified in a small country like The Gambia, with good informal linkages between individuals, and if this is the case the same result could be achieved through some existing body, such as the Farming Systems Group. Whichever system is adopted, there should be defined liaison procedures that ensure that all persons working with animal traction whether based at Sapu, Yundum, ITC, or in an NGO project can meet regularly to discuss their work, and that they all be informed when new animal traction documents become available within the country.

Secondly, a search should be made to identify existing experience in the region in the various areas of research highlighted in this report. This would involve obtaining publications and reports, and making contact with organizations in neighboring countries that have tackled similar issues. This search should not be taken to imply that the research areas identified are necessarily of greatest priority, but rather the information gathered should allow more informed decisions to be taken on which programs are likely to be most productive.

Thirdly, those research workers who are likely to be involved in the animal traction program should participate in a 3-5 day multi-disciplinary group trek to villages in all Divisions in The Gambia. This tour would allow joint discussions with farmers by specialists in agronomy, agricultural engineering, animal health, and socio-economics, and other appropriate

disciplines and would act as an itinerant workshop designed to define and discuss the priority areas for research, and appropriate methodologies. Such an activity need not focus entirely on animal traction, and it could be usefully combined with a more general farming systems tour. It could also be linked with an overland visit (of 3 to 10 days) to selected areas in Senegal and Southern Mali, to observe systems of rice, maize, groundnut, and cotton cultivation using draught animals, and the use of draught cows and animal powered water pumps and grinding mills.

Having undertaken the multi-disciplinary tour and agreed on action programs for appropriate research and development programs, the methodology suggested above (Section 7) would be followed. Thus contacts would be made with other countries that have experience in the fields being investigated; and where appropriate study visits could be made and prospects for mutually beneficial collaboration investigated. Close liaison should be maintained between the different workers, and regular multi-disciplinary evaluation of the programs should be undertaken, in cooperation with the farmers.

10.3. POTENTIAL TECHNICAL ASSISTANCE AND TRAINING ACTIVITIES

Any technical assistance in the field of animal traction should be aimed at supporting and stimulating the research activities of Gambian staff. As there are presently only a very limited number of Gambian staff available, priority research areas identified during the multi-disciplinary tour might well benefit from some medium-term technical assistance provision, and this should be discussed after the proposed tour when research priorities have been agreed.

Emphasis should be placed on allowing Gambian staff to benefit from the existing experience of other countries, in order to make their programs more effective. One way of supporting the Gambian staff would be through obtaining, screening and distributing relevant documents and research reports from elsewhere. While such an activity should, as soon as practicable, be the responsibility of the national officer charged with liaison relating to draught animals, in the first instance such a service could usefully be undertaken within the framework of short- or medium-term technical assistance.

Short-term technical assistance could also be used to facilitate contacts with neighboring countries that might result in technical cooperation between developing countries (TCDC). Such facilitation would involve assessing the potential for training visas to other programs in the region, perhaps on a reciprocal basis, and assisting in the planning and implementation of study tours. Wherever possible, emphasis should be placed on stimulating mutually beneficial exchanges within West Africa. For example, if cooperation with Sierra Leone is envisaged in swamp rice work, it might be suggested that a senior officer makes a visit to Sierra Leone of about one week, and an intermediate staff member be trained there for two months. At the commencement of the work in The Gambia, a senior Sierra Leonean might be involved for a one week visit, and if felt desirable, an intermediate level technician could assist initial work for a few weeks.

Comparable and mutually beneficial technical cooperation between West African countries would be feasible in many areas. As already noted, a brief overland study tour by a small group of researchers to projects and organizations in Senegal and Mali that are involved in animal traction would be very useful.

The short- or medium-term technical assistance envisaged would be primarily designed to stimulate and facilitate information exchange and the duties could be usefully combined with regional networking initiatives and/or specific technical support to key Gambian research programs. The combining of such duties would require more detailed planning and consultation than was possible on this mission. Thus it is recommended that while such options are explored the technical assistance envisaged be started as soon as practicable on a short-term basis.

REFERENCES

Cham, P.A., M.S. Jeng, I. Jobe, F.O. Dumbuya, M. Darbo and C.P.S. Sanyang. 1982. Draft proposals for a 5-year (1981/82 - 1985/86) programme for mechanization of crop production, storage and postharvest processing of agricultural produce. Department of Agriculture: Banjul The Gambia. (unpublished) 26p. (E).

