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AN ASSESSMENT OF ANIMAL TRACTION IN FRANCOPHONE WEST AFRICA

by
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ACRONYMS USED IN TEXT

ADB:	African Development Bank
ADF:	African Development Fund
ARCOMA:	Atelier Regional de Construction de Materiel Agricole
BADEA:	Banque Arabe pour le Developpement Economique de l'Afrique
BDPA:	Bureau pour le Developpement de la Production Agricole (Francais)
CCCE:	Caisse Centrale de la Cooperation Economique (Francaise)
CEEMAT:	Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropicale (Francais)
CER:	Centre d'Encadrement Rurale
CFDT:	Compagnie Francaise pour le Developpement des Fibres Textiles
CGOT:	Compagnie Generale Oleaginaux Tropical
CIDA:	Canadian International Development Agency
CIDR:	Compagnie Internationale pour le Developpement Rurale (Francaise)
CILSS:	Comite Inter-Etats pour la Lutte contre la Secheresse dans le Sahel
CMDT:	Compagnie Malienne pour le Developpement des Fibres Textiles
CNPAR:	Centre National de Perfectionnement des Artisans Ruraux
CNRA:	Centre National de Recherches Agronomiques (Seneglais)
COBEMAG:	Cooperative Beninoise de Machinisme Agricole
FAC:	Fonds d'Aide et de Cooperation (Francais)
FAO:	Food and Agriculture Organization
FCFA:	Francs de la Communaute Financiere Africaine
FED:	Fonds Europeens de Developpement
FIDES:	Le Fond d'Investissement et du Developpement Economique et Social
FRG:	Federal Republic of Germany
IBRD:	International Bank for Reconstruction and Development

ICRISAT: International Crop Research Institute for the Semi-Arid Tropics

IDRC: International Development Research Centre

IER: Institut d'Economie Rurale (Malien)

IRAT: Institut des Recherches d'Agronomie Tropicale et des Cultures Vivrieres

ISDB: Islamic Development Bank

MAC: Ministere d'Aide et de Cooperation (Francais)

OACV: Operation Arachide et Cultures Vivrieres (Malienne)

OCDE: Organisation de Cooperation et de Developpement Economique

ORD: Organisme Regional de Developpement (Voltaique)

ORSTOM: Office de Recherches Scientifique et Technique d'Outre-Mer (Francais)

PAM: Programme Alimentaire Mondiale (U.N.)

SATEC: Societe d'Aide Technique et de Cooperation (Francaise)

SEDES: Societe d'Etudes pour le Developpement Economique et Sociale (Francaise)

SISCOMA: Societe Industrielle Seneglaise pour la Commercialisation du Materiel Agricole

SODEVA: Societe de Developpement et de Vulgarisation Agricole (Seneglaise)

SRVCO: Section de Recherches sur les Cultures Vivrieres et Oleagineuses (Malienne)

UNCDF: United Nations Capital Development Fund

UNDP: United Nations Development Program

USAID: United States Agency for International Development

ZER: Zone d'Extensification Rurale

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I. INTRODUCTION

The use of draft animals as a power source for farm operations is widely regarded as a technology appropriate for small farmers in West Africa. Experience in Asia, Europe, and the Americas generally shows that animal power can help the farmer overcome seasonal labor constraints and execute critical operations in a more timely manner than is possible with hand tools. Substantial agronomic benefits are also claimed due to deeper and more uniform tillage and the incorporation of crop and animal by-products into the soil. Nevertheless, despite a relatively long history of attempts by both colonial and national administrations to promote animal traction, adoption has been uneven throughout most of West Africa.

The slow and uneven spread of animal traction is particularly significant when viewed against the changes which have occurred in West African farming systems during the past several decades. When combined with adequate economic incentives, new crops have spread rapidly (Hogendorn, 1975; Berry, 1974; Dumett, 1971; Hill, 1963). Studies have consistently found African producers to be responsive to incentives (Norman, 1977; Helleiner, 1975; Jones, 1960). In short, experience belies the argument that the African farmer is bound by tradition and slow to respond to innovation. Rather, he tends to respond rationally when change is possible and consistent with the multiple goals which guide his farm operation.

A. Problem, Objectives, and Approach

1. Problem

The uneven results of animal traction projects raise fundamental questions about the efforts to promote that technology in the West African environment. This issue may be addressed at four levels: (1) Are current animal traction packages technically sound? That is, given the soils, climate, and crops of the region, are substantial agronomic benefits realized under farmers' conditions? (2) Are the inputs required of animal traction systems compatible with the resources available to most farmers in the region? (3) Is the investment in animal traction equipment financially and economically profitable? (4) Is there an adequate support system? In particular, are equipment and complementary inputs available in a timely manner and with adequate credit provisions? Are veterinary and

maintenance services readily available and oriented to the needs of small farmers?

Finding answers to these questions becomes increasingly urgent in view of the recent increase in animal traction investments on the part of both national governments and donor agencies. Since the drought years of 1969 to 1973, approximately 50 projects which involve animal traction have been funded by foreign donors in francophone West Africa alone. In order to avoid costly mistakes, planners must better understand the potential and problems of draft animal projects. This paper attempts to assess animal traction technology on the basis of project experience already accumulated in the region.

2. Objectives[1/]

The paper addresses three major objectives:

a. To place current projects in an historical perspective by tracing the evolution of draft animal programs in francophone West Africa.[2/]

b. To provide an inventory and economic analysis of draft animal projects in the region.

c. To put forward policy guidelines to assist project officers and field personnel in improving the design, implementation, and evaluation of projects involving an animal traction component.

3. Approach

This report is based on a review of 125 animal traction projects in francophone West Africa supplemented by the practical experience of the authors. Twenty-seven of the 125 projects were selected as the primary data base for this assessment. The remaining projects could not be used in the detailed assessment due to insufficient data on the performance of animal traction.

[1/] Refer to USAID Contract No. REDSO/WA 78-144, Article I: Statement of Work, B: Description of Services, and C: Reports.

[2/] The following countries are included: Senegal, Mali, Mauritania, Ivory Coast, Upper Volta, Togo, Benin, Niger, and Chad. The Gambia is also included because it has a long experience with animal traction projects.

Of the documents reviewed, the majority were of two types--project design papers prepared by either national agencies or external donors, and technical reports published by regional research institutions. Two reports providing overviews of projects in the region (Le Moigne and Zerbo, 1977; Casse, Dumas, and Garin, 1965) proved very useful. Very few project evaluation reports were found to include a rigorous ex post analysis of project effects (Wedderburn, 1979; Mettrick, 1978; Mesnil, 1970; Bonnefond, 1967). Only a few studies have analyzed the impact of animal traction packages on output, incomes, and employment under farmers' conditions (Delgado, 1979; Barrett et al., 1981; Wedderburn, 1979; IER, 1978; Mettrick, 1978; Mesnil, 1970; Bonnefond, 1967; Garin, 1966; Peacock et al., 1966; Geradin, 1964). Unfortunately, the general absence of adequate monitoring and evaluation activities within past and current animal traction projects in francophone West Africa makes it very difficult to reach definitive conclusions on animal traction in the region.

The report has been organized into four main parts. The remaining sections of Chapter I briefly describe the characteristics of a model farming system based on the use of draft animal technology. Chapter II presents a brief history of the introduction of draft animal power in the region. Chapter III summarizes technical evidence of the effect of animal traction on productivity. Chapter IV provides an analysis of 27 projects initiated during the last two decades.[1/] The major technical, economic, and institutional elements of these 27 projects are compared and key problems identified and evaluated. Conclusions and recommendations are presented in Chapter V.

B. A Model Animal Traction Farming System

The adoption of draft animal technology is generally assumed to provide several benefits: (1) power for tillage operations, which can increase farm production, (2) manure to maintain and improve soil structure and fertility, and (3) red meat which can be sold for additional farm revenue. The model animal traction farming system takes advantage of

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[1/] A tabular summary of the 27 projects is presented in Appendix I. A list of all 125 projects examined during the review is shown in Appendix II.

interdependencies between the animal and crop subsystems. Animals provide the power for cropping activities while crop residues and by-products furnish an important source of feed for the draft animals. Growing legume and grass forage for livestock feed allows the fallow land to be put to a productive use and provides green manure to be plowed under. Under such a system (as opposed to slash and burn agriculture), continuous cultivation of a given land area becomes possible. The model animal traction farming system also uses labor and land resources more efficiently. More rapid performance of critical operations such as weeding allows expansion of the area cultivated and more timely task execution. Off-season activities such as carting increase slack period employment and generate income for the farm household. Sale of meat or fattened animals can add to cash income substantially.

Project designers generally assume that animal traction is an appropriate technology for small farmers, and well suited to the resources and institutions of West African nations. Animal traction is expected to generate increases in farm size, promote intensive cropping, and stimulate the creation of small-scale manufacture and repair facilities. These expectations appear to rest on research station results, and on widespread adoption of animal traction in areas such as southern Mali and the Sine-Saloum region in Senegal. The extent to which these potential benefits have, in fact, been realized, and the factors associated with favorable or unfavorable project results, are the focus of subsequent sections.

II. HISTORY OF ANIMAL TRACTION IN FRANCOPHONE WEST AFRICA

Historically, the introduction and spread of draft animal power within francophone West Africa can be divided into three eras: pre-World War II, World War II to 1973, and post-drought, from 1973 until the present.

A. Pre-World War II

Although animal-drawn plows are reported to have been in use in Senegal as early as 1850 (Casse et al., 1965), adoption remained limited until the beginning of the 20th century. The earliest concerted effort to introduce animal plow technology began in 1914 in Guinea. Adoption rates were substantial and, by 1930, 4,000 farms were using plows.

The 1920s and 1930s saw increased efforts to develop a wider range of tillable equipment adapted to West African conditions, and to provide financial assistance to adopters. Early implements were all of European design imported by colonial administrations. By 1928, however, adaptive research at the IRAT station in Bambey, Senegal, had resulted in the development of a light weight "Allouette" hoe for donkey or horse scarification. In 1930, an improved single-row seeder was perfected (Monnier, 1975: 215-20).

Extension efforts during the 1920s and 1930s were concentrated within areas of high cash crop production potential (Gaury, 1977: 273-275; Labrousse, 1971: 3-5). For example, plows and seeders were being distributed in 1930 in the Sine-Saloum region of Senegal, an area of extensive groundnut cultivation (Baldwin, 1957; de Wilde, 1967). In 1933, the French colonial service in Mali introduced plows in the Central Delta (Office du Niger) and Haute-Vallee regions for the production of rice and groundnuts, respectively. Because this program did not provide for animal training, extension advice, or maintenance of animals and equipment, much of the equipment was unused or converted into hand tools by local blacksmiths (OACV, 1978: 1).

A more comprehensive approach initiated by the IRAT station at Bambey in the early 1930s was to establish "government farms." These were intended to serve as training centers for pilot farmers and their oxen, as demonstration farms to promote wider adoption, and as field test sites to

carry out local trials as directed from Bambey, Senegal. These farms (e.g., Baroueli, Saboucire, Nienebale, Soninkoura, and Bannikoro in Mali; Barkoissy in Togo; and Kolo and Koulou in Niger) were numerous, but their role diminished following World War II. A few of these farms were successful, and by providing a sufficiently inclusive program they fostered the localized expansion of animal traction (e.g., Baroueli and M'Pesoba in Mali) (Casse et al., 1965: Vol. II: 1-3).

Centers to train oxen drivers were also established by the colonial administration during the 1930s. The oxen drivers subsequently served as farm-level extension agents. As the first coordinated program in the francophone region, it greatly accelerated adoption of the animal-drawn plow. By 1940, more than 20,000 plows had been distributed (Casse et al., 1965: II, p. 3).

B. World War II to 1973

With the onset of World War II, resources to develop and popularize draft animal technology were substantially reduced. Projected food shortages led the French colonial administration to initiate large-scale projects wich relied primarily on cultivation by tractors (Labrousse, 1971: 4-5). These projects were again concentrated in high potential areas, including the Richard Toll and Sefa areas of Senegal, and the Moloda and Sikasso areas of Mali. The projects were generally shortlived, due to inappropriate European equipment, maintenance problems, and escalating operating costs. By 1952, development efforts had shifted back to promotion and adoption of animal-power agriculture.

An additional impetus to the renewed emphasis on animal traction was provided by aid received through the Marshall Plan, which supported local research centers and manufacturing enterprises and provided an increased supply of credit and Massey-Harris plows (Casse et al., 1965: II, p. 3). The number of government training and demonstration farms was substantially expanded (upwards of 500) between 1954 and 1958 (Bonnefond, 1967: 7). During the late 1940s, cooperative development societies were established in Senegal and Mali. Adoption of animal traction was further promoted by the creation in 1947 of Le Fond d'Investissement et du Developpement Economique et Social (FIDES), which improved farmers' access to credit for agricultural investments.

Increased post-war funding also resulted in substantial progress in the area of adaptive research. Working with commercial manufacturers, engineers at IRAT/Senegal focused on developing more durable and flexible low-cost equipment packages. They achieved a particularly important breakthrough in equipment design in 1955 with the development of the polyculteur or multi-purpose tool bar. By 1961, La Societe Industrielle Senegalaise pour la Commercialisation du Materiel Agricole (SISCOMA), in cooperation with IRAT, became the first manufacturing firm to undertake the production of a uniform line of animal-drawn implements in West Africa (Le Moigne and Zerbo, 1977: 2).

Realizing that the adoption of animal traction involved radical changes in all aspects of traditional farming systems, and that potential complementarities existed between livestock and crop enterprises, research and extension emphasis during the 1950s shifted to the development of fully integrated mixed farming systems.[1/] With animal traction as one of the central themes, rural extension centers (CER) were established in the region beginning in 1955 to increase farmer contact. Numbering 20 by 1961 (Bonnefond, 1960), these centers provided continuity with earlier programs by continuing the practice of diffusion through farm visits by mobile agents. During the 1952-58 period, pilot farms were established to develop and demonstrate the benefits of a fully integrated mixed farming system (Casse et al., 1965: 4). For example, between 1952 and 1958, 461 pilot farms were set up in Upper Volta (Casse et al., 1965: II, 19-15). Each farm was provided with a set of animal-drawn equipment (multi-purpose tool bar, plow, harrow, cart), two oxen, a shed for storage, a stable, and a silo--all at a cost of 128,000 FCFA (Francs of the Communaute Financiere Africaine), in 1956 prices. According to a model farm plan developed by the Agricultural Service, the pilot farmer was expected to grow at least 2.5 hectares of crops, establish a 0.5 hectare orchard, and keep a garden.[2/]

Within three to five years, however, a majority of participants had stopped using animal traction. One major factor was that several years

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[1/] Conceptually, this was a major departure from the earlier crop-specific and export commodity orientation.

[2/] This model reflects concern for an integrated cropping system. The orchard shows a recognition of the need for replacing trees removed from fields.

were required to establish the farm and learn the new techniques. Moreover, veterinary services, spare parts, delivery and marketing systems, and extension support were frequently found to be lacking. Many farmers apparently viewed participation as a task imposed by the colonial administration, which required three years' supervision by the extension service. Farmers did not perceive the replacement of animals or the maintenance of equipment as their responsibility, and loan repayment rates remained extremely low.

Problems encountered elsewhere in the pilot farm program were generally a function of local conditions. In Mauritania, efforts to diffuse animal traction were frustrated because the only affordable draft animals were donkeys and horses, which lacked sufficient power to till the heavy soils of rice fields in the Senegal River Valley. The land tenure patterns of the rice plains in Niger inhibited the expansion and consolidation of cultivated areas. On the Mossi plateau in the central region of Upper Volta, high population density, problems of feeding and watering animals, and low millet prices restricted the expansion of animal traction. In the Bobo-Dioulasso area of Upper Volta, animal-powered deep tillage led to soil erosion and localized problems of laterization.

C. The Period Since 1973

The Sahelian drought of 1967-73 dramatically demonstrated the need to improve agricultural production systems. One result was a quantum increase in external donor assistance. Table 1 indicates a four-fold increase in total foreign assistance to Sahelian countries, from $174.8 million in 1969 to $708.7 million in 1976. An increasingly important share was directed to the agricultural sector, rising from 9.9 percent in 1975 to 24.3 percent in 1977 (CILSS, 1978). There was continuing interest in efforts to extend animal traction. The significant numbers of animal traction units being used in Mali and Senegal (columns 4 and 5 in Table 2) led to a general belief that the technology was profitable in the Sahel, and that it could be readily expanded via intensified extension programs.

The large number of farmers using animal traction in Mali and Senegal cannot be easily explained, but some of the more common arguments for its success in these areas are: (1) the farmers were accustomed to raising large animals; (2) additional land was readily available; (3) the

rainfall/soil relationships were conducive to draft animal technology; and (4) both southern Mali (cotton) and the Sine-Saloum region of Senegal (groundnuts) had cash crop opportunities which increased the profitability of animal traction and ensured the availability of extension support. In summary, draft animal technology appeared to offer a proven farming system backed by several decades of local research and successful on-farm adoption. Thus, during the drive to increase agricultural production between 1973 and 1978, at least 50 agricultural development projects emphasizing animal traction were initiated in the Sahelian region. The accomplishments and key elements of several of these projects are evaluated in Chapter IV. First, however, we turn to a review of research evidence on the technical and economic benefits of animal traction.

Table 1. OFFICIAL DEVELOPMENT ASSISTANCE TO SAHELIAN COUNTRIES, 1969-76
(in millions of U.S. $)

	1969	1970	1973	1975	1976
Cape Verde				8.8	24.8
The Gambia	3.6	1.3	6.3	8.1	11.9
Upper Volta	23.9	22.0	57.2	88.9	84.1
Mali	23.1	21.3	71.2	144.5	89.0
Mauritania	11.9	7.5	30.9	61.5	180.2
Niger	33.3	31.7	71.0	140.7	129.6
Senegal	55.4	42.7	78.8	132.7	126.8
Chad	23.6	22.4	45.3	65.0	62.3
TOTAL	174.8	148.9	360.7	650.2	708.7

Source: OCDE, "Repartition geographique des resources financieres mises a la disposition des pays en developpement." (Versement 1969 a 1975. Paris 1977, mis a jour le 6.10.78).

Table 2. ESTIMATED ANIMAL TRACTION EQUIPMENT NUMBERS IN SAHELIAN WEST AFRICA, 1967-77

	1967 Mauritania	1976 Chad	1976 Gambia	1976 Mali	1977 Senegal	1977 Upper Volta	1977 Niger
Plows	2,397	58,056	2,550[a/]	106,704	13,000	16,520	4,500
Multi-Purpose Tool Bars		3,883	15,000[b/]	40,555		11,000[e/]	4,300
Hoe		1,727		14,058	204,000[d/]	14,000[f/]	7,200
Seeders	100		13,000[c/]	9,707	220,000	204	900
Carts			1,800	52,204	89,600		3,300

Source: Taken from Le Moigne and Zerbo, 1977, except Gambia, which is derived from Mettrick, 1978.

[a/] Ridger-plows sold between 1960-1971.

[b/] Based on Mettrick's estimate that 43 percent of the "dabadas" (work groups) use animal traction for ground preparation ploughing and the fact that most use the Sine equipment line.

[c/] Based on Mettrick's estimate that 36 percent of the "dabadas" use seeders.

[d/] Including Sine and Arara multi-purpose tool bars.

[e/] Le Moigne and Zerbo, 1977: p. 20.

[f/] Le Moigne and Zerbo, 1977: figure from p. 19 reduced by the number of multi-purpose hoes, p. 20.

III. RESEARCH EVIDENCE ON THE POTENTIAL BENEFITS OF ANIMAL TRACTION

This chapter examines the expected technical and economic benefits from the adoption of animal traction as suggested by the results of trials on research stations in francophone West Africa. Agricultural research in this region has been dominated by the research station in Bambey, Senegal. Originally established in 1914 by the Institut de Recherches d'Agronomie Tropicale et de Cultures Vivrieres (IRAT), a French parastatal research organization, the station has pursued substantial research on improved mechanical technologies, and on the agronomic aspects of the animal traction farming system. The Bambey station is now the headquarters for the Senegalese Centre National de Recherches Agronomiques (CNRA).

A. Technical Effects

Research reports frequently discuss the impact of animal traction in terms of "intensification" effects, which are improvements in production per unit area, and "extensification" effects, which are increases in production due to expanding the area under cultivation.[1/] Extensification may also lead to an increase in the productivity of labor. Unfortunately, presenting research results (and designing the experiments) in terms of these two partial effects cannot capture the overall impact of animal traction on the farm system. However, this perspective cannot be entirely avoided given the format of the studies reviewed.

1. Intensification

There are at least five field activities through which animal traction techniques can influence yields: (1) land preparation, (2) planting, (3) weeding, (4) harvesting, and (5) soil improvement. The research evidence on each of these topics is presented below.

[1/] David Norman has suggested (personal communication) that intensification has been emphasized relatively more in francophone West Africa (especially Senegal) than in anglophone West Africa, where extensification has been emphasized.

a. Land Preparation

Land preparation may encompass deep tillage, end-of-season or pre-season plowing, or plowing under organic matter. Deep plowing with draft animals can improve the homogeneity of particle size and cohesion and increase soil porosity (Nicou and Poulain, 1972: 35-40). This, in turn, increases water infiltration and water holding capacity, and improves drought resistance in areas of irregular rainfall. Significantly improved root development due to deep tillage has been demonstrated on several major food and cash crops in Bambey, Senegal (Tourte et al., 1967; Nicou et al., 1970) as well as in other Sahelian locations (IRAT/Ivory Coast, 1971).

The potential yield effects from deep tillage (plowing to a depth of 15-20 cm) are believed to be substantial. In experiments conducted at IRAT/Senegal, Charreau and Nicou (1971, p. 935) observed yield increases averaging 19 percent for groundnuts, 20 to 30 percent for cereals, 27 percent for cotton, and greater than 50 percent for rainfed paddy rice. Ramond and Tournu (1973) report that plowing increased sorghum yields by 50 percent and cotton yields by as much as 130 percent in the Sine-Saloum region of Senegal. Kline et al. (1969) report greater than 40 percent yield increases in both millet and groundnuts in The Gambia. In some of these studies, however, it is not clear whether part of the increased yield effect attributed to deep tillage is due instead to improved varieties or fertilizer. One study which clearly separates yield effects due to fertilizer from those due to animal plowing was undertaken in Mali (SRCVO, 1978). Table 3 shows that yield increases were higher on average: (1) for oxen (21 percent) compared to donkey traction (5 percent), and (2) for maize and sorghum (29 percent) compared to groundnuts, cotton, and millet (5 percent).

IRAT/Senegal results (Table 4) indicate that end-of-season plowing is only slightly more beneficial than beginning-of-season plowing done early. However, end-of-season plowing is substantially better than beginning-of-season plowing done late, and better still than no plowing at all.[1/] These

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[1/] Land preparation by hand tools is generally carried out after initial rains have softened the soil, thus delaying planting operations. Beginning-of-season plowing with animal traction may also be delayed if the soils are too hard or the animals too weak.

Table 3. SUMMARY OF PERCENTAGE YIELD INCREASES OVER CONTROL, MALI, 1978[a/]

	Ground-nuts	Cotton	Maize	Sorghum	Millet	Overall
Animal Traction Effects						
Donkey Traction	- 2	- 2	+ 18	+ 24	- 12	+ 5
Oxen Traction	+17	+ 9	+ 37	+ 36	+ 6	+21
Fertilizer Effects						
Recommended Application	+15	+ 46	+ 53	+ 61	+455	+44[b/]
Heavy Application	+32	+ 74	+ 61	+ 93	+545	+65
Combined Effect						
Donkey-Recommended	+14	+ 44	+208	+ 94	-	+51[c/]
Oxen-Recommended	+41	+ 55	+295	+ 72	-	+56
Donkey-Heavy	+44	+ 80	+313	+150	-	+91
Oxen-Heavy	+58	+100	-	-109	-	+79

Source: SRCVO, 1978, Chapter IV, p. 5.

[a/] Control = no animal traction, no fertilizer.

[b/] Excluding millet.

[c/] Excluding maize.

Table 4. EFFECTS OF TIME OF PLOWING AND PLANTING, SENEGAL, 1971

Crop	Yield Index (Control = 100)			
	End of Season Plowing Early Planting	Beginning of Season Plowing Early Planting	Beginning of Season Plowing Late Planting	Control No Plowing Early Planting
Groundnuts	121	123	100	100
Sorghum	158	147	132	100
Maize	157	162	146	100
Cotton	141	139	132	100

Source: Tourte et al., 1971, p. 638.

conclusions are supported by more recent trials by ICRISAT/Upper Volta, which demonstrated 60 percent yield increments for end-of-season plowing of millet, and up to 90 percent increases for sorghum (ICRISAT/Upper Volta, 1979). These same trials found only negligible yield effects for millet due to early season plowing, but up to a 45 percent increase for May plowing of sorghum.

Part of the yield effect of end-of-season plowing derives from incorporation of organic material and improved moisture retention. Trials at IRAT/Senegal indicate that as much as 65 percent of residual moisture can be conserved by end-of-season plowing (Sargent, 1974). However, these results do not indicate the type of organic material plowed under; they also present the combined effect of several crop rotation systems, fertilizer, and plowing under. This is also true of Tourte et al. (1971), whose results are presented in Table 5.

b. Planting

The short rainy season characteristic of the Sudano-Sahelian zone of West Africa makes it necessary to plant full-season varieties immediately after the onset of the rains. This generates a labor conflict between adequate soil preparation and early seeding. In principle, the use of animal-drawn plows and seeders can permit more rapid and timely execution of these tasks.

The yield advantages of early planting have been well documented in experimental trials in northern Nigeria, as shown in Tables 6 and 7. Other results from northern Nigeria indicate that a delay of two weeks can reduce output by nearly 10 percent for cotton, by more than 30 percent for groundnuts, and by as much as 60 percent for sorghum (Andrews, 1975: 25). Similarly, ICRISAT/Upper Volta experiments have shown that sorghum yields are depressed by 40 to 60 percent with a 2½ week delay in planting date (ICRISAT/Upper Volta, 1978). Nonetheless, animal-drawn seeders are considered too expensive in most of the Sahel and their use is prevalent only in Senegal and The Gambia.[1/]

[1/] The range of available seeding implements is described in Kline et al. (1979: 370-371) and in FAO-CEEMAT (1972: 16).

Table 5. DIRECT AND RESIDUAL YIELD EFFECTS FROM PLOWING UNDER ORGANIC MATERIAL, SENEGAL, 1971

Rotation[a]	Control[b] (kg/ha)	Average Yields with Plowing Under[c]	
		kg/ha	% Increase
1. Groundnuts	1,731	1,881	9
2. Millet	873	1,173	28
1. Millet	867	1,288	49
2. Groundnuts	1,516	1,740	15
1. Maize	1,474	2,444	66
2. Sorghum	2,325	2,915	25
1. Maize	1,744	3,231	85
2. Sorghum	2,019	2,662	32
3. Groundnuts	2,000	2,280	14
1. Sorghum	1,520	1,879	24
2. Sorghum	1,618	2,323	43
3. Groundnuts	2,489	2,665	7

Source: Tourte et al., 1971, p. 640. Charreau and Nicou, 1971, p. 650.

[a] All rotations are preceded by fallow crops which are either natural growth, cultivated green manure, or straw added to natural growth. All organic matter is plowed under at the end-of-season.

[b] Control = previous year in fallow, burned off, no plowing.

[c] Negative results in 23 of the 135 trials were not used by Tourte et al. in calculating these average yield effects. Negative results were also discarded by Charreau and Nicou.

Table 6. EFFECTS OF DELAYED SOWING ON COTTON YIELDS IN NORTHERN NIGERIA

No. of Weeks Delay in Sowing	Yield as a Percentage of That Obtained From Sowing at Optimum Time
0	100
2	92
4	67
6	54

Source: Prentice, A. N., Cotton, With Special Reference to Africa, Longman Group, Ltd., London, 1972, p. 169.

Table 7. VARIATION IN GROUNDNUT YIELDS BY DATE OF PLANTING: NORTHERN NIGERIA, 1952

Date of Planting	Mean Days to Optimum	kg/ha Yields	Percent of Maximum
May 6-9	-6	1,175	82
May 11-16	-	1,426	100
May 18-23	7	1,289	90
May 25-30	14	967	68
June 1-6	21	645	45
June 8-12	28	553	39
June 16-20	36	254	18
June 21-27	43	127	9
June 28 on		failure	

Source: Baldwin, 1957. Table XIV as cited in: Cleave, African Farmers: Labor Use in the Development of Smallholder Agriculture, New York: Praeger Publishers, 1974.

c. Weeding

Increased weeding capacity is an essential element in the animal traction package. In a review of farm management studies throughout semi-arid West Africa, Newman et al. (1980) identified weeding as the most serious constraint on production under traditional technologies. Among northern Nigerian farmers, Matlon and Newman (1979) show that sorghum and millet yields are reduced by an average of 8 percent per week due to delayed first weedings. Similarly, research station trials have demonstrated that a two-week delay in weeding cotton can reduce yields by 30 percent while a six-week postponement reduces yields as much as 60 percent (de Wilde II, 1969, p. 323).

The use of animal-drawn weeding implements can substantially reduce the labor time required for weeding.[1/] Timely land preparation and sowing allows weeding to start more promptly. Also, the use of the mouldboard plow during seedbed preparation will turn under weeds and inhibit their regrowth, thus reducing the need for supplemental weedings (Kline et al., 1979, p. 368; Mettrick, 1978). Despite these apparent advantages, less than 25 percent of animal traction users in the Sahel use weeding implements; hence, labor for weeding remains a critical bottleneck constraining both yields and area expansion.

d. Harvesting

The only direct use of animal traction in harvesting operations is groundnut lifting and crop transport by animal cart. There is no readily available research on the yield effects of groundnut lifting. With all crops competing for available labor at harvest time, however, animal traction may assist in removing a higher percentage of the groundnuts. On the other hand, given the priority attached to harvesting cereals, the soil is frequently too hard to use the lifter before the groundnut harvest begins. The use of the cart to move harvested crops to the compound or to the marketplace can save labor and make it available for use in direct harvesting activities. The inclusion of the cart in animal traction packages also opens up possibilities for utilizing animals throughout the year.

[1/] For a description of weeding implements which have been employed in West Africa, see Kline et al. (1969: 365-368), FAO-CEEMAT (1972: 80-124, and Mathews and Pullen (1976).

e. Soil Improvement

Under the traditional system of shifting cultivation, yields on newly cleared fields decline with each subsequent cropping season. Ten to fifteen years of natural fallow is often required for the regeneration of soil nutrients after several years of cropping. With population pressure increasing the need for continuous cultivation, it is becoming more important to consider not only short-term yields, but also the maintenance and improvement of soil and yields in the long run. New techniques will be necessary to maintain soil fertility given a minimal fallow period. The quantities and types of nutrients removed from the soil depend on the choice of crops. Balanced cropping rotations are therefore an important aspect of a fully integrated animal traction farming system.

Forage crops provide a source of livestock feed, establish ground cover to reduce erosion, improve soil structure, and increase organic matter in the soil (Bouchard and Rakotoarimanana, 1970; Crowder and Chedda, 1977). Through the fixation of nitrogen and the mobilization of phosphorus and potassium, leguminous forage crops improve the nutrient levels in the soil (Masefield, 1961). Organic matter in the soil can be significantly increased by plowing under the fallow crop.

There is relatively little research evidence on the long-term yield effects of crop rotations. Table 5 above indicates the potential magnitude of yield effects from a combination of soil regeneration techniques including a crop rotation, end-of-season plowing, and plowing under of a fallow crop. Both studies referenced in Table 5 conclude that cereal crops benefit more from plowing under than do groundnuts, suggesting a rotation of two cereal crops followed by groundnuts. Although the short-term yield effects of these techniques are demonstrated in these tables, the long-term effects on soil quality and fertility are not clear. No experimental studies on this aspect of animal traction were found in the literature.

A further method of maintaining soil fertility levels and improving the organic matter content is the incorporation of livestock manure into the soil. This is especially important in an animal traction farming system which calls for continuous cultivation of the land. There is considerable evidence demonstrating that application of 6 to 10 tons of manure per hectare annually will increase the yields of most crops

substantially above yields on control fields.[1/] For example, Hamon (1972) reports a 63 percent increase in rice yields in the Ivory Coast; Vidal et al. (1962) report a maximum of 120 percent increase in sorghum yields in Senegal; and in the Kano region of northern Nigeria, Dennison (1961) reports that yields can be increased by 45 percent for millet, 31 percent for groundnuts, and by as much as 145 percent for sorghum.[2/]

Full exploitation of manure can involve other changes in traditional practices. For example, composting, although labor-intensive, is often promoted to enhance the manure's value (FAO-CEEMAT, 1972), based on results such as those shown in Table 8. Also, stabling of animals is encouraged to increase manure availability and to reduce loss during extensive grazing (Nourissat, 1965).

2. Extensification

Because the demand for labor in land preparation, planting, and weeding occurs within a relatively short time in Sahelian West Africa, animal power can significantly reduce labor inputs per hectare and, where surplus land is available, permit area expansion. The following results from experiment station research suggest that for a fully integrated animal traction farming system aggregate labor inputs for most crops can be reduced by as much as 40 percent.

In a comparison of labor requirements between manual and animal-powered cultivation of groundnuts and cereals in Mali, IRAT found in on-station trials that total labor requirements are reduced by 43 percent for both crops (Table 9). The greatest labor savings occur for weeding and ridging and, in the case of groundnuts, for planting. In contrast, the

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[1/] Whether such application rates could be realized with a single pair of draft animals, however, is not clear. For Upper Volta, de Dinechin, Malcoiffe, and de Hayes (1970) cite 5 tons of manure as the average annual production for a pair of mature oxen. In contrast, Hamon (1972) reports evidence from Senegal indicating that two 500 kg. animals are capable of producing 5 tons in only 5 months, and Nourissat (1965) cites 14 tons per year as the annual potential manure production of two 400 kg. animals. It should also be noted that work animals are not enclosed 24 hours a day and the farmer will not have access to the animals' total production.

[2/] By definition, the incorporation of manure into the soil requires plowing. Consequently, the results presented do not reflect simply the effect of using manure but also the effect of plowing.

Table 8. YIELD EFFECTS OF MANURE AND MANURE COMBINED WITH COMPOST AND CHEMICAL FERTILIZER

Country	Crop	Research Station	Yield With Manure Alone kg/ha	Manure With Compost		Manure With Compost and Chemical Fertilizers	
				kg/ha	Percent Increase	kg/ha	Percent Increase
Senegal	Millet	Bambey	331	958	189	1,328	301
		Sefa	2,458	2,807	14	2,829	15
Madagascar	Maize	Tananarive	503	1,456	154	3,100	441
Cameroun	Maize	Dschang	1,090	2,134	96	2,947	88
Ivory Coast	Rice	Bouake	1,190	1,940	63	1,610	35

Source: Tourte et al. (1971), p. 645.

Table 9. PER HECTARE LABOR REQUIREMENTS FOR GROUNDNUTS AND SORGHUM/MILLET PRODUCTION UNDER MANUAL AND OX-POWERED CULTIVATION, MALI[a/]

Operation	Manual Cultivation Man-Days	Ox-Drawn Cultivation Man-Days	% Reduction in Man-Days
Groundnuts			
Land Preparation	12.50	13.00	-
Planting	10.00	2.00	80
2nd Weeding	25.00	10.50	58
3rd Weeding	18.75	6.00	68
Harvesting/Threshing	26.25	22.50	14
Internal Transport	12.00	5.75	52
TOTAL	104.50	59.75	43
Sorghum/Millet			
Land Preparation	12.05/8.50[b/]	10.0/6.50[b/]	17/24[b/]
Planting	2.50	2.00	3
1st Weeding	12.00	6.00	50
Ridging	6.25	2.00	68
2nd Weeding	12.00	6.00	50
Internal Transport	10.00/9.00	5.75	43/36
TOTAL	54.35/49.80	31.75/28.25	42/43

[a/] Labor requirements for groundnuts are based upon 1,200 kg/ha yields. Requirements for the transport of cereals are based upon 900 kg/ha yield for sorghum and 725 kg/ha yield for millet. Ox-drawn equipment includes: multi-cultivator, seeder, groundnut lifter, and cart. I.R.A.T., Operation Arachide, as cited in: I.B.R.D., Appraisal of Integrated Rural Development Project, Mali, Report No. 340a-MLI. (Washington, D.C., May 13, 1974), Annex 3, Table 2.