Cham, P.A. 1979. The use of appropriate technology in Gambian agriculture. pp 59-63 in Report of West Africa Rural Technology Meeting held 14-22 May 1979 at Yundum, The Gambia and Dakar, Senegal, Commonwealth Secretariat, London. 111p. (E).

Dunsmore, J.R., A. Blair Rains, G.D.N. Lowe, D.J. Moffat, I.P. Anderson, and J.B. Williams. 1976. The agricultural development of The Gambia: an agricultural environmental and socioeconomic analysis. Land Resource Study 22, Land Resources Division, Overseas Development Administration, U.K. (E)

Eyre, C.V. 1980. Village-based farmer training. Report to The British High Commissioner, Banjul 3p. (unpublished) (E).

Kemp, D.C. 1976. The role of UK manufacturers in the supply of ox-cultivation implements with particular reference to The Gambia since 1971. pp 47-50 in Mettrick, H. 1978. Oxenisation in The Gambia. Ministry of Overseas Development, London. 68p. (E).

Lhoste, P. 1983. Développement de la traction animale et évolution des systemes pastoraux au Siné Saloum, Sénégal (1970-1981). Rev. Elev. Méd. vét. Pays trop., 36 (3) 291-300. (F).

Lowe, G.D.N. 1976. Social and economic aspects of change in Gambian agriculture. pp. 359-372 in: Dunsmore, J.R., A. Blair Rains, G.D.N. Lowe, D.J. Moffat, I.P. Anderson, and J.B. Williams. 1976. The agricultural development of The Gambia an agricultural environmental and socioeconomic analysis. Land Resource Study 22, Land Resources Division, Overseas Development Administration, U.K. (E).

Matthews, M.D.P. and D.W.M. Pullen. 1974. Groundnut cultivation trails with ox-drawn equipment: The Gambia 1973/74. Report Series, Overseas Department, National Institute of Agricultural Engineering, Silsoe, UK. 127p. (E).

Matthews, M.D.P. and D.W.M. Pullen. 1975 Cultivation trials with ox-drawn implements using N'Dama cattle in The Gambia. Report Series, Overseas Department, National Institute of Agricultural Engineering, Silsoe, UK. 62p. (E). (Based on Matthews and Pullen, 1974).

Matthews, M.D.P. and D.W.M. Pullen. 1976 Cultivation trials with ox-drawn implements using N'Dama cattle in The Gambia. Report Series, Overseas Department, National Institute of Agricultural Engineering, Silsoe, UK. 49p. (E).

Matthews, M.D.P. and D.W.M. Pullen. 1976. Cultivation and ox-drawn implements. Technical Bulletin Nc 1, Department of Agriculture, Banjul The Gambia. 42p. (E)

Mettrick, H. 1978. Oxenisation in The Gambia. Ministry of Overseas Development, London. 68p. (E).

Owens, S. 1986. Animal traction experiences in The Gambia. In: Poats, S.V., J. Lichte, J. Oxley, S.L. Russo, and P.H. Starkey. 1986. Animal traction in a farming systems: perspective. Report of networkshop held Kara, Togo March 3-8 1985. Farming Systems Support Project. University of Florida, USA. (in press). (E,F).

Senela 1981. Ideas that work. Senela (The Gambian Field workers Magazine) 18: 16-17. (E).

Shulman, R. 1986. Mixed Farming project cultivator program, 1985 season. Mixed Farming Project, Banjul, The Gambia. 30p. (unpublished). (E).

Willcocks, T.J. 1969. Animal drawn toolbar. Bulletin No. 2. Tropical Agricultural Engineering information, National Institute of Agricultural Engineering, Silsoe, U.K. 16p. (E).

Wright, J., J. Doll, R. Koegel, and A. Peterson. 1986. Project proposal: the effect of tied ridges made with draft animals on maize, sorghum and millet in The Gambia. University of Wisconsin, Madison, USA. (unpublished) 6p. (E).

Wright, J. and M. Rodriguez. 1986. Project de cloisonnement de billons par traction animale (TRAP) Newsletter de PC31 SAFRAD OUA 12: 8-11. (E,F).

12. LIST OF PERSONS CONTACTED DURING THE MISSION

Mr. M. S. Sompo Ceesay, Assistant Director of Agriculture, Research.
Mr. K. M. Banja, Assistant Director of Agriculture, Extension and Training.