[b/] Where two figures are cited, the first refers to sorghum, the second to millet.

labor requirements for land preparation, groundnut harvesting, and cereal planting are not significantly reduced.[1/] Depending on the relative magnitude of the two enterprises and the timing requirements, it is possible that labor bottlenecks would merely be shifted. Kline et al. (1969: 362) and Zalla (1976: 9) cite examples where partial adoption of animal traction equipment has shifted labor bottlenecks from land preparation to weeding. The consequence is reduced area expansion and/or reduced yield potential.

Data from Upper Volta (Delgado, 1979), Nigeria (Asuquo, 1977), and Senegal (Sargent, 1974) suggest that harvesting labor could be reduced by developing appropriate animal-drawn harvest implements other than the groundnut lifter. However, the weeding bottleneck still appears to be the critical one, in part because the timing of harvest is more flexible (Norman, personal communication; Barrett et al., 1981). Finally, the area that can be plowed with animals will be limited by the farmer's ability to destump his land, usually a manual activity (Monnier, 1965: 12).

Given conflicting evidence, it is difficult to generalize on the typical rate of area increase to be expected from the adoption of animal traction. Jones (1970: 287, 302) reports that in Mali animal power permitted approximately a 20 percent expansion of sorghum hectarage before the manual weeding constraint was reached. In Gambia, Peacock et al. (1966: 7) report that area per worker expanded by 33 percent with the use of animal traction for ploughing, weeding, and groundnut lifting.[2/] Garin (1966: 367) reports an area expansion of 20 percent in Senegal with the use of animal power for planting, weeding, and groundnut lifting. Barrett et al. (1981: 83) cite only a 10 percent increase in area cultivated per worker, based on a 1978-79 farm survey in Upper Volta.

B. Economic Benefits

Most studies of animal traction in francophone West Africa estimate hypothetical benefits rather than effects actually observed under on-farm conditions. These hypothetical benefits are generally based on a

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[1/] Since many farmers in the Sahelian zone plant cereals directly without land preparation, animal plowing may actually increase labor use for land preparation.

[2/] Derived from Mettrick (1978: Table 3, p. 26).

calculation of maximum production derived from enterprise budgets based on technical coefficients taken from experimental station trials or demonstration farms.

There are several drawbacks to this approach. Research station experiments tend to be run under near ideal conditions, ignoring labor and time constraints. Because farmers do not have control over environmental factors, yields tend to be lower, and/or areas cultivated reduced. Farm level data generated from model farms or model villages are likely to reflect superior management. Experiment station studies cannot capture the process of on-farm decision making, and often do not reflect the objectives and choices of small farmers. Consideration is not given to the risk of crop failure, and the farmer's response to that risk. Finally, the use of enterprise budgets (as opposed to whole farm budgets or farming systems analysis) does not provide a true picture of the economic benefits from, or the resource needs of, non-farm activities, or the interactions between several farm enterprises (Norman, 1980).

1. Maximum Benefits

Many studies of animal traction estimate maximum potential economic benefits. For example, Monnier (1972) develops optimal farm plans for the following animal traction packages: (1) donkey or horse traction; (2) single-row oxen traction; and (3) multiple-row oxen traction. The amount of land cultivated is calculated as the maximum amount which can be worked with each equipment package, using technical coefficients derived from experiment station trials to determine equipment hours and labor time required by enterprise and activity.[1/] Taking this as the optimum scale of operation, budgets are derived for each equipment package, as shown in Table 10. Net farm income is then calculated using yield estimates based on research station trials.[2/]

[1/] The enterprises included in the farm model are maize, cotton, sorghum, and groundnuts. Maximum labor use in the first two equipment packages occurs in the 30-day period for seeding and first weeding. For multiple-row oxen traction, the labor peak occurs during harvest.

[2/] Monnier (1972), Tourte et al. (1971), and Ramond (1971) all project the consequences of a change from the dominant cereal crop (millet) to the higher yielding sorghum and maize. This approach confuses the benefits of animal traction with those of a higher return cropping pattern.

Table 10. COMPARISON OF RETURNS FROM THREE HYPOTHETICAL ANIMAL TRACTION PACKAGES IN SINE-SALOUM, SENEGAL, FROM MONNIER

	Donkey Traction	Single-Row[a] Oxen Traction	Multiple-Row[a] Oxen Traction
Numbers of Workers[b]	3.4	5.1	6.3
Crops[c] (hectares)			
Maize	1.3	2.1	3.0
Cotton	.78	1.26	1.8
Sorghum	1.3	2.1	3.0
Groundnuts	1.82	2.94	4.2
TOTAL	5.20	8.40	12.0
Yields (kg/ha)			
Maize	1,000	2,000	3,000
Cotton	800	1,500	2,000
Sorghum	1,000	2,000	3,000
Groundnuts	1,000	1,500	2,000
Value of Production (FCFA)	94,562	279,155	511,200
Production Costs (FCFA)			
Variable	19,820	50,194	72,420
Fixed[d]	10,200	34,000	59,100
Net Returns[e] (Net Farm Income, FCFA)	64,542	189,961	379,680
Index of Net Returns	100	294	588
Net Returns/ha[f] (FCFA)	12,412	22,614	31,640
Net Returns/worker[g] (FCFA)	18,983	37,247	60,267

Source: Monnier (1972), pp. 41-43.

[a]Both oxen packages include higher levels of fertilizer and other chemical inputs, improved cultural practices, and higher levels of land, labor, and capital.

[b]Labor necessary to cultivate maximum area with given package based on research station coefficients.

[c]Maximum area that can be cultivated with the given package based on research station coefficients.

[d]Donkeys amortized, cost of oxen not included.

[e]Net returns = value of production minus production costs.

[f]Net returns divided by the number of hectares.

[g]Net returns divided by the number of workers.

Tourte et al. (1971: 662-665) use the same approach to determine the maximum amount of land that can be cultivated with four workers. Table 11 shows that the area cultivated is lower for multiple-row oxen traction than for donkey or single-row oxen traction, due to the introduction of cotton and the extremely high assumed yields, which leads to a higher labor requirement for cultivation and harvest of 10 hectares than four workers can provide. However, the revenue generated by cotton and the increase in yields of other crops more than outweigh the lower area cultivated.

The studies by Monnier and Tourte et al. show that single-row oxen traction has maximum potential benefits equal to about double the net farm income obtainable from donkey traction. Even greater potential benefits are estimated for multiple-row oxen traction. However, these results are not a reliable indicator of on-farm performance, since: (1) estimated benefits of animal traction are inflated by shifting to a higher-value cropping pattern; and (2) coefficients derived from experiment station trials are generally not relevant to on-farm conditions.

Ramond (1971) also estimates the maximum potential benefits of animal traction, but compares hypothetical "optimum" farm plans using animal traction with farms without animal traction. His results are based on 41 farms from the Koumbidia Experimental Unit in the Sine-Saloum region of Senegal during the 1969/70 agricultural season.[1/] Ramond's farm data are limited to inventories of land, and utilization of equipment and fertilizer. Two assumptions are made about potential yield improvements, based on experiment station trials at Bambey. The farm sample is divided into five groups according to area cultivated, and a different number of oxen traction teams is proposed for each. Only three farm enterprises--groundnuts, cotton, and cereals--are budgeted. As illustrated in Table 12, Ramond compares net farm income generated under the two yield hypotheses with net farm income for each farmer group, assuming no animal traction. Net farm

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[1/] The Experimental Units are pilot villages which have been used for on-farm trials by IRAT and ISRA since 1968.

Table 11. COMPARISON OF RETURNS FROM THREE HYPOTHETICAL ANIMAL TRACTION PACKAGES, SENEGAL, FROM TOURTE ET AL.

	Donkey Traction	Single-Row[a] Oxen Traction	Multiple-Row[a] Oxen Traction
Number of Workers	4	4	4
Crops (hectares)[b]			
Fallow	2.5	2.63	--
Groundnuts	5.0	5.26	2.61
Sorghum	2.5	2.63	2.61
Cotton	--	--	2.61
TOTAL	10.0	10.52	7.83
Yields (kg/ha)			
Groundnuts	1,500	2,000	2,200
Sorghum	1,800	2,800	3,200
Cotton	--	--	2,200
Value of Production (FCFA)			
Groundnuts (18.5 FCFA/kg)	138,750	194,620	106,190
Sorghum (17 FCFA/kg)	76,500	125,120	141,950
Cotton (38 FCFA/kg)	--	--	160,720
TOTAL	215,250	319,740	408,860
Production Costs (FCFA)			
Fixed[c]	29,322	41,650	73,335
Fertilizer	5,400	8,400	6,000
Seed	16,625	16,400	8,400
TOTAL	50,347	66,450	87,735
Net Returns[d] (Net Farm Income) (FCFA)	164,903	253,290	321,125
Index of Net Returns	100	154	195
Net Returns/worker (FCFA)[e]	41,225	63,320	80,820
Net Returns/ha (FCFA)[f]	16,490	24,075	41,010

Source: Tourte et al. (1971), pp. 663-665.

[a]Both oxen packages include higher levels of fertilizer and other chemical inputs, improved cultural practices, and higher levels of land and capital.

[b]Maximum area that can be cultivated with the given package and 4 workers.

[c]Fixed costs = 5-year amortization of equipment packages; repairs = 50 percent of amortization and feed costs. Donkeys amortized, but cost of oxen not included.

[d]Net returns = value of production minus production costs.

[e]Net returns divided by the number of workers.

[f]Net returns divided by the number of hectares.

Table 12. ESTIMATED OPTIMUM RETURNS FROM OXEN TRACTION COMPARED TO FARMS WITHOUT OXEN TRACTION, SENEGAL, FROM RAMOND

Item	Farm Area (ha)				
	4	4-8	8-12	12-20	20+
Farms Without Oxen Traction					
Ave. No. of Farm Workers	4	5.4	7.25	11.2	16.8
Ave. Area Per Farm (ha)	2.67	6.25	10.01	15.45	26.3
Net Returns (Net Farm Income) (FCFA)	41,200	73,360	107,722	186,592	446,300
Index of Net Returns	100	100	100	100	100
Net Returns/Worker	10,300	13,660	14,860	16,600	26,560
Optimum With Oxen Traction					
Number of Oxen Teams	0	1	2	3	4
Net Returns (Net Farm Income) (FCFA)	46,687				
Less Than Two Years' Experience		115,520	171,972	268,710	594,870
Index		157	160	144	133
Two Years' or More Experience		161,870	246,338	383,179	686,700
Index		221	229	205	154
Net Returns/Worker					
Less Than Two Years' Experience	--	21,510	23,720	23,990	35,409
Two Years' or More Experience	--	30,140	33,980	34,220	40,870

Source: Ramond (1971).

[a]Yield hypotheses:

Crop	Less Than Two Years' Experience	Two Years' or More Experience
Groundnuts	1,260	1,800
Millet	1,000	1,200
Sorghum	1,740	2,400
Cotton	1,490	1,500

income per worker is also calculated.[1/] The primary implication of Ramond's estimates is that animal traction is more profitable for farms between 4 and 12 hectares than for smaller or larger farms. However, the reasons for this finding are not clear.

Monnier and Talibart (1972) use an approach similar to Ramond's but only for a single farm and with a single yield hypothesis. They estimate that the optimum farm plan would generate the following increase in net returns over observed levels without animal traction:

	Observed	Optimum
Net Returns	317,311 FCFA	557,870 FCFA
Index of Net Returns	100	176

Unfortunately, the studies by Ramond (1971) and Monnier and Talibart (1972) provide no better an indication of the potential benefits of animal traction under small farmer conditions than do the studies by Monnier (1972) and Tourte et al. (1971).

2. Labor Allocation

An important issue is the impact of animal traction on farm labor allocation. Ideally, the use of animal traction should improve the productivity of labor and ease critical labor bottlenecks. Both the seasonal pattern of labor use and the overall level of labor input are likely to change with the adoption of animal traction.

The studies by Monnier (1972) and Tourte et al. (1971) use research station data to derive coefficients for the labor requirements of the animal traction farming system, by crop and labor activity. Their farm models incorporate the labor requirements of maximum crop production. By

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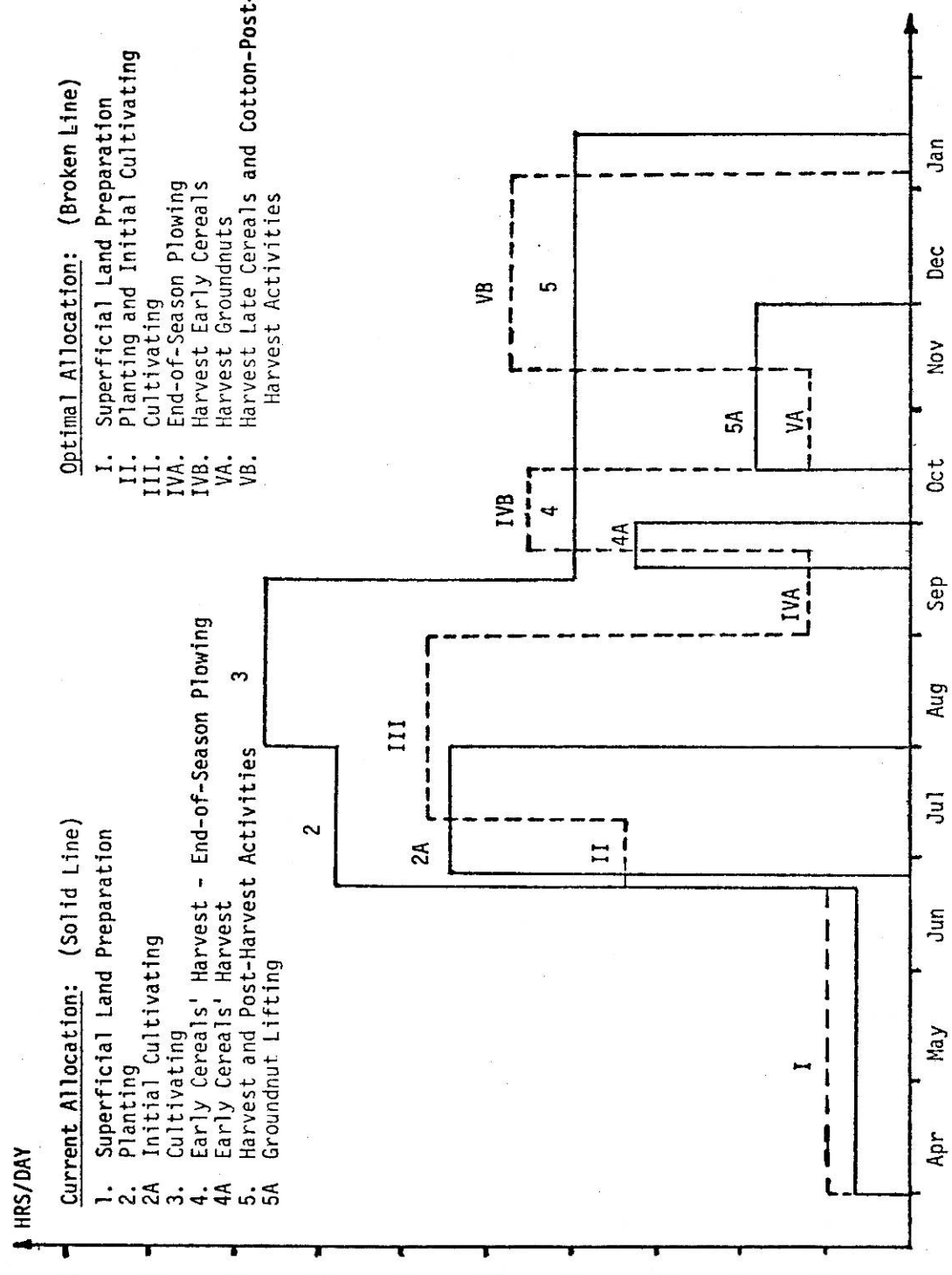
[1/] The studies discussed here frequently present the benefits of animal traction in terms of returns to land or labor. However, the definition of these measures is somewhat different than that used in U.S. or U.K. farm management analysis, in that the opportunity cost of other resources has not been deducted. Fixed and variable costs are deducted from gross crop income to give net returns, but no opportunity cost of labor is deducted in calculating returns to land. Similarly, no opportunity cost of land is deducted in calculating returns to labor. Except for Tourte et al., the studies often ignore production costs such as equipment repair, animal maintenance, and veterinary drugs. The net result is to inflate the projected returns from animal traction.

contrast, Monnier and Talibart (1972) specify the labor requirements of the different equipment packages based on the levels of labor use observed in a case study of one farm in the Experimental Unit of Nioro-du-Rip in the Sine-Saloum region of Senegal.[1/] The Monnier and Talibart study compared the observed levels of labor use with the pattern of labor required by optimal use of the animal traction equipment package, assuming the same family size and farm area. As shown in Figure 1, the labor requirements of animal traction are generally below those of the hand hoe system, except for higher labor requirements during land preparation and harvest. However, assuming that the farm family can provide 78 hours of labor per day (13 workers x 6-hour day), the animal traction farming system is not constrained by labor supply during these periods.

Whereas Monnier and Talibart estimated labor demand using a partial enterprise budget approach, a more recent study by Delgado (1979) examines the demand for labor within a whole farm context, using linear programming. Delgado's study is based on a survey of 41 farm households in southeastern Upper Volta during 1976-77. His objective was to compare the profitability of traction and non-traction farming, focusing specifically on seasonal competition for resources. His overall conclusion was that supply of adult labor during the harvest period was not sufficient to meet the needs of harvesting and animal herding simultaneously, and that adult labor would be more profitably employed in hoe-cultivated cereal production than in crop production using animal traction. However, Delgado's conclusions are weakened by methodological problems. He had no animal traction users in his sample of Mossi and Bisa households; labor requirements for herding were extrapolated from data on care of entire herds by Fulani, rather than care of a single oxen team. Also, the model did not allow for the use of child labor in herding, which is commonly observed in West Africa (Barrett et al., 1981), nor did it take account of other mechanisms which are commonly used to reduce the labor used in herding oxen, e.g., staking oxen near fields being worked, storage of dry season feed, and cooperative labor arrangements.

[1/] The case study household cultivated 17.4 hectares and had 20 family members, of which 13 were farm workers. This is a much larger farm operation than usual, and is therefore not representative. Ramond's study indicated that 40 percent of farms in that area were 4-8 ha in size, and that farm households had 5.5 workers on average (Ramond, 1971: 10).

FIGURE 1 ALLOCATION OF FARM LABOR: A SINGLE CASE STUDY FROM THE EXPERIMENTAL UNITS, SINE-SALOUM, SENEGAL



SOURCE: Monnier and Talibart, 1972, p. 17 and p. 45.

The 1978-79 survey of traction and hoe farmers in eastern Upper Volta reported in Barrett et al. (1981) revealed several changes in labor allocation associated with use of animal traction. First, labor inputs per hectare were 18.5 percent lower for animal traction households than for hand hoe households, due primarily to lower labor for soil tillage. The reduction in labor input was greater for oxen traction (26 percent) than for donkey traction (12 percent). Second, the seasonal labor profiles were very similar for traction and hand hoe farmers, with some indication that traction weeding reduced labor inputs during the peak periods. Third, as might be expected, traction farmers spent slightly more time on livestock husbandry and crop trading than hoe farmers.

3. Incidence of Benefits and Costs Over Time

The studies by Monnier, Tourte et al., and Monnier and Talibart construct average-year budgets which do not take account of the timing of costs and benefits. There is no consideration of the time required by farmers to learn to use animal traction efficiently and thus to achieve the full benefits in terms of area expansion or yield increase.[1/] One-year budgets also do not capture the financial problems posed by high cash outlays in the early years of adoption when increases in crop production due to animal traction are still modest.

Bonnefond (1967) introduces a more realistic approach by analyzing the costs and benefits of animal traction over a three-year period. Sleeper (1978) carries out a cash flow analysis of oxen traction over a four-year period, as shown in Table 13. Sleeper's calculations show that net farm income drops by 18 percent in the first year following adoption, but rises substantially after that to a level 85 percent above the base income level by the fourth year after adoption. This result is only slightly below the approximately 100 percent increases projected by IRAT studies of maximum potential benefits, but it illustrates the learning period required.[2/]

[1/] Ramond (1971) addresses this problem by using two yield assumptions: one for the initial adoption period, and one for an established traction package.

[2/] Sleeper's analysis is based on research station data drawn largely from IRAT sources.

Table 13 INDICATIVE ANNUAL CASH REVENUES AND CASH COSTS FOR A FARM ADOPTING BOVINE TRACTION[a]

Item	Year 0	1	2	3	4
Groundnuts (ha.)	3.0	3.15	3.31	3.48	3.65
Millet (ha.)	3.0	3.15	3.31	3.48	3.65
Total (ha.)	6.0	6.30	6.62	6.96	7.30
(fallow)	(7.0)	(6.70)			
Value of Production[b] (FCFA)					
Groundnuts	105,825	133,340	140,112	147,308	154,505
Millet	45,000	61,425	64,545	67,860	71,175
Custom-carting revenues	-	10,390	10,390	10,390	10,390
Custom-seeding revenues	-	1,842	1,842	1,842	1,842
Sale of oxen fourth year[c]	-	-	-	-	88,440
Total	150,825	206,997	216,889	227,400	326,452
Production Costs (FCFA)					
Downpayment (25% value of investment)[e]	-	31,740	-	-	-
Debt service (3 yrs. @ 7.5% p.a.)	-	38,882	36,501	34,121	-
Repairs (10%)	-	7,936	7,936	7,936	7,936
Hand tools	1,000	1,000	1,000	1,000	1,000
Millet seeds (6 kg./ha.)	540	567	596	627	657
Groundnut seeds (100 kg./ha.)	12,450	13,073	13,737	14,442	15,148
Oxen work ration[f]	-	800	800	800	800
Veterinary drugs	-	150	150	150	150
Purchase of oxen fourth year[c]	-	-	-	-	47,600
Total	13,990	94,148	60,720	59,076	73,291
Net Farm Income	136,835	112,849	156,169	168,324	253,161
Index of Net Farm Income	100	82	114	123	185
Value of Subsistence and Taxes[d]	68,003	68,003	68,003	68,003	68,003
Net Cash Income (profit and depreciation)	68,832	44,846	88,166	100,321	185,058
U.S. $ (rounded)[g]	($275)	($179)	($353)	($401)	($740)
Index of cash income (Year 0 = 100)	100	65	128	146	269

Source: Sleeper, 1978, pp. 35-37.

Footnotes for Table 13 (on previous page)

[a] Estimated farmgate prices, taxes, and input costs (except value of investment) are drawn from: IBRD, Appraisal of Sine-Saloum Agricultural Development Project, Senegal, Report No. 661a-SE, (Washington, D.C., May 5, 1975). Credit terms and value of investment are drawn from: M. Sargent, IRAT: Research on Cereal Production Technology in Senegal and Upper Volta, USAID mimeographed report (Washington, D.C., September 24, 1974). Custom revenues are based on estimates in: M. Garin, "Bilan Economique de la Culture Attelee dans Quatre Villages du Laghem Orientale," Oleagineaux, Vol. XXI, No. 6 (1966), pp. 365-370. Yields in Year 0 are drawn from the FAO Production Yearbook for 1974.

[b] Crop yields and prices:

	Year 0 Yields kg/ha	Years 1-4 Yields kg/ha	Index of Yields	1974 Estimated Farmgate Prices FCFA/kg
Groundnuts	850	1,020	120	41.5
Millet	500	650	130	30.0

[c] Purchase of oxen fourth year: 238 kg @ FCFA 100 x 2
Sale of oxen fourth year: 402 kg @ FCFA 110 x 2

[d] Value of subsistence and taxes (FCFA):

Family consumption (9 persons)	
Millet (220 kg/person)	59,400
Groundnuts (15 kg/person)	5,603
Taxes (FCFA 500/working adult)	3,000
	68,003

[e] Value of investment (FCFA):

"Arara" tool bar	25,000	
Hoe	7,700	
Two one-row seeders	24,860	
Yoke	1,800	
Cart (without sides)	20,000	
Sub-Total	79,360	($317)
Oxen	47,600	($190)
TOTAL	126,960	($507)

[f] Oxen work ration: 100 g/day protein/mineral concentrate for 200 days @ FCFA 40/kg.

[g] FCFA 1 = $0.004.

We prepared a similar multi-year budget to compare the net benefits of single-row oxen traction with donkey traction.[1/] Table 14 shows the results, which are based on yields and areas from a 1976-77 survey of animal traction farmers in the Sine-Saloum region of Senegal (SODEVA, 1977). A complete oxen package is incorporated, but multiple-row oxen traction is not considered, since it does not appear economically viable except on large farms of 12 hectares or more, given its higher investment and maintenance costs. The cropping pattern includes millet rather than the higher yielding sorghum incorporated in studies of maximum potential benefits, since millet is grown on 75 percent of the cultivated land in the region.

Table 14 shows that by the sixth year after adoption the value of production for oxen traction increases by only 25 percent over donkey traction. This is well below the 49 percent and 190 percent increases projected by Tourte et al. (1971) and Monnier (1972). Net farm income declines in Years 1 and 2, eventually increasing to 23 percent over that for donkey traction. This is less than half the 54 percent increase projected by Monnier. The lower figures shown by our calculations result primarily from a longer, more realistic learning period, and more complete accounting of production costs.[2/]

The Upper Volta study by Barrett et al. (1981) also presents multi-year budgets for donkey and oxen traction. Separate calculations are made for packages comprising plowing, plowing and weeding, and plowing, weeding, and phosphate fertilizer. Among the conclusions suggested by their analysis are: (1) the private profitability of donkey traction frequently exceeds that of oxen traction, because of lower investment and recurrent costs and because the learning period for donkey traction is shorter; and (2) cash flow problems are likely to arise in the first 3-4 years following adoption, especially for the oxen traction package. The quality of the data, analysis, and presentation in the Barrett et al. report appears to be substantially higher than that of most other studies reviewed here.

[1/] This comparison is relevant for areas where soil conditions are suitable for both oxen and donkey traction.

[2/] With this comparison of donkey and oxen traction in mind, it is worth noting that the 1976-77 Sine-Saloum survey (SODEVA, 1977) indicated that yields on farms using donkey traction were 79 and 83 percent above the regional average for groundnuts (905 kg/ha) and millet (662 kg/ha), respectively. The survey admits to a bias toward superior donkey traction farms, but the results suggest the potential benefits of the relatively simple donkey traction technology.

TABLE 14

HYPOTHETICAL BENEFITS FROM THE ADOPTION OF OXEN TRACTION:
SINE-SALOUM, SENEGAL, 1976-77

	Donkey Traction	Single Row Oxen Traction (Year)					
	0	1	2	3	4	5	6
Crops[a] (Hectares)							
Groundnuts	5.9	6.2	6.5	6.8	7.0	7.0	7.0
Millet	3.5	3.5	3.6	3.7	3.8	3.8	3.8
	9.4	9.7	10.1	10.5	10.8	10.8	10.8
Yields[b]							
Groundnuts	1,620	1,645	1,670	1,695	1,721	1,721	1,721
Millet	1,212	1,247	1,282	1,317	1,350	1,350	1,350
Value of Production[c]							
Groundnuts (41.5 FCFA/kg)	396,657	423,259	450,483	478,329	499,951	499,951	499,951
Millet (37 FCFA/kg)	156,954	161,487	170,762	180,297	189,810	189,810	189,810
Sale of Oxen (4th year)	-	-	-	-	130,000	-	-
	553,611	584,745	621,245	658,626	819,761	689,761	689,761
Index	100	106	112	119	148	125	125
Production Costs							
Debt Service (7.5% x 5 yrs)[d]		55,342	55,342	55,342	55,342	55,342	-
Repairs[e] (10%)	9,800	13,120	13,120	13,120	13,120	13,120	13,120
Hand Tools	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Millet Seed 6 kg/ha	777	777	799	821	844	844	844
Groundnut Seed 100 kg/ha	24,485	25,730	26,975	28,220	29,050	29,050	29,050
Fertilizer[f]	29,380	30,340	33,728	35,068	36,070	36,070	36,070
Maintenance and Work Ration[g]	4,750	13,820	13,820	13,820	13,820	13,820	13,820
Veterinary Drugs	150	150	150	150	150	150	150
Replacement of Oxen (4th year)	-	-	-	-	90,000	-	-
	71,342	141,279	145,934	148,541	240,396	150,396	95,054
Net Farm Income[h]	482,269	443,446	475,311	510,085	579,365	539,365	594,707
Index	100	92	99	106	114	112	123
Increase in Net Farm Income	-	(38,823)	(6,858)	27,816	72,838	57,096	112,438
Family Consumption and Reserve[i] (11 members, 6 workers)[j]							
Millet (220-260 kg/ca)	89,540	93,610	97,680	101,750	105,820	105,820	105,820
Groundnuts (25 kg/ca)	11,413	11,413	11,413	11,413	11,413	11,413	11,413
	100,953	105,023	109,093	113,163	117,233	117,233	117,233
Net Cash Income[k]	381,316	338,423	366,218	396,922	462,132	422,132	477,474
Index	100	89	96	104	121	111	125

Footnotes for Table 14 (on previous page)

a/ Crop areas are taken from the 1976-77 survey of 97 animal traction farms (SODEVA, 1977). The survey admits a bias in having included larger than average donkey traction farms. A simple step function is used to approximate the rate of increase.

b/ Yields are taken from the same survey as areas. Donkey traction yields are low yield figures (without manure). Again, the survey admits a bias of having included better than average donkey traction users. Oxen traction yields are the better of the two with or without manure yield figures. A simple step function is used to approximate the rate of increase.

c/ Prices are also taken from (SODEVA, 1977).

d/ Debt service for the following equipment package based on local terms of credit, 7.5 percent interest for 5 years:

Arara Tool Bar	46,000 FCFA
Ox Cart	59,500 FCFA
Super Eco Seeder	25,700 FCFA
1 Pair of Oxen	90,000 FCFA
	221,200 FCFA

Equipment prices are for Dakar (Le Moigne and Zerbo, 1977) and ignore project subsidies. No equipment or animal purchase is shown in Year 1 since it is assumed that the package is obtained through credit in kind.

e/ Repairs are estimated at 10 percent of the cost of the equipment.

f/ Fertilizer use is based on use by farms in the survey, i.e., 76 kg/ha for donkey users and 94 kg/ha for oxen users with single-row equipment.

g/ Maintenance and work ration are estimates for on-farm maintenance of a donkey and a pair of oxen derived from Eastern ORD, 1978 and SODEVA, 1977.

h/ Net Farm Income -- from crops budgeted only.

i/ Family consumption and reserve -- both family consumption and the amount of food crops kept in reserve for food security are expected to increase with production and income. Since donkey users are expected to have already made some of these adjustments, the quantity of millet retained by the family starts at a higher level (220 kg/person) than would a family using manual cultivation, and increases to 260 kg/person. Given the high level of groundnut production with donkey traction, groundnut consumption is not expected to increase further. A step function is used to approximate the rate of increase.

j/ Family size -- average families for both the donkey and single-row oxen traction had approximately 11 members and 6 workers.

k/ Net Cash Income -- for crops budgeted only.

Even the more thorough evaluations of animal traction benefits over a multi-year horizon do not take account of the risks of crop failure, animal mortality, or breakdown of input supply or repair services. Such misfortunes are common in francophone West Africa; when they occur, output and incomes can be severely depressed. It might be argued that the agronomic effects of the animal traction farming system will stabilize crop output by improving fertility and moisture retention. In addition, off-season earnings from carting or sale of animals may smooth out income flows. On the other hand, the financial risks of adopting animal traction are substantial. As Barrett et al. (1981) illustrate, cash flow deficits may occur in the first several years after adoption, even when normal yields are assumed. When considering the possibility of below-average returns, farmers who are not financially secure may find animal traction too risky to be attractive. More research on the variability of costs and returns to animal traction, relative to hand hoe farming, would make possible a more complete evaluation of the economic benefits of animal traction. As will be seen in Chapter 4, failure to protect farmers from the risks of adopting animal traction is an important factor explaining the limited success of some animal traction projects.

IV. ANALYSIS OF SELECTED ANIMAL TRACTION PROJECTS

The 27 projects included in this review range from small experimental programs such as the Experimental Units involving 350 farms in Senegal and the Matourkou project covering 465 farms in Upper Volta, to very large regional development projects such as the Integrated Rural Development Project in southern Chad covering 110,000 farms and 138,000 square kilometers. The projects are located in several ecological zones, with annual rainfall varying from 300 to 1,200 millimeters. Some projects are located in areas with little history of animal traction; in other areas such as southern Mali and the Sine-Saloum region of Senegal, animal traction users number in the tens of thousands.

Several aspects of the 27 projects will be considered in the analysis: (1) characteristics of the package introduced by the project, including the type of animal, equipment, and crop mixture recommended; (2) institutions and services supporting animal traction; and (3) the impact of project interventions at the farm and project levels, including financial and economic performance where the data permit.

A. Characteristics of the Package

The ideal animal traction farming system described in Chapter 1 includes a complete set of equipment, crop rotation and tillage practices, and animal health care and nutrition. A complete equipment package would consist of a multi-purpose tool bar with attachments for a plow, weeder, and groundnut lifter, a seeder, and a cart.[1/] Most of the projects

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[1/] The development of the multi-purpose tool bar in 1955 by Jean Nolle of IRAT/Senegal allowed a number of tools to be attached to the same frame. This was followed in the early 1960s by the development of the medium-weight Arara and Sine multi-purpose tool bars and the lightweight Western hoe (Arara attachments: 10" plow, ridger, 3 groundnut lifter blades, 3-or 5-tine cultivator, one-row seeder--two can be attached side by side; Sine attachments: 8" or 10" plow, ridger, 3 groundnut lifter blades, 3- or 5-tine cultivator, one-row seeder--two can be attached side by side; Western hoe attachments: 6" or 8" plow, ridger, 3- or 5-tine cultivator, 1 groundnut lifter blade, one-row seeder). Developed at the Bambey station and produced by SISCOMA (Senegal), these equipment lines are used throughout francophone West Africa and are recommended in 12 of the 27 projects. Since 1970, Mali and Upper Volta have produced their own multi-purpose tool bar-the Ciwara in Mali (for oxen) and the HVA (for donkeys) and HVB (for oxen) in Upper Volta. Since 1974, COBEMAG has produced the Arara equipment in Benin.

reviewed incorporated a partial package comprising the animal(s) and certain implements. Only 8 out of the 27 projects included all equipment plus extension advice on agronomic and animal husbandry practices. Moreover, in most projects, even those introducing a partial package, farmers adopted only certain elements of the package. These points will be elaborated later in the chapter. In general, the effect of partial design and adoption is production benefits which are substantially lower than those of the ideal animal traction farming system, which often forms the basis for justifying a project to be financed by a foreign donor.

Before discussing the details and rationale for the equipment used in the case study projects, a brief description of the common packages is worthwhile. In areas of light soils, the package will usually involve a donkey, horse, or single ox with a light plow or scarifier and a weeder. For heavier soils, the package will typically include two or more oxen, a heavy plow, and a weeder. Seeders are less commonly used, although they are found in Senegal and The Gambia, as are groundnut lifters. The package will occasionally include a ridger. The prevalence of carts varies; donkey carts are quite common in eastern Upper Volta and Senegal. Projects where the equipment package is generally limited to a plow, weeder, and cart include: OACV, Mali; Office du Niger, Mali; Operation SATEC Mossi, Upper Volta; and Operation Charrue, Mauritania. Projects in Senegal often include a seeder but no plow. This is a response to sandy soils and a comparatively short rainy season which puts a premium on timely planting.

1. Land Preparation Equipment

The choice of technique and tool for land preparation is a function of: (1) soil and rainfall, which determine the desired timing and depth of plowing, and whether ridges are constructed; and (2) the availability and cost of the animals and equipment. Land preparation in the project areas reviewed generally involved shallow plowing (around 10 centimeters in depth) or scarification (5 cm or less) rather than the deep plowing (15 to 20 cm) which is widely recommended based on experiment station trials (for example, SRCVO, 1978). Twenty-two of the 27 projects included a plow in the package, but were not reported to emphasize any particular depth of plowing. Deep plowing and plowing under of organic material were not reported in any of the project documents.

One reason for the lack of deep plowing is the scarcity of well-trained, well-fed oxen strong enough to plow to a depth of 20 cm. Mouldboard plows range in size from 6 inches to 10 inches, with only the 9-inch and 10-inch plows capable of deep plowing. The 10-inch plow is designed to be pulled by two 500 kg animals, which is an above-average weight for the available breeds. Secondly, although deep plowing would generally be undertaken only every three to four years (Norman, personal communication), even plowing to a shallower depth takes time which the farmer may not be willing to spend, given the tradeoff between plowing and early planting. The labor demands of plowing under organic matter may also conflict with those of harvest, since both operations tend to occur during September to November.

A third factor discouraging moderate or deep plowing is the undesirable long-range effects which plowing may have on some of the sandy and fragile Sahelian soils. Two projects launched since the 1969-73 drought (Maradi in Niger and OACV in Mali) explicitly discourage plowing in favor of scarification. In northern and central Senegal as well, scarification has long been the prevailing land preparation technique.

A final factor affecting the decision to plow is the relatively high cost of oxen. Whereas a donkey can be purchased for 10,000 to 20,000 FCFA, a pair of oxen can cost from 60,000 to 120,000 FCFA in 1980. Even where a 5-year credit program is available to finance purchase, annual loan repayments for oxen would be 10,000 to 20,000 FCFA higher than for donkeys. While expected increases in value of production are correspondingly higher for oxen, the achievement of full production benefits is slow, leaving farmers unable to meet loan repayment or other cash expenditure requirements in the initial years after adoption. A related factor is that oxen are more difficult to train and manage than donkeys (Barrett et al., 1981).

Ridging as distinct from plowing is a land preparation technique that was introduced in the 1950s and 1960s.[1/] Twelve of the 27 projects included a ridger in the package of equipment available to farmers. Arguments for the ridger are that it facilitates row planting, it is designed for

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[1/] In 1969, the Emcot ridger was the most common animal-drawn tool owned or used in anglophone West Africa, with over 60,000 units in Nigeria alone (Kline et al., 1969). Norman reports (personal communication) that ridgers are still very popular in northern Nigeria.

both land preparation and weeding, it inhibits waterlogging in flat areas of heavy soils, and it permits contour ridging to control erosion. However, several factors have limited the adoption of ridging. Mechanized seeding on ridges is more difficult, and the ridge seeder is twice as expensive as the flat land seeder (Mathews and Pullen, 1974: 12). Contour ridges in light sandy soils are frequently washed out. In most cases of ridging in francophone West Africa, ridging is preceded by an initial plowing, which increases the labor required for land preparation and may delay planting. Moreover, the yield effects of ridging are not substantial (Mathews and Pullen, 1974). Nonetheless, in areas of Nigeria with intense rainfall or heavy soils, ridging is frequently used to prevent waterlogging.

2. Planting Equipment

The potential advantages of animal-drawn seeding are faster, earlier, and more uniform planting, and easier animal-drawn weeding of the row-planted crop. Eight dryland projects and two irrigated rice projects incorporated a seeder in the equipment package, but the use of animal-drawn seeders has found broad acceptance only in Senegal and Gambia. As noted above, seeders are particularly common in central and northern Senegal, where farmers avoid a planting season bottleneck by planting directly into the untilled sandy soil. Possible yield reductions from non-plowing are offset by the larger area cultivated, made possible by animal-drawn seeding and weeding.

Low adoption of the seeder elsewhere in francophone West Africa can be partially explained by its high cost. The one-row seeder may cost as much as all the other multi-purpose tool bar attachments together. It is not surprising that farmers choose to forego the advantages of faster planting where the planting period is long enough and labor is available. Technical problems are also experienced with the seeder.[1/] Finally, lack of adoption may be traced in part to poor extension regarding effective use of the seeder.

[1/] The Super Eco seeder (SISCOMA) which is widely available blocks up frequently in wet soil, has difficulty planting at a uniform depth, and tends to drill seed rather than pocket-drop seed, which is the recommended technique (Le Moigne and Zerbo, 1977; Mathews and Pullen, 1976).

3. Weeding Equipment

Animal-drawn weeding can potentially increase yields through more timely and thorough weed removal, and can allow an expansion of cultivated area by reducing the labor requirements of weeding.[1/] However, it is not clear from the project documents whether animal-drawn weeding was given active encouragement. Although 20 of the 27 projects included an animal weeder, all but one reported that less than one-fifth of farmers actually carried out animal traction weeding.[2/] The exception is the Sine-Saloum region of Senegal, where over 70 percent of farmers used their weeding implements (SODEVA, 1971: Tome I, p. 10).

The low adoption of animal-drawn weeding is explained in part by the lack of emphasis on weeding techniques by extension services. The importance of planting in rows, e.g., with an animal-drawn seeder, as a prerequisite to animal weeding is not often underlined. A second explanation is that weeding, especially with two oxen, is difficult and potentially damaging to the crop where there has been inadequate training of animals and farmers. It appears that farmers may be reluctant to engage in animal-drawn weeding until they have acquired several years' experience with animal traction (Barrett et al., 1981). Finally, the design of the weeding implement has not yet been perfected (Norman, personal communication).[3/]

[1/] Data from Mali, reported in Table 9 above, indicate that animal-drawn weeding reduces labor requirements for weeding by about 60 percent with groundnuts and about 50 percent for cereals.

[2/] In The Gambia, only 20 percent of farmers with weeding implements used them (Peacock et al., 1966: 15). No farmers used weeding equipment in the Yatenga region of Upper Volta (Gerardin, 1964: 140-141). As of 1978-79 in the eastern region of Upper Volta, about 20 percent of farmers with two years' or less experience with animal traction owned a weeder or ridger. Those with more experience were more likely to own a weeder or ridger--roughly 60 percent for oxen and 35 percent for donkey owners. However, of farmers who owned weeders, only 56 percent actually used them, because their animals were too weak or ill-trained, or because they had not planted in rows (Barrett et al., 1981: 64-67).

[3/] In the Maradi project in Niger, the groundnut lifter has been adopted as a weeding implement. With proper adjustment, the groundnut lifter blades can perform the same weeding operations as the 3- or 5-tine cultivator at approximately one-third the purchase price.

4. Harvesting Equipment

The only direct use of animal traction in harvesting is unearthing groundnuts. Only eight of the projects included a groundnut lifter in the equipment package, and little use was made of it by farmers. Ideally, groundnuts should be harvested when the soil is still moist. However, since farmers give first priority to the cereal harvest, the soil becomes too dry by the time groundnuts are harvested. The lifter is difficult to manipulate in the hardened soil, the tines do not penetrate sufficiently, and a certain percentage of the groundnuts are lost. Some farmers therefore use a hand hoe, or even a mouldboard plow or ridger, to unearth the nuts from the hardened soil. As with the occasional use of the groundnut lifter for weeding purposes, this is an example of innovative equipment use by farmers.

Animal-drawn carts allow an indirect use of animal traction in harvesting. Carts can save labor in transporting the crop from the field to storage, to the homestead, or to the market.

5. Farm Level Transportation

Animal-drawn carts are used throughout francophone West Africa. One popular variety is the 2-wheel, wooden flat-bed wagon with rubber tires, drawn by horse or oxen. Smaller 2-wheel donkey carts are also available, and are especially common in eastern Upper Volta, where ox carts are considered too big (Barrett et al., 1981). Fourteen of the 27 projects included a cart, but farmers were frequently encouraged to repay part of their initial equipment loan before investing in a cart.

Dry season use of the cart to move crops, firewood, construction materials, etc., provides cash revenue and helps maintain the training of the animals. However, purchasing a cart (at 40,000 to 60,000 FCFA) generally doubles the equipment cost for animal traction. Moreover, cash revenues from rental work are highly variable and depend on the extent of the local market for transport services.

6. Recommended Cropping Pattern

The projects reviewed differ in the type of cropping pattern recommended, in terms of emphasis on particular crops, crop rotation, and the

incorporation of forage plants. Historically, in francophone West Africa, a sharp distinction has been drawn between food and cash crops. Food crops (millet, sorghum, maize) are those produced largely for home consumption with only a small proportion being marketed.[1/] Cash crops (cotton, groundnuts, rice) are produced for sale in national and international markets.

Almost all of the animal traction projects emphasized the production of cash crops. Colonial powers invested in transport and market infrastructure and research and extension services in regions with good export crop potential. As a result, more productive biochemical technologies were developed for cash crops than for food crops. Cash crops provided a source of valuable financial support for project administration, through deductions made from farmer sales. Established market outlets for cash crops also increased the likelihood that farmers would be willing and able to repay their animal traction loans.

Following independence, many countries attempted to reorient projects toward food production. An example is the Action SATEC Mossi project in central Upper Volta described in Mesnil (1970), where the change in crop emphasis increased the food reserves of farmer participants by 30 percent but insufficient cash income was generated to cover loan repayment. As a result, the project was restructured after four years to increase the role of groundnuts in the farming system.

A review of the 27 projects indicates that the most common cash crops are cotton and groundnuts. Twelve of the 27 projects include cotton in the cropping system, and 7 can be classified as cotton projects. An example is the CMDT project in southern Mali, one of the largest and most advanced animal traction programs in francophone West Africa, and as such often regarded as a model for other projects. Cotton has a high potential return per hectare, but several drawbacks: it requires substantial purchased inputs (fertilizer and pesticides) which increase the risk to the farmer, it is labor-intensive (4-7 pesticide treatments), it is sensitive to planting date, and is very demanding of soil nutrients.

Groundnuts are grown more widely than cotton. Groundnuts are included in the cropping pattern of 22 of the 27 projects, and are the primary

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[1/] The market for food crops is still not as well established as markets for cash crops; hence, the sale of food crop surpluses is more difficult and prices are less certain.

source of cash revenue in 13. Groundnuts are suited to a wider range of soils, they are less fertilizer- and labor-intensive, and less sensitive to time of planting, and as a legume they have nitrogen-fixing capacity. Groundnut hay is an excellent livestock forage which is important in dry season animal maintenance.

Rice production has increased in response to growing urban demand. Returns per hectare from rice are often substantially higher than those generated by cotton or groundnuts. Partly for this reason, the Office du Niger project in Mali substituted irrigated rice for irrigated cotton in its cropping plan. Rice is part of the crop mix in 12 of the projects, and is a major income source in 6 of them. Two are devoted exclusively to irrigated rice. Rainfed lowland (bas-fond) rice is increasingly cultivated, but lack of effective water control discourages fertilizer use and therefore reduces yields. Animal-powered cultivation of rice has been limited. Heavy lowland soils require oxen for plowing, and weeding equipment has not been adapted to the narrow row spacing used in rice production (Le Moigne and Zerbo, 1977: 114).

Cowpeas are a secondary cash (and food) crop included in 10 of the projects. Cowpeas are a good livestock feed; cultivation of cowpeas for this purpose is expanding rapidly in Mali. However, the presence of cowpeas in the crop mix can impede animal weeding, since cowpeas are usually intercropped with millet or sorghum.

Millet and sorghum are the most important food crops in the Sahel, and are included in 25 of the 27 projects. Millet is grown where rainfall is less than 600 mm, and on lighter soils where donkey traction and scarification rather than plowing is undertaken. Sorghum is found where rainfall is from 700 mm to 1,100 mm.

Above 1,100 mm of rainfall, maize can be grown. Maize was reported in only five projects, located in areas south of the Sahelian ecological zone. However, maize is a useful food crop even in the northern part of the region, where it is the first crop to be harvested, along with 70-day millet. In years of food scarcity, maize or 70-day millet may provide the only source of food before the main cereal crop harvest. It is interesting to note that maize yields are more responsive to animal traction plowing than other food crops (Table 3 above, and ICRISAT, 1980: G51).

A second element of project crop choice is crop rotation. Crop rotation is considered a part of the ideal animal traction farming system

because of its role in maintaining soil fertility and controlling disease and pest infestation under conditions of continuous cultivation.[1/] Part of the crop rotation may also allow fallowing with a leguminous cover crop which provides livestock feed as well. For example, a crop rotation might include a combination of cash and food crops, with four or five years of cropping followed by two years under a leguminous crop.

Despite these potential benefits, only 9 of the 27 projects promoted crop rotation, and of the 9 only 4 recommended fallowing. Where crop rotation has been recommended, it has generally not been adopted by farmers, e.g., in Sine-Saloum (Senegal), Benin, the Mixed Farming Centers (The Gambia), and the CMDT and Office du Niger projects (Mali). Legumes or forage grasses are often not included in the crop rotation, in part because research has not yet identified optimal varieties or their desired sequence in the rotation.

7. Animal Husbandry Practices

The ability of farmers to maintain large animals is an important constraint on the adoption of animal traction. Unless lowland pasture is accessible, grazing alone cannot support oxen and donkeys through the dry season without weight loss.

Nevertheless, only 11 of the projects specifically address animal feeding practices. Recommendations focus on the use of a salt and mineral supplement (one project), grass hay and/or legume hay (five projects), and either cottonseed or rice by-product supplements (five projects). Implementation problems also occur. Farmers in the OACV project, Mali, complained about lack of access to by-products from crop processing and of the difficulty in maintaining oxen without them. The CMDT project, Mali, had a breakdown in its supply of cottonseed which disrupted its otherwise established supplemental feeding practices. Farmers in both projects have responded by placing an increased importance on the cultivation and use of cowpeas (Lichte, 1978). In eastern Upper Volta, dry season animal maintenance is also considered as a major problem (Eastern ORD, 1978).

[1/] Many researchers and planners in francophone West Africa have argued that shifting cultivation should be replaced by continuous cultivation, or "sedentarization," especially as population pressure grows.

Most projects do not include programs for training farmers in basic animal health care. Exceptions are the OACV project (Mali) and the Eastern ORD project (Upper Volta).

B. Institutions and Support Services

Farmers adopting animal traction need access to services in support of animal traction technology. These include extension and training, product and input marketing, credit, veterinary care, and equipment maintenance and repair.

1. Agricultural Extension and Training

In all of the projects reviewed, agricultural extension and training institutions have been entrusted with project implementation and assigned responsibility for all aspects of project execution. Twenty-four of the 27 projects are involved in some aspect of credit administration. In most cases, this means the evaluation and selection of borrowers as well as loan collection, accounting, monitoring, and enforcement. The four Niger projects do receive some assistance from the UNCC (Union Nigerienne de Credit et de Cooperation), but the credit responsibility usually falls on the extension agent. Most on-going projects are attempting to establish village or multi-village cooperative associations to select candidates for credit and assure payment. Although established in Senegal, Mali, Upper Volta, Niger, and Benin, it is not yet clear to what extent these have reduced the extension agent's workload.

In all 27 projects, the agricultural service is also responsible for animal traction equipment delivery and other agricultural inputs including improved seed, fertilizer, and pesticides. At least 23 of the 27 projects are at least partially involved in the marketing of cash crops and/or cereals including primary collection, weighing, grading, purchasing, transportation, and accounting services. Some projects coordinate their marketing activities with national marketing boards, national affiliates of the CFDT (Campagnie Francaise de Developpement des Textiles), etc.

The agricultural extension service is also often responsible for forestry development and livestock production. Responsibilities in forestry development consist of promoting reforestration and tree cropping, primary collection, weighing and marketing of tree crops, and the introduction of

new tree varieties (i.e., grafted fruit trees). Responsibility for livestock production usually is shared with the veterinary service. Extension activities encompass the whole range of species from chickens to cattle. The extension service is also responsible for monitoring the project's performance and for providing agricultural statistics to national policy makers.

With the responsibility for so many activities borne by the extension service, devoting resources and manpower to information, communication, training, and advising responsibilities is often precluded. Farmers need information, training and advice on equipment, crops and cropping techniques, purchased inputs, financial affairs, and general farm management. However, only six of the projects even have specific programs to teach farmers how to train and handle draft animals and the accompanying equipment.

The quality of extension advice is limited by the agent's training and experience. The local extension agent is usually a generalist with a junior high school education and one to two years of vocational training. In short, he is likely to have neither the time nor the training for his animal traction extension duties, or for coordinating delivery of inputs and marketing of outputs.

2. Agricultural Credit

There is some debate over the need for credit to finance purchase of the animal traction package. It is evident that the investment in animals and equipment is substantial in relation to farm income. The cost of an Arara multi-purpose tool bar, seeder, ox cart, and two oxen would amount to one and a half times the annual gross value of production and over three times the value of annual net cash income for a typical 6-hectare farm in

the Sine-Saloum region of Senegal.[1/] Based on figures from Upper Volta, the cost of a donkey, plow, seeder, and cart would be equal to annual gross value of production and three times annual net cash income.[2/] For this reason, medium-term credit is often considered necessary to enable the typical West African farmer to purchase the animal traction package. However, several project evaluations have questioned whether capital, e.g., the availability of credit, is a real constraint to the adoption of animal

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[1/] Oxen Package

Arara Tool Bar	46,000 FCFA
Ox Cart	59,500 FCFA
Super-Eco Seeder	25,700 FCFA
2 Oxen	90,000 FCFA
TOTAL	221,200 FCFA

Equipment prices are FOB, Dakar, 1977 (Le Moigne and Zerbo, 1977: 281). The cost to farmers may be somewhat less as many projects subsidize various pieces of equipment.

Cost citations for a pair of oxen range from 60,000 to 120,000 FCFA.

Gross production and net cash income estimates are for a six-hectare farm in the Sine-Saloum (Senegal) producing three hectares of groundnuts and three of millet.

Gross Value of Production:	150,825
Net Cash Income:	68,832

(Sleeper, 1978: Table 3, pp. 135-137)

[2/] Donkey Package

Western Hoe	25,300
Donkey Cart	47,000
Super-Eco Seeder	25,700
Donkey	15,000
TOTAL	113,000

Equipment prices are FOB, Dakar, 1977 (Le Moigne and Zerbo, 1977: 281). The cost to farmers may be somewhat less as many projects subsidize various pieces of equipment.

Cost citations for a donkey range from 10,000 to 20,000 FCFA.

Gross production and net cash income estimates are for a 3.85-hectare farm in the Tenkodogo region of Upper Volta. Production consists of 3.3 hectares of millet, sorghum, and cowpeas, 1/4 hectare of groundnuts, and 1/5 hectare of rice.

Gross Value of Production:	112,159 FCFA
Net Cash Income:	35,112 FCFA

(Delgado, 1979: 217-221)

traction.[1/] In some parts of Upper Volta, 75 percent of animal traction equipment is sold on a cash basis (Sargent, 1979). Lack of a credit program has also not appeared to hinder adoption in southern Chad (Integrated Rural Development Project) or in The Gambia prior to 1972. Nonetheless, the fact that 23 of the 27 projects include a medium-term credit program indicates a general belief that the average farmer in the Sahel needs assistance in financing the cost of animal traction.

Credit programs typically require downpayments which may range from 3,000 to 10,000 FCFA. Seven projects reported allowing a grace period of one to two years on repayment, with repayment spread over a range from two to seven years. Credit is subsidized in all projects, with interest rates varying between 5 and 10 percent.[2/] Only 7 of the 27 projects report specific loan repayment rates; they range from 97.8 percent (CMDT, Mali) to 24 percent for Action SATEC Mossi (Upper Volta). Although the sample is small, it appears that the projects with high repayment rates have a cash crop focus and control the marketing of the crop. A variety of factors seem to be associated with low repayment, including poor credit administration and follow-up regarding repayment, selection of farmers with low debt-carrying capacity (e.g., lack of working capital to maintain the traction package, or lack of non-farm income to cover repayment needs in a poor crop season), and short repayment periods (e.g., three to five years) which require large payments during the initial period of adoption before

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[1/] Gerardin (1964) found that early adopters of animal traction in the GERES-Ouahigouya project of Upper Volta had families 70 percent larger than the non-adopters sampled, and farms twice as large as the non-adopters. Peacock et al. (1966), in a survey of Mixed Farming Center Trainees in The Gambia, showed that animal traction users had a higher standard of living than hand cultivators, especially in terms of number of cattle owned and size of farm. However, the direction of causality is not clear. Peacock et al. argue that the higher standard of living results from using animal traction. On the other hand, Weil (1969) interprets the same data as indicating that animal traction adopters were wealthier than non-adopters prior to adoption, particularly in terms of cattle ownership.

[2/] Informal sector interest rates are generally much higher. Stickley and Tapsoba (1979) and Sargent (1979) report private rural interest rates ranging from 30 to 40 percent in Upper Volta. Sargent further observes that farmers very explicitly took advantage of the cheap credit available for animal traction in order to use their own funds for other purposes. Subsidized credit for animal traction also provides a cheap way of getting cattle which are a good investment in their own right.

income increases have been achieved (Stickley and Tapsoba, 1979; Barrett et al., 1981). (For further discussion, see section C.2.b. below.)

Animal insurance programs were reported only by three projects in Upper Volta (Matourkou, AVV, and Eastern ORD), where insurance is mandatory. The aim is to protect the farmer's substantial investment. The animal insurance programs are usually accompanied by a series of preventative veterinary health treatments, paid for by the farmer along with the insurance premium.[1/] If the farmer adheres to the loan terms, the insurance will pay 80 to 100 percent of the cost of replacing an animal which dies. In areas where veterinary services are inadequate, such insurance programs are likely to increase farmer acceptance of animal traction.

3. Veterinary Services

Traditionally, veterinary services and agricultural extension services have been supplied by separate agencies. Moreover, cooperation between the two services has been impeded in some countries by competition for a share of the national budget, and by differences in professional status.[2/] Veterinary services in the past have concentrated largely on sporadic nationwide vaccination campaigns, rather than on regular animal health programs. These campaigns focus on the large itinerant herds where a single contact can lead to hundreds of cattle being treated. Between campaigns, the veterinary service often lacks manpower, vehicles, and even medicine. This situation has not facilitated the development of animal health care facilities suited to the needs of sedentary animal traction users, who need regularly available services.

The projects reviewed illustrate several approaches to this problem. Upper Volta has formally integrated the veterinary service into the Regional Development Organizations, through which animal traction projects are often implemented. The CMDT project in Mali established its own veterinary service in the Fana region, and organized regular village visits so that a number of cattle could be treated at one time (Lichte,

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[1/] Premiums in Upper Volta are 750 FCFA for a donkey and 3,000 FCFA for a pair of oxen.

[2/] Veterinary staff tend to have more advanced degree qualifications (e.g., Doctor of Veterinary Medicine) than agricultural staff (typically Bachelors or Masters degrees).

1978). Finally, health cards for each working animal are part of the design of the Niamey Productivity Project (Niger), and have existed for the last five years in northern Benin.

4. Equipment Maintenance and Repair Services

Equipment breakdowns coupled with inadequate maintenance and repair services are a critical constraint on the efficient use of animal traction technology. Le Moigne and Zerbo (1972), for example, estimate that 50 percent of the existing equipment in the Maradi region of Niger is unused due to the need for repair. To alleviate this problem, 7 of the 27 projects provide training programs for village blacksmiths. The training programs last from two months (COBEMAG, Benin) to nine months (CNPAR, Upper Volta) and cover the new metal-working techniques necessary for working on animal traction equipment. They provide blacksmiths with equipment designs and specifications, and in three projects provide credit for new tools and raw materials.

All of the francophone West African countries have national training centers for rural artisans. Originally for blacksmithing, they have expanded their work to include carpentry, motorbike mechanics, and masonry. In the Maradi (Niger) project, blacksmiths can obtain up to 220,000 FCFA in credit payable in five years at 10 percent interest for new tools (i.e., hand-crank blower forge, anvil, vise, hand tools). Although the tools are necessary for animal traction work, they are usable in a wide range of rural artisanal activities.

C. Financial and Economic Effects

This section draws on data from the 27 case study projects regarding: (1) farm production and income, (2) adoption rates, and (3) credit repayment rates. Unfortunately, the majority of the projects did not include any formal evaluation; hence, even this basic information is not always reported in their project documents.

1. Farm Level: Production and Incomes

Increased farm production and income is a key objective at the farm level, and is a measurable phenomenon. It provides direct evidence of benefits to farmers and can be aggregated over the total number of adopters to measure benefits attributable to the project. Farm income is a more useful measure than production alone, since changes in cost as well as output are considered and changes in non-project income and activities can be brought into the evaluation.

There are no projects or studies in the literature which evaluate a set of farms over a period of years to show how production and incomes change with the adoption of animal traction and the transition to an integrated animal traction farming system. An evaluation of adopters and non-adopters has been completed in only four projects: Action SATEC, Mossi, Upper Volta; Eastern ORD, Upper Volta; Mixed Farming Centers, The Gambia; and the Gambian Rural Development Project.[1/] Such comparisons can reveal the benefits of animal traction if other factors (labor and land availability and quality, fertilizer, seed, plant density, etc.) are held constant. Only the two Gambia studies and the Eastern ORD study controlled for labor availability and only the Eastern ORD and the Gambian Rural Development Project studies controlled for fertilizer and seed.[2/]

None of the project evaluations except the Eastern ORD study use a farming systems approach or even techniques such as whole farm budgeting. Consequently, it is generally not possible to determine if the increases in crop production and crop income cited represent net increases in family production and income or if they required a reduction of time, effort, and resources devoted to other farm or family activities.

a. Area Expansion

Although 12 of the 27 projects assert that some farm area expansion has taken place, only 6 attempt to quantify these increases. Gorse and Larrieu (1967) claim a 30 percent area expansion in Mauritania's Operation

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[1/] Mesnil (1970), Barrett et al. (1981), Peacock et al. (1967), and Wedderburn (1979), respectively.

[2/] Barrett et al. (1981) is a very careful analysis of the Eastern ORD (Upper Volta) project. Since the report is readily available, its findings are not presented in detail here.

Plow.[1/] The Sine-Saloum project reports a 55 percent expansion in farm area. Bonnefond (1967) estimated that long-term area increases were limited to about 30 percent in Action SATEC, Upper Volta.[2/] Barrett et al. (1981) report an average 10 percent increase in area cultivated per worker in Eastern Upper Volta, 18 percent for donkey traction users and 4 percent for oxen users.

The Gambia studies report area increases per worker and per capita. Farmers who had attended Mixed Farming Centers increased area cultivated per worker by 46 percent over non-animal traction users. Animal traction farmers without training increased area by 36 percent per worker (Mettrick, 1978: Table 3). In the Rural Development Project, the area increases were 38 and 25 percent per capita for recent adopters and previously mechanized farms, respectively (Wedderburn, 1979). Most of the area increase was in groundnuts. To the extent that the seeder was an important factor in these projects, these 25 to 55 percent increases in area may overstate the increases which can be expected in regions where seeders are inappropriate.

b. Yield Effects

Thirteen of the 27 projects comment on yield effects but they are documented in only 8 projects. The BDPA study by Gorse and Larrieu (cited in Le Moigne and Zerbo, 1977: 172) claims a 14 percent yield increase in Mauritania's Operation Plow.[3/] The BDPA Review claims a 20 to 25 percent increase in groundnut yields in the Bokoro project, Chad (Casse et al., 1965). The OACV project in Mali showed mixed results, with groundnut yields decreasing when animal traction was not combined with fertilizer

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[1/] Gorse, J. and Larrieu, C. (1967) as cited in Le Moigne and Zerbo (1977: 172).

[2/]

	Estimated Percent Area Increases	
	By SATEC	By Bonnefond
2nd Year Participants	5	10
3rd Year Participants	25	20
4th Year Participants	34	30
5th Year Participants	34	30

Bonnefond (1967)

[3/] Except where explicitly stated, none of these reported results isolate the effects of animal traction from the effects of other components in the production package (fertilizer, improved seed, pesticides, etc.).

use and cereal yields increasing an average of 40 percent (Institut d'Economie Rurale, 1978). Operation SATEC Mossi showed no significant yield effects (Mesnil, 1970). Senegal's Experimental Units reported yield increases of 40 percent for groundnuts, 36 percent for cotton, and 73 percent for cereals. However, yield effects reported in the Sine-Saloum project, a much larger project in the same region of Senegal, were negligible. Mettrick (1978) claims that no yield effects can be substantiated in Gambia's Mixed Farming Center project. Wedderburn (1979: 23, 31) argues that in the Gambian Rural Development Project groundnut yields with animal traction and fertilizer improved yields 33 percent over manual farming with no fertilizer, but only 6 percent over manual farming with fertilizer. In Eastern Upper Volta, Barrett et al. (1981) found significantly greater yields among traction households only for groundnuts and maize, with increments of 200 percent (only for oxen traction) and 60 percent, respectively.

c. Income

Improvement in incomes associated with animal traction is documented in six projects. Once again, these improvements are from full production packages, not animal traction alone.[1/] OACV Mali shows 44 percent increases in gross production and 42 percent in cash revenues (Institut d'Economie Rurale, 1978). Wedderburn (1979: Table 44) presents farm budgets showing little change in returns per hectare, but increases in per capita cash incomes due to increases in groundnut area.

The Action SATEC Mossi project (Upper Volta) estimated an 18 percent increase in gross value of production but since most of it was in cereals which were consumed, the increase in cash income was only 800 FCFA or 4 percent. This was not adequate to cover the farmer's loan repayments of 3,000 FCFA per year (SATEC, 1967: Vol. 4). Zinder (Niger) estimates cash revenues at 35,100 FCFA after adoption (Le Moigne and Zerbo, 1977: 237-243). This is barely adequate for the annual loan repayment of 30,000 FCFA for the oxen package and leaves little for variable inputs, taxes, and other personal needs. The Maradi project (Niger) projects much higher incomes for the same animal traction package but assumes 100 percent yield

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[1/] It is also difficult to establish whether uncontrolled household characteristics partly account for higher incomes for animal traction farmers.

increases in millet (Wedderburn, 1979: Tables 39 and 41). Such production increases cannot be considered realistic. In Eastern Upper Volta, average incomes per household member generated in crop production activities in 1978/79 were 11 percent higher for oxen traction farmers than for hoe farmers. In contrast, donkey traction farmers had 36 percent lower crop production incomes, due primarily to localized drought conditions (Barrett et al., 1981).

d. Incidence of Benefits and Costs Over Time

Table 15 illustrates the hypothetical benefits of oxen traction over hoe cultivation, based on area and yield increases reported for Gambia's Rural Development Project.[1/] This table is similar to Table 14 except that it compares single-row oxen traction to hoe cultivation rather than to donkey traction. The value of production increases to 59 percent over hoe cultivation, and net farm income increases 46 percent in the sixth year, after loan repayment is completed. Net farm income declines 25 percent and 12 percent, respectively, in the first and second years and increases substantially in the fourth year. Net cash income drops dramatically in the first year. It is not consistently positive until after loan repayment is completed in the sixth year, when it increases to 69 percent over manual cultivation.

The 46 percent hypothetical increase in net farm income in Table 15 is only about one-half of that which the literature estimating maximum potential benefits would have led one to expect.[2/] This literature compared oxen traction to donkey traction, creating an expectation of even larger increases over unimproved manual cultivation. While this 46 percent increase in net farm income may be sufficient to attract many farmers, a farmer must have sufficient non-crop income or resources to support his family through the first three years when there is a serious cash flow problem. Furthermore, if a substantial portion of these benefits can be achieved through the use of lower-cost donkey traction and/or fertilizer,

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[1/] For the details of this project, see Appendix I. See also the footnotes to Table 15.

[2/] Our calculations use more realistic estimates of yield increases and area expansion, a longer learning period, and more complete accounting of costs.

Table 15 HYPOTHETICAL BENEFITS FROM THE ADOPTION OF OXEN TRACTION IN THE GAMBIA

	Hoe Cultivation	Single Row Oxen Traction					
		Year					
	0	1	2	3	4	5	6
Crops[a] (ha.)							
Groundnuts	1.43	1.84	2.25	2.66	3.08	3.08	3.08
Cereals	3.34	3.38	3.42	3.46	3.50	3.50	3.50
	4.77	5.22	5.67	6.12	6.58	6.58	6.58
Yields (kg./ha.)[b]							
Groundnuts	1,188	1,288	1,388	1,488	1,584	1,584	1,584
Cereals	1,189	1,168	1,146	1,125	1,103	1,103	1,103
Value of Production (FCFA)[c]							
Groundnuts (41.5 FCFA/kg.)	70,502	98,352	129,605	164,260	202,467	202,467	202,467
Cereals (37 FCFA/kg.)	146,937	146,070	145,015	144,023	142,839	142,839	142,839
Sale of oxen (4th yr.)					130,000		
Total	217,439	244,422	274,620	308,283	475,306	345,306	345,306
Index (value at production)	100	112	126	142	219	159	159
Production Costs (FCFA)							
Debt service (10% x 5 yrs.)[d]	-	55,342	55,342	55,342	55,342	55,342	-
Repair (10% of equip. cost)[e]	-	13,120	13,120	13,120	13,120	13,120	13,120
Hand tools	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Sorghum seed (10 kg./ha.)	1,236	1,251	1,265	1,280	1,295	1,295	1,295
Groundnuts seed (100 kg./ha.)	5,935	7,636	9,338	11,039	12,782	12,782	12,782
Fertilizer (51 kg.ha.)	-	6,656	7,229	7,803	8,390	8,390	8,390
Maintenance & work ration[g]	-	2,884	2,884	2,884	2,884	2,884	2,884
Vet drugs	-	150	150	150	150	150	150
Purchase oxen (4th yr.)					90,000		
Net Farm Income[h]	208,268	155,383	183,292	214,665	289,343	249,343	304,685
Index (net farm income)	100	75	88	103	139	120	146
Increase or (loss) in Net Farm Income		(52,885)	(24,976)	6,397	81,075	41,075	96,417
Family Consumption Reserve[i] (17 members, 12 workers)							
Sorghum (200-260 kg./capita (FCFA)	125,800	135,232	144,670	154,105	163,540	163,540	163,540
Groundnuts (15-25 kg./capita) (FCFA)	10,583	12,346	14,110	15,874	17,638	17,638	17,638
Value of Consumption (FCFA)	135,383	147,578	158,780	169,979	181,178	181,178	181,178
Net Cash Income[k]	72,885	7,805	24,512	44,686	101,165	68,165	123,507
Index (Net Cash Income)	100	11	34	61	148	94	169

Footnotes for Table 15 (on previous page)

a/ Crop areas are derived from a socioeconomic survey of the Gambian Rural Development Project (Wedderburn, 1979: Tables 39 and 41). Wedderburn's area for oxen traction has been adjusted to reflect the same amount of labor found in his unimproved manual cultivation budget. Equal annual increases are assumed for the first four years.

b/ Yields are taken from the same survey; cereal yields are a weighted average for millet, sorghum, maize, and rice. Equal annual increases are assumed for the first four years.

c/ Prices are taken from Senegal (SODEVA, 1977) so that Tables 14 and 15 will be consistent.

d/ Debt service for the same equipment package as Table 14 and based on local terms of credit and 10 percent interest for five years:

Arara Tool Bar	46,000 FCFA
Ox Cart	59,500 FCFA
Super Eco Seeder	25,700 FCFA
1 Pair of Oxen	90,000 FCFA
	221,200 FCFA

Equipment prices are FOB Dakar (Le Moigne and Zerbo, 1977) and ignore project subsidies.

e/ Repairs are estimated at 10 percent of the cost of equipment.

f/ Fertilizer use of 51 kg/ha is based on average use found in the survey (Wedderburn, 1979).

g/ Maintenance and work ration are estimates for maintenance of a donkey and a pair of oxen "in the bush" derived from Eastern ORD (1978) and SODEVA (1977).

h/ Net Farm Income--only for the crops budgeted, which in this case includes practically the entire cropping system (Wedderburn, 1979).

i/ Family consumption and reserve--as in Table 14, a step function is used to approximate the increase in family consumption and the amount of food kept in reserve. The original quantities consumed are less than in Table 14 due to the lower initial production and income. Cereal consumption starts at 200 kg/person and increases to 260 kg/person. Groundnut consumption is also expected to increase in this case from 15 kg/person to 25 kg/person.

j/ Family size--also taken from Wedderburn's (1979) budgets, but standardized to a 17-member family with 12 workers.

k/ Net cash income--only from the crops budgeted, which in this case includes practically the entire cropping system (Wedderburn, 1979).

much of the serious decline in net cash income could be avoided. A drop in net cash income is particularly serious on the small farms (3 to 5 ha) typical of the Sahel, where incomes are already low. When one considers the risks of partial or complete crop loss in Sahelian countries, the low rate of adoption of animal traction is understandable.

2. Project Level Performance

Adoption rates and credit repayment rates are important criteria for evaluating project level performance. Adoption rates are an indication of the impact of a project on a region. They are a gauge of the effectiveness of the project in reaching farmers. Credit repayment rates are also an indication of the relationship between the farmers and the project. Poor credit repayment rates show a breakdown in this relationship. This may be due to poor credit administration, but may also indicate lower than expected returns to farmers from the project. A poor credit repayment rate strongly attests to a need to modify credit administration and/or project design.

a. Adoption Rates

The total number of animal traction adopters in the francophone West Africa region is not known. A rough approximation is given by the equipment numbers presented in Table 2. Fifteen of the project documents report figures on the number of total adopters, but only five present adoption rates over time. Another five projects required the adoption of animal traction in order to participate in the project: three rice projects in Mali (Office du Niger, Sikasso, and Segou) and two resettlement projects in Upper Volta (Matourkou and AVV). Only two older projects discuss attrition rates (Pilot Farms and Operation SATEC-Mossi, Upper Volta); one of these, SATEC-Mossi, reported that 27 percent of the adopters dropped out after five years (Mesnil, 1970: 37).

In the five projects reporting adoption rates over time, there is a consistent pattern of slow adoption at first followed by significant increase in the later years of the project. Not only is the overall adoption rate a function of time, but for the individual farmer it takes three to five years to master the new animal traction technology. This is true both of the number of traction operations performed, and of the skill with which

they are executed. Similarly, farmers tend to observe the initial adopters (often larger or wealthier farmers who can afford the risks inherent in the new technology) for a few years before making their decision.

b. Credit Repayment Rates

Only 7 of the 27 projects report repayment rates. The reported rates vary significantly, and their precise definition is not clear. As Stickley and Tapsoba (1979) show for the Eastern ORD project (Upper Volta), it makes quite a difference whether the repayment rate is defined as a percentage of total loans due (which they found to be 1 percent in 1979), or as a percentage of loans due in a given year (31 percent in 1979). They argue that the latter definition is more appropriate.

The only evidence on credit repayment rates over time is from the Operation SATEC-Mossi project (Upper Volta), where they fell from 99 percent to 24 percent in seven years, and the Eastern ORD project (Upper Volta), where the percentage of the portfolio in arrears rose from 2 percent in 1976/77 to 28 percent in 1979/80 (implying a decline in repayment rate) (Barrett et al., 1981: 30). In the Experimental Units (Senegal), the repayment rate for farmers to their cooperative associations was 45 percent, yet the cooperatives paid 85 percent of their debt to the government. It appears that the cooperatives were able to cover most of the bad debts with revenues from their marketing activities.

There is little reported analysis of the reasons for non-repayment by farmers. For the Eastern ORD project, however, Stickley and Tapsoba (1979) found that: (1) 37 percent of the cases of delinquency were the fault of the borrowers (due either to indifference or unwillingness to repay); (2) 37 percent were the fault of the ORD as the lending institution (late delivery of equipment, poor analysis of the borrower's debt-carrying capacity, and failure to ask for repayment); and (3) 26 percent were the fault of nature (family health problems or poor crop yields). Stickley and Tapsoba found that borrowers frequently felt less obligation to repay their formal loans from the ORD than they did to repay informal loans from money lenders.

V. CONCLUSIONS AND RECOMMENDATIONS

This report analyzes animal traction technology in francophone West Africa based on a review of available literature and a detailed assessment of 27 projects. Our analysis shows that the benefits to farmers from animal traction have been quite variable, often falling well below expectations.

The expected benefits from animal traction have often been based on analyses of "maximum potential benefits." As illustrated in Tables 10-12, these studies predict substantial increases in net farm income. However, such studies rely on experiment station trials rather than on-farm testing, and thus tend to exaggerate the benefits which might reasonably accrue to farmers.

A. Constraints on Adoption and Effective Use of Animal Traction

The examination of 27 projects in Chapter IV disclosed a number of problems which largely explain the modest level of benefits achieved to date from animal traction programs. One of the most important problems is the lack of improved farmer-tested bio-chemical production technology, which is needed to complement the mechanical technology of donkey and oxen cultivation. Farm-level constraints and weak supporting services also inhibit the adoption and effective use of animal traction.

1. Technological Deficiencies

Prototype animal traction packages have been formulated for most dryland farming systems in the Sahel, based primarily on experiment station research. For numerous reasons, a package which has been tested and proven at the farm level is not available for widespread adoption in most countries in francophone West Africa, as of 1981. Lack of significantly improved technology is particularly acute for dryland food crops, but in many parts of the region the opportunities for profitable cash crop production are nearly as limited. As noted in Chapter III, even where cotton and groundnuts can be grown, their yields are not always sufficiently attractive to offset their financial risks and demands for labor. Without a profitable food or cash crop, farmers adopting animal traction face the prospect of substantial cash flow deficits.

Researchers are finding that many of the recommended soil conservation and crop rotation practices are not seen by farmers as profitable in the short run. Thus, short-run behavior diverges from that necessary for the long-run viability of continued production on a given piece of land. One area where such long-term considerations are apparently recognized by farmers is the Southern Mali CMDT zone where some farmers are beginning to compost and plow under animal manure and crop by-products, grow leguminous forage crops, and use substantial amounts of fertilizer. Such mixed cropping systems are a step towards the balanced crop rotations necessary to maintain and improve the soil. In many areas, however, such a balance may require reducing the cultivation of a dominant cash or food crop, which may conflict with the need to ensure the family's food supply.

Weeding with draft animals is done by relatively few farmers in West Africa, particularly when seeders are not used. Weeding, therefore, typically remains a major constraint on area expansion. Oxen weeding has been hindered by the difficulty encountered in manuevering poorly trained ox teams without damaging the crop. Weeding with a single ox, horse, or donkey should be encouraged. The cost of weeding equipment could also be reduced by using a groundnut lifter for weeding, as is done in the Maradi project, Niger, and in northern Benin. Where equipment is used to facilitate rapid row marking, use of seeders may be efficient even though they are expensive and the planting period is not a constraining labor bottleneck. Minimum tillage techniques should also be considered for sandy and lateritic soils. For this reason, plowing and ridging are now discouraged in OACV, Mali and Maradi, Niger. Where minimum tillage is used, a donkey or horse will likely be a more efficient power source than oxen.

2. Farm Level Constraints

The availability of land for farm expansion is a critical constraint at the farm level, particularly in areas of high population density like the Mossi Plateau, Upper Volta and Maradi, Niger. Initial benefits from the animal traction farming system may come from improved cultivation of existing area rather than from area expansion, but full use of animal traction is likely to involve area expansion. Available bio-chemical technology can increase yields per unit of land, but it requires the use of costly variable inputs (fertilizers and pesticides) and is often less

reliable than traditional technology under adverse conditions. The risk associated with this financial investment persuades many farmers to pursue a less risky area expansion strategy rather than to intensify their production through the adoption of bio-chemical technology.

The large fixed investment in animal traction also implies a threshold farm size below which net farm income is too small to cover loan repayment. This threshold will depend on agro-climatic factors, cropping opportunities, etc.; it will generally be higher for oxen than for donkey traction. Even in farms above these thresholds, net farm income will decrease during the first few years after adoption, requiring outside sources of wealth or income to support animal maintenance, loan repayment, and family consumption needs (Tables 14 and 15). Only the AVV credit program in Upper Volta takes account of the farmer's cash flow profile by allowing payments to be increased as the farmer gains experience.

Both extensification and intensification require increased labor in specific time periods. The competing demands for labor between crops, cropping operations, and non-cropping and non-farm activities frequently have not been considered in many projects and, as a result, benefits are often overestimated.

Many farmers have difficulty maintaining their animals during the dry season. This has been a problem in the southern Mali CMDT project and in the Eastern ORD, Upper Volta project. Cowpeas intercropped with grains can provide dry season forage. The OACV in Mali is pursuing this strategy.

3. Support Services

Lack of adequate support services appears to be a major cause of low benefits to farmers and low adoption rates in projects. Critical support services are: the delivery of production inputs including equipment and spare parts; marketing, credit, and veterinary services; and rural artisan and extension training. If any one of the critical services breaks down, the production process is disrupted and farm profitability can be seriously compromised. The inadequacy of these support services is well documented in many of the projects analyzed. The maintenance of adequate support services over many years has contributed importantly to the relative success of animal traction in southern Mali and in the Sine-Saloum Region, Senegal.

For the average Sahelian farmer, animal traction is probably the largest investment he is likely to make. Given the relationship between the cost of an animal traction package and annual farm incomes (Chapter IV. B. 2.), credit must be provided if the average Sahelian farmer is to undertake this major investment. Investment risk should be minimized by providing insurance schemes for both animals and equipment, and a credit program with well-articulated conditions for default and foreclosure. A credit structure needs to be established to assess the credit-carrying capacity of loan candidates and to provide systematic collection of loan payments. Credit management should be provided by loan officers rather than local extension officers. An extension agent's role as counselor and facilitator of change is compromised by his role as loan collection agent. Separate loan officers are successfully employed in several projects in Niger. Interest rates in most projects are extremely low relative to prevailing private interest rates, and to the real cost of lending. This tends to erode the capital of the lending institution, and may require heavy subsidization.

Improved health care for work animals requires a reorientation of veterinary services from intermittent large-scale vaccination campaigns to more regular preventive and curative care at the farm level. A system based on the use of health cards purchased by farmers has proven effective in northern Benin. The Niamey Productivity project is using health cards to integrate animal health care and insurance.

Animal traction equipment is frequently not used by farmers because of the lack of equipment maintenance and repair. The most practical way to provide such services is to establish a network of village artisans. Training in new technologies alone is not sufficient; these artisans need access to credit for the purchase of equipment and raw materials, as is provided by the CMDT, Mali and the Maradi project, Niger.

Agricultural extension and training services in support of animal traction also need to be improved. Farmers must understand the technology and achieve confidence that they can handle it effectively, and have access to knowledgeable persons who can help them if they encounter problems. Teaching farmers to train animals and to adjust and maintain equipment is crucial to establishing this confidence. The extension agents should also be trained to help farmers with specific problems. Training programs and periodic seminars can provide agents with the necessary knowledge and experience.

B. Implications for Project Design and Implementation

1. Project Design

The constraints mentioned above must be addressed in future projects involving animal traction. In the past, animal traction schemes in francophone West Africa have not incorporated an effective mechanism for moving from prototype technology to a field-tested package. Introduction of animal traction would be more likely to succeed in the future if the equipment package, production practices, and supporting services were designed through a process of farming systems research (Norman, 1980). Animal traction technology needs to be tailored to suit local agronomic and economic conditions, and farmer goals and resources. This process requires several years of interaction between researchers, farmers, and extension staff. Applied research on the current farming system should therefore be included as a project activity.

At the technical level, project design should consider the trade-offs between the use of oxen, donkeys, and horses. The choice of plowing versus minimum tillage should be examined. Donkey traction and minimum tillage are often economically more attractive. Animal-drawn weeding should be strongly encouraged and less expensive equipment like the groundnut lifter substituted as the weeding implement where possible. Because of its high cost the seeder should not be a compulsory part of the equipment package. Its use should be evaluated in terms of the time and labor available for hand planting and the cost of alternative row marking procedures. There should also be careful assessment of whether to include a cart, given local demand for transport services.

Farm size thresholds should be considered when estimating a farmer's loan repayment capacity. Project design should minimize the investment risk incurred by farmers by making loan obligations as clear as possible, by establishing insurance schemes for animals and equipment, and by maintaining support services.

A balanced cropping system should be promoted which reflects concern for both short-run needs for cash, food, and animal maintenance as well as for long-term considerations of soil improvement and continuous land use. Legume forages should be included as a source of soil nitrogen and livestock feed.

Extension efforts will have to first demonstrate that short-term benefits can be gained without unacceptable risks before farmers will adopt practices leading to long-term soil improvements. However, farmers rarely can be expected to adopt the entire system at once. Adoption will usually be piecemeal and will include only those elements which appear profitable in the short run because they relieve an existing bottleneck or serve a felt need. Nevertheless, the project should encourage the sequential adoption of package components with the long-run goal of sedentary land use and soil fertility maintenance in mind.

2. Implementation

Greater use of pilot projects seems desirable, since well-adapted technical packages are not generally available at the outset for all parts of the project zone. Just as the farmer has a slow learning curve in adopting animal traction technology, the project staff themselves need time to develop, test, and extend the recommended technology progressively throughout the project area. Launching full-scale credit and extension programs before the basic technology is proven is a waste of resources. Related to this, the emphasis should shift from requiring farmers to purchase a total animal traction package to a sequential process where farmers can buy a donkey or ox and one piece of equipment at a time.

Project design should include systematic monitoring of project activities, and evaluation of project impacts. Project monitoring provides the necessary feedback of information for the modification and redesign of project components which do not perform as expected.

Methods of sharing extension responsibilities with local institutions such as village cooperative associations should be pursued. Due to the lack of rural infrastructure and institutions, the agricultural extension service has been required to provide a wide range of support services. In many cases, this has resulted in overburdening the extension service to the extent that it cannot provide support services adequately.

C. Research Priorities

We have already emphasized the need for improved bio-chemical technology to support the mechanical components of the animal traction farming

system. Higher productivity and returns from crop production are essential for widespread adoption and successful utilization of animal traction. Resources should be devoted to developing this technology as a first priority.

Further research is also needed on the impact of animal traction. No adequate study of net benefits from animal traction under farmer conditions has been made in francophone West Africa. Future research on animal traction should always include comparative data on hand and animal cultivation; it should clearly isolate the impact of animal-powered tillage from that of complementary inputs such as improved seed or fertilizer; and it should examine the effects of animal traction over a multi-year period. Research should also address the extent to which the beneficial interactions commonly expected from animal traction--e.g., productivity improvements from recycling of crop and animal products--are realized in practice.

APPENDIX I:

INVENTORY OF 27 PROJECTS REVIEWED

This inventory presents the components of 27 animal traction projects in francophone West Africa. These 27 projects form the major data base for our assessment. The information was gathered from project design and evaluation documents, research reports, and personal observation.

NOTE: Abbreviations for the vaccines administered have been used in the sections concerning veterinary services.

RPAP = rinderpest, pleuropneumonia, anthrax, and pasteurellosis

RPA = rinderpest, pleuropneumonia, and anthrax

CHARACTERISTICS OF 27 AGRICULTURAL AND RURAL DEVELOPMENT PROJECTS IN WEST AFRICA WITH AN ANIMAL TRACTION COMPONENT

	Project	Project	Project
	(1) CMDT Mali	(2) OACV Mali	(3) Office du Niger Mali
Region	Southern Mali	Central Mali	Central - Niger Delta
Years	1964-	1972-	1934-
Funding Sources	IBRD, FAC, IDRC	IBRD	IBRD, FAC, Soviet
Physical Environment			
Rainfall	700-1200 mm	500-1000 mm	500-1000 mm, irrigation
Scope of Project	390,357 ha. cultivated	138,000 km^2	52,200 ha.
Population Affected/Pop. Density	1,052,700 10-25/km^2	1,100,000 5-40/km^2	52,500 5-25/km^2
Number of Farms/Ave. Farm Size	91,400 5.13/ha.	110,000 2.5-5.5 ha.	4,863 9.5/ha.
Average Number of Workers per Farm	3.5 Workers	4.2 to 6.4 Workers	3 Workers
Power Source	Cattle and donkeys	Cattle and donkeys	Cattle and donkeys
Equipment Package and Operations Performed	Cotton Cereal Plowing 68% Plow TM Ridging 23% 4% Plow TM Multiculteur Weeding 61% 8% Multiculteur Scarification Multiculteur Seeding Seeder	Cattle Scarification Mutliculteur CIWARA-tine cultivator Weeding CIWARA-tine cult. G.nut Harvest CIWARA-g.nut lift Subsoiling CIWARA subsoiler for heavy soils (Plow and ridger attachments frequently demanded but discouraged) Donkey Plowing Western hoe-8" plow Scarification Western hoe-tine cultivator Weeding Western hoe-tine cultivator G.nut harvest Western hoe-g.nut lifter	Plowing 100% Plow TM Harrowing 90% Gurmier harrow Tine cultivator Ridger Transport 100% 2-wheel donkey cart
Crops			
a. Crops Grown	Cotton, millet, sorghum, groundnuts, maize, cowpeas	Groundnuts, millet, sorghum, cowpeas	Rice, cotton, millet, sorghum, groundnuts
b. Rotation Advised	Cotton, millet, groundnuts fallow, fallow		Rice, rice, cotton, fallow
c. Rotation Practiced	Cotton, cereal		Continuous rice
Credit System			
a. Credit Coverage	Equipment and animals	Equipment and animals	Equipment and animals
b. Terms	10,000 FCFA downpayment, no grace, 3 equal annual payments, 6.5% Interest	16 2/3% downpayment, no grace, 3 equal annual payments, 6.5% Interest	No downpayment, no grace, 3 equal annual payments at 5% Interest
c. Repayment Rate	97.8%	Repayment serious problem during drought	82%
d. Animal Insurance	None	None	None

Animal Maintenance	(Observed) cotton seed, grass and legume hay, salt.	(Observed) cotton seed, grass and legume hay, salt	(Observed) rice flour, rice bran, rice straw, salt/mineral
Veterinary Services a. Vaccines b. Parasite Control c. Trypanosomiasis Control	RPAP Suppressant & resistant breeds		RPAP Veterinary charge-2500 FCFA/yr.
Extension Services a. Administration b. Training	Extension agent responsible for credit, equip. & other input deliveries, & marketing Young farmer training centers & limited on-farm extension, no animal-equipment training	Extension agent responsible for credit, equip. & other input deliveries, & marketing Limited on-farm extension, no animal-equipment training	Extension agent responsible for credit, equip. & other input deliveries, & marketing Limited on-farm extension, no animal-equipment training
Artisan Programs	No data on blacksmiths trained, 30 blacksmiths provided with equipment credit of 500,000 FCFA for 3 yrs., for elect. generator, welder, & elect. mill		
Income Effects a. Area b. Yields c. Custom Work d. Income	Area expansion observed Yield increase observed Income increase observed	Groundnut area increased 200% to 800%, but little change in area/worker Cereal-40% increase g.nuts-little change except where fertilizer used--8% Gross Product/capita 44% increase Net Revenue/capita 25% increase Cash Revenue/capita 42% increase	Production of rice, cereals and groundnuts increased 80% 1972-76. 50% increase attributed to animal traction, largely through area expansion. Plowing 5000 FCFA/ha. Harrowing 1000 FCFA/ha. Income increased 50% over nearby nonparticipating villages to ave. income of 173,700 FCFA (1971)
Adoption Rates a. Adoption b. Attrition Rates	12,300		Participants required to use animal traction
Comments	Cotton seed shortage disrupting animal maintenance practice.	In contrast to general results, village in lowest rainfall zone (600 mm) experienced greatly increased area & reduced yields.	There is an infrastructure tax of 400 kg. rice/ha. Weeding is a serious bottleneck.

	Project	Project	Project
	(4) Operation Riz-Segou Mali	(5) Operation Riz-Sikasso Mali	(6) Operation Riz-Mopti Mali
Region	Central Mali	Southern Mali	Central Mali
Years	1973	1974	1972
Funding Sources	FED	FED	IBRD, FAC
Physical Environment			
Rainfall	600-800 mm	900-1200 mm	500-700 mm
Scope of Project	40,000 ha.	15,000 ha.	36,800 ha. cultivated
Population Affected/Pop. Density	30-40/km^2	10-18 km^2	5-25/km^2
Number of Farms/Ave. Farm Size	13,300	.5 ha. rice/parti-cipating worker	4 ha.
Average Number of Workers per Farm	3 ha. rice + 2-3 ha. outside project		
Power Source	Cattle and donkeys	Cattle	Cattle
Equipment Package and	Plowing 100% Plow TM Harrowing 100% SOMECA Harrow Weeding CIWARA-tine cultivator Seeding 20% Nodet Gougis seeder Transport 80% 2-wheel donkey cart	Plowing 100% Plow TM CIWARA Harrowing 100% SOMECA harrow Seeding 20% Nodet Gougis seed. Weeding CIWARA Transport 2-wheel cart	Plowing Bajac B2 Harrowing Tine cultivator
Crops			
a. Crops Grown	Rice, millet, sorghum, cowpeas, bambard nuts	Rice, corn, sorghum	Rice, millet, sorghum
b. Rotation Advised			
c. Rotation Practiced			
Credit System			
a. Credit Coverage	Equipment and animals	Equipment and animals	Equipment and animals
b. Terms	No downpayment, no grace, 2-3 equal annual payments at 5% interest	No downpayment, no grace, 2-3 equal annual payments at 5% interest	No downpayment, no grace, 2-3 equal annual payments at 5% interest
c. Repayment Rate			
d. Animal Insurance	None		None
Animal Maintenance	(Observed) transhumance or cotton-seed, hay, salt/mineral	(Observed) cotton seed, rice flour, rice straw, salt/mineral	
Veterinary Services			
a. Vaccines	RPAP	RPAP	
b. Parasite Control			
c. Trypanosomiasis Control	Suppressant and resistant breeds		
Extension Services			
a. Administration	Extension agent responsible for credit, equip. & other input deliveries, & marketing.	Extension agent responsible for credit, equip. & other input deliveries.	Extension agent responsible for credit, equip. & other input deliveries, & marketing.
b. Training	Limited on-farm extension, no animal-equipment training.	Limited on-farm extension, no animal-equipment training.	Limited on-farm extension, no animal-equipment training.

Artisan Programs			
Income Effects a. Area b. Yields c. Custom Work d. Income	Area expansion observed Yield increase observed Plowing 5000 FCFA Harrowing 1250 FCFA Seeding 1250 FCFA Weeding 1500 FCFA Average rental revenue 7500 FCFA Income increase observed	Area expansion observed Yield increase observed Income increase observed	
Adoption Rates a. Adoption b. Attrition	Participants required to use animal traction		
Comments			Short on power in heavy soil, 4 oxen teams suggested

	Project	Project	Project
	(7) Operation Mil-Mopti Mali	(8) Mixed Farming Centers Gambia	(9) Gambian Rural Development Project Gambia
Region	Central Mali	Whole Country	4 Divisions
Years	1972	1956-	1972-
Funding Sources	U.S. AID	British, Gambian	IBRD, U.K., Arab Bank
Physical Environment			
Rainfall	300-700 mm	1000-1400 mm	1000-1400 mm
Scope of Project		10,400 miles^2	
Population Affected/Pop. Density	600,000 5-25/km^2	25-50 km^2	
Number of Farms/Ave. Farm Size	3.5 to 4 ha.	35,000 farms 4 ha.	3,000 farms
Average of Workers per Farm	5 workers	5-6 workers	
Power Source	Donkeys, cattle and horses	Cattle 33% Horse 13% Donkeys 27%	Cattle and donkeys
Equipment Package and Operation Performed	Plowing Plow Sine #9 Western Hoe-6" plow Scarification Hoe Manga	Present Plowing Hoe Sine-mouldboard plow Harrowing Hoe Sine-tine cultivator Weeding Hoe Sine-tine cultivator Scarification Hoe Sine-tine cultivator G.nut harvest Hoe Sine-g.nut lifter Seeding Super Eco planter Transport 2-wheel cart (Before 1970, the Emcot ridger used for plowing, ridging & weeding or the 2-wheeled Aplos multipurpose tool bar used for plowing, weeding, groundnut lifting, and carting.)	Plowing Hoe Sine-mould-borad plow Harrowing Hoe Sine-tine cultivator Scarification Hoe Sine-tine cultivator Weeding Hoe Sine-tine cultivator Seeding Super Eco. seeder G.nut harvest Hoe Sine-g.nut lifter Transport 2-wheel cart
Crops			
a. Crops Grown	Millet, sorghum, groundnuts, vegetables	Groundnuts, rice, millet, sorghum, digiteria	Groundnuts, rice, corn, millet, sorghum
b. Rotation Advised		Cotton or groundnuts followed by cereal, groundnuts, fallow	
c. Rotation Practiced		50% groundnuts, 50% cereal	
Credit System			
a. Credit Coverage	Equipment and animals	No credit available at present	
b. Terms	4500 FCFA downpayment, no grace, 3 equal annual payments	Credit was available for the Aplos with 25% dowpayment, no grace, 2 equal annual payments at 5% interest	1 yr. grace, 4 equal annual payments at 10% interest
c. Repayment			
d. Animal Insurance	None	None	

Animal Maintenance			
Veterinary Services a. Vaccines b. Parasite Control c. Trypanosomiasis Control		Lack of veterinary services was a problem.	
Extension Services a. Administration b. Training	Extension agent responsible for credit, equip. & other deliveries & marketing. Limited on-farm extension, no animal-equipment training.	Training center agent responsible for equip. & other input deliveries. Two-three months training for both animals and young farmers.	Extension agent responsible for credit, equip. & other input deliveries & marketing. Limited on-farm extension, no animal-equipment training.
Artisan Programs			
Income Effects a. Area b. Yields c. Income		Groundnuts 25% - 42% Cereal None to 46% None to 8% 13% to 25% income increase estimated	19% expansion of g.nut area expansion of short cycle rice area also observed. 23% increase for g.nuts over manual cultivation with fertilizer and 36% increase over manual cultivation without fertilizer. Returns per hectare constant but net cash income per capita increased with area expansion.
Adoption Rates a. Adoption b. Attrition Rates			1100 complete packages
Comments		Parts and delivery inadequate g.nut prices subsidized mid-1960s. Many equipment units appear to have been purchased in Senegal. Direct planting with seeder 2-4 times faster than plowing, but weeding time is greater than land prep. and weeding combined--also lower yields. Donkey and horse are faster but have less stamina than oxen.	

	Project	Project	Project
	(10) Action SATEC Mossi Upper Volta	(11) Eastern ORD Upper Volta	(12) Pilot Farms Upper Volta
Region Years Funding Sources	Central Mossi Plateau 1961-1968 SATEC, FAC	Fada N'Gourma 1974- U.S. AID, UNDP	Entire Country 1954-1957 France
Physical Environment Rainfall Scope of Project Population Affected/Pop. Density Number of Farms/Ave. Farm Size Ave. Number of Workers per Farm	600-1000 mm 1,300,000 50-70/km^2 122,000 3-4 ha. 4-5 workers	500-1100 mm 50,000 km^2 420,000 8/km^2 4-5 ha. 5-9 workers	500-1200 mm 8-70/km^2 504 farms 2-3 ha. 6-8 workers
Power Source	Donkey	Donkeys and cattle	Cattle
Equipment Package and Operations Performed	Scarification 75% Hoe Manga Ridging Hoe Manga Weeding 78% Hoe Manga	Plowing 83% of best farmers Weeding 16% of best farmers Ridging 6% of best farmers Donkey Plowing HV2A or TOM 5" plow Scarification HV2A-3 tine cultivator Ridging HV2A Weeding HV2A-3 tine cultivator Transport 2-wheel cart-steel bed & wooden bed Cattle Plowing HV2B or BM2M 9" plow Ridging HV2B or BM2M Weeding HV2B or BM2M-3 or 5 tined cultivator Transport 2-wheel cart-wooden bed	Plowing Kirby plow Harrowing Ebra harrow Transport 2-wheel cart
Crops a. Crops Grown b. Rotation Advised c. Rotation Practiced	Millet, sorghum, groundnuts, cotton	Millet, sorghum, groundnuts, cowpeas, cotton, maize, soybeans	Millet, sorghum, cotton, rice, groundnuts
Credit System a. Credit Coverage b. Terms c. Repayment d. Animal Insurance	Equipment and animals No downpayment, no grace, 5 equal annual payments Fell 99% to 24% over 7 years None	Equipment and animals Donkey-no downpayment, no grace, 3 equal annual payments at 5.5% interest Cattle-no downpayment, 1 yr. grace 3 equal annual payments at 5.5% interest 69% Donkey-750 FCFA/year Cattle-1500 FCFA/year	Equipment, animals and construction No terms specified Little or no repayment None

Animal Maintenance	(Advised) pasture, 1 kilo/day sorghum	(Observed) pasture, legume hay, salt/mineral, millet & sorghum stalks	(Advised) pasture, 1-2 kg. grain per day
Veterinary Services a. Vaccines b. Parasite Control c. Trypanosomiasis Control	Poor, had serious loss of animals due to disease	2 project vets for 1600 units spread over project area RPA Internal Suppressant	Poor
Extension Services a. Administration b. Training	Extension agent responsible for credit, equip. & other input deliveries. Limited on-farm extension	Extension agent responsible for credit, equip. & other input deliveries & marketing. Specialized agents train animals, & train farmers in use of animal traction. Limited on-farm extension	Regional gov. farm agents responsible for equip. & other input deliveries. Mobile agents train animals & train farmers in use of animal traction. Regional demonstration farms
Artisan Programs		Artisan training center proposed (CNPAR)	
Income Effects a. Area b. Yields c. Custom Work d. Income	2nd yr. participants 5-10% 3rd yr. participants 20-25% 4th yr. participants 30-34% No significant increase Value of gross production increased 3600 FAFA. Cash revenue increased only 800 FCFA & was insufficient to cover the 3000 FCFA/yr. loan repayment (5 yrs.)		
Adoption Rates a. Adoption b. Attrition	1962-1965 8,679 1966 27.2%	1600 units	504 1966- 90%
Comments	1. Inadequate veterinary care 2. Poor repayment led to cash crop emphasis following early focus on cereal production 3. Inappropriate cropping mix	1. 1977-78 no vaccine program 65 animal deaths 2. Vet care insufficient 3. Dry season maintenance inadequate 4. Rotation system not developed 5. Inadequate equipment repair 6. Inadequate repair facilities	1. Project ended after 3 years due to obvious failure 2. Even 3 hectares insufficient to feed typical family 3. Project designed to create farms using model integrated farming system

	Project	Project	Project
	(13) ORD of Bobo-Dioulasso Upper Volta	(14) Matourkou Upper Volta	(15) AVV Upper Volta
Region	Southwestern Upper Volta	Southwestern Upper Volta	South Central Upper Volta
Years	1970-	1963-1976	1973-
Funding Sources	IBRD	UNDP, U.S. AID	FAC, IBRD, UNDP, Netherlands
Physical Environment			
Rainfall	1000-1200 mm	1000-1200 mm	800-1200 mm
Scope of Project	180,000 ha. cultivated		263,000 ha.
Population Affected/Pop. Density	300,000 10-12/km^2	10-12/km^2	0-30/km^2
Number of Farms/Ave. Farm Size	30,000 6 ha.	465 8 ha.	950 9 ha.
Ave. Number of Workers per Farm	7-10 workers		3-5 workers
Power Source	Cattle and donkeys	Cattle	Cattle
Equipment Package and Operations Performed	Cattle Plowing HV2B-9" plow BM2M-8" plow Ridging HV2B or BM2M Scarification HV2B or BM2M-3 or 5 tine cultivator Weeding HV2B or BM2M-3 or 5 tine cultivator Donkey Scarification Hoe Manga Ridging Hoe Manga Weeding Hoe Manga	Plowing HV2B-9" plow Ridging HV2B Scarification HV2B-3 or 5 tine cultivator Weeding HV2B-3 or 5 tine cultivator	Plowing HV3B or BM2M 9" or 8" plow Ridging (27%) HV2B or BM2M Scarification HV2B or BM2M-3 or 5 tine cultivator Weeding (11%) HV2B or BM2M-3 or 5 tine cultivator Harrowing Harrow
Crops			
a. Crops Grown	Cotton, maize, millet, sorghum, groundnuts, sesame	Maize, cotton, millet, sorghum, groundnuts	Millet, sorghum, maize, cotton, groundnuts
b. Rotation Advised			Cotton, sorghum, legume, cereal fallow
c. Rotation Practiced			50% cereal 50% cash crop
Credit System			
a. Credit Coverage	Equipment and animals	Equipment and animals	Equipment and animals
b. Terms	No downpayment, 1 yr. grace, 4 equal annual payments at 5.5% interest	No downpayment, 2 yrs. grace, 5 equal annual payments at 5% interest	3000 FCFA downpayment, 1 yr. grace, 7 progressive annual payments at 6.1% interest
c. Repayment		1974 - 66%	
d. Animal Insurance	None	1500 FCFA per pair of oxen-covers 80% of loss	3000 FCFA/pair annual insurance
Animal Maintenance			Observed to be inadequate
Veterinary Services			
a. Vaccines			Minimal
b. Parasite Control			
c. Trypanosomiasis Control			

Extension Services a. Administration	Extension agent responsible for credit, equip. & other input deliveries.	Extension agent responsible for credit, equip. & other input deliveries & marketing.	Extension agent responsible for credit, equip. & other input deliveries & marketing of cash crops.
b. Training	Limited on-farm extension. No animal-equipment training.	Training seminars at center and strong on-farm extension.	Strong on-farm extension (1 agent for 25 farms) but not specifically oriented towards animal traction.
Artisan Programs	Have artisan training center, blacksmiths receive anvil, vice and iron on credit.		9 artisans trained 1976-78.
Income Effects a. Area	Area expansion observed		Production increase: Cotton 11% Sorghum 31%
b. Yields	Yield increase observed		Observed to be due largely to area expansion, not increased yield.
c. Custom Work			Custom work observed.
d. Income	Income increase observed	Net revenue ranges from 17,000 FCFA to 150,000 FCFA.	
Adoption Rates a. Adoption b. Attrition Rates		1976- 465	1978- 1,200
Comments	1. 75% of animal traction with purchased for cash.	2. Project exemplified the community development approach, but the cost per farmer was much too high to replicate.	3. Very low income during settlers early years. Need to clear land prevents self-sufficiency and requires off-farm employment. This slows land clearing and achievement of self-sufficiency. Cash needs for loan repayment (36,000 FCFA for years 3-8) and cash inputs conflict with food needs.

	Project	Project	Project
	(16) Vallee de Kou Upper Volta	(17) Unités Experimentales Senegal	(18) Promotion Rurale de Sine-Saloum Senegal
Region	Western Upper Volta	Sine-Saloum	Sine-Saloum
Years	1967-	1969-	1975-
Funding Sources	Taiwan, Mainland China, FAC	FAC, Senegal	IBRD
Physicial Enviornment			
Rainfall	1000 mm	700-900 mm	700-800 mm
Scope of Project	1260 ha. irrigated cultivation	12,000 ha.	908,000 ha. cultivated
Population Affected/Pop. Density	9000 10-12/km^2	4,200	770,000 32/km^2
Number of Farms/Ave. Farm Size	870 1 ha. rice + dryland	350 8 ha.	74,000 6-8 ha.
Average Number of Workers per Farm	3 workers	7 workers	7 workers
Power Source	Cattle	Cattle, horse, donkey	Cattle, horse, donkey
Equipment Package and Operations Performed	Plowing BM2M or HV2B-8" or 9" plow Harrowing Harrow or BM2M or HV2B with tine