Mr. Tom Senghore, Senior Scientific Officer, Agronomy, Sapu.
Mr. Alphu Marong, Senior Scientific Officer, Rice Research, Sapu.
Mr. Omar Sonko, Agricultural Officer/Station Officer, Sapu.
Alhaji Lamin K. Janneh, Principal Agricultural Officer, Irrigated Rice Project, Sapu.
Mr. Duncan Boughton, Farm Management Economist, ODA/Sapu.
Dr. R. W. Willey, Cropping System Research Consultant, ODA/University of East Anglia

Mr. Sana K. F. Jatta, Deputy Project Manager, Jahaly Pachar Rice Project.
Mr. Sheriff S Dibba, Agricultural Supt. Jahaly Pacharr Rice project.

Mr. Papa Cham, Head of Agricultural Engineering Unit, Yundum.
Mr. Dawda M. Sarr, Agricultural Engineer, Yundum.

Dr. S.B.K. Quartey, Director, Dept. Animal Health and Production.

Prof. Ian McIntyre, Director, International Trypanotolerance Center.
Dr. Bakary Touray, Deputy Director, ITC.
Dr. Derek Clifford, Animal Production Officer, ITC.
Mr. Ousman Njie, Livestock Assistant, ITC.
Dr. John Trail, Livestock Productivity and Trypanotolerance Group, ILCA.

Dr. Elon Gilbert, Chief of Party, GARD.
Mr. David Gibson, Project Administrator, GARD.
Ms. Chris Elias, Irrigation Research Associate/Rural Sociologist, GARD.
Dr. Fred Madison, Soil Management Consultant, GARD.
Dr. Emmett Schulte, Soil Fertility Consultant, GARD.
Dr. Earl Gritton, Agronomy Consultant, GARD.

Dr. Glen Fulcher, Chief of Party, Mixed Farming Project.
Dr. Sandra L. Russo, Forage Agronomist, Mixed Farming Project.
Dr. Scotty Deffendol, Range Economist, Mixed Farming Project.
Mr. Solomon Owens, Scientific Officer, Mixed Farming Project.
Mr. Dick Shuman, Peace Corps Volunteer, Mixed Farming Project. USAID Mixed Farming Project Evaluation Team.

Mr. Ralph Conley, Agricultural Development Officer, USAID, Banjul
Mr. Thomas Hobgood, Assistant A.D.O., USAID.

Mr. Sutay Bah, President Livestock Owners Association, Niorro Jattaba.
Alhaji Kani, Faraba Banta, and other farmers.

APPENDIX A: NETWORKING CONTACTS ON ANIMAL POWERED WATER PUMPS

13.1 ANNOTATED ADDRESS LIST

Association Francaise des Voluntaires du Progrés (AFVP),
B.P. 2, 91310 Montlhéry, France.

French volunteer organization that has volunteers working on animal powered water pumps in Senegal Mali and Burkina Faso.

Direction Machinisme Agricole,
B.P. 155, Bamako, Mali.

Government, department that is undertaking trials, in cooperation with AFVP, on pumps designed to extract water from rivers. Work still at prototype stage.

ENDA (Environment and Development for the Third World)
B P 3370, Dakar, Senegal

NGO that has been working for many years on several different designs of animal powered water pump and Grinding mills in Senegal Works closely with AFVP, GRDR, GATE and IT Dello. Has published several leaflets. Would be happy to arrange visits to village sites for persons interested in this technology. While most staff are francophone, it is a bilingual organization.

German Appropriate Technology Exchange (GATE),
GTZ, D-8236 Eschborn 1, Postfrach 5180,
Dag Hammarskjold Weg 1, Federal Republic of Germany.

Appropriate technology section of German bilateral aid organization GTZ. Has sponsored animal powered pump and mill projects in several countries in Africa. Useful publication on animal powered devices by Lowe (1983).

Groupe de Recherche et de Réalisations pour le Développement Rural dans la Tiers Monde (GRDR),
60 rue du Fg Poissonnière, 75010: Paris, France.

French NGO working with animal powered pumps in Senegal and Mali. Works closely with ENDA, GRET and AFVP.

Groupe de Recherche et d'Echanges Technologiques (GRET),
60 rue de Charrone, 75010 Paris, France.

French NGO information dissemination service for appropriate technologies. Has published information leaflets on animal powered pumps including Fiches techniques T325, 492 and 682.

Institut Technologique Dello (IT Dello),
Le Moulin Rouge, 60410 Verberie, France.

Intermediate technology organization that has carried out studies on animal powered pumps and mills in Burkina Faso and France.

Intermediate Technology Development Group,
9 King Street, London WC2E 8HN, U.K.

British NGO appropriate technology organization that has carried out studies on animal powered water pumps, and has good contacts with other anglophone organizations working in this area.

Project Consult,
Savignystrasse 41, D6000, Frankfurt a Main, West Germany.

Consultancy firm specializing in animal powered water pumps and mills that has implemented several GTZ-funded projects.

Rural Industries Innovation Centre,
Private Bag 11, Kanye, Botswana.

NGO appropriate technology centre that has links with several appropriate technology organizations in Europe and North America. Has developed a pump powered by 9 donkeys that extracts 6 cubic metres per hour from 45 metre depth. Ten of these pumps have been in operation for two years.

13.2. SOME LITERATURE AVAILABLE

Goubert, D. 1982. Exaure à traction animale au Sénégal. ENDA, Dakar, Sénégal. 18p. (F).

Jacobi, C. and Lowe, P. 1984. Diffusion des managès: l'approche d'ENDA. E.T. 119, ENDA, Dakar, Sénégal. 2p. (F).

Jacobi, C. and Lowe, P. 1984. Quelques techniques d'exhaure de l'eau au Sahel. E.T. 120, ENDA, Dakar, Sénégal. 8p. (F)

Jacobi C. and Lowe, P. 1984. Diffusion des pompes guéroult: impacts techniques et sociaux. E.T. 121, ENDA, Dakar, Sénégal. 8p. (F).

Jacobi C. and Lowe, P. 1984. Pomper l'eau avec le guéroult au village. E.T. 122, ENDA, Dakar, Sénégal. 13p. (F).

Lowe, P. 1983. Animal power and power gears: an alternative in form mechanization. German Appropriate Technology Exchange (GATE), GTZ, Eschborn, Germany. 62p. (E,F,G).

Sarda, J. 1985. Mouture de céréales par manèges è traction animale. Expérimentation de prototypes de moulin manège au Burkina Faso et en France. Rapport Technique, IT Dello, France. 25p. (F).

13.3. NOTES ON ANIMAL POWERED PUMPS AND MILLS IN SENEGAL

13.3.1. Le Sahores

The Sahore is a piston pump system powered by a single donkey that is designed for wells up to a depth of 20m/ Extraction rates are 6 cubic metres per hour at a depth of 6 metres, falling to 1.8 cubic metres per hour at 20 metres. Current costs are about CFA 400,000 for the complete installation. The PVC pipes used in the pump wear out, and training is required to ensure these can be replaced quickly by village artisans. These have been used under village conditions in Senegal for several years.

13.3.2. Le sytème Guéroult

The Guéroult uses a pair of oxen to pull water in rubber or leather sacks from wells up to 100 metres in depth. Extraction rates are 3 cubic metres per hour at 40 metres, dropping to 1.2 cubic metres per hour at 80 metres. The cost is higher than the Sahores at CFA 750,000.

13.3.3. Animal powered mills

Mills for millet and maize are relatively new, with the earliest installed in a village in 1985. To date this has worked for six months, at about four hours each day, and seven more have been installed recently. Each woman brings her own donkey to power the mill, which works at a rate of about 15kg grain per hour. The mills have been imported and the installation carried out by a local blacksmith. Costs are about CFA 150,000 for the mill and CFA 150,000 for the installation.

13.3.4. Sites near to The Gambia

Guéroult and Sahore pumps are installed in a group of five villages around Guéroto, Séhoro, Ndiayène and Kountouata which are only about 35km north-northwest of Georgetown. however for technical discussions it would be better to visit some villages to the north of Kaolack. One Guéroult and one mill can be found at the village of Lambelkelly between Kaolack and Gossas. Two AFVP volunteers work in this village and can give technical information,

as can the blacksmith at Gossas who makes the pumps and mill installations. A Sahores system and a millet mill can be seen at the village of Ngan, to the north of the road from Kaolack to M'bour, and an AFVP volunteer works in this village also. The staff of the Relais Technologique of ENDA would be prepared to make arrangements for a group visit to these sites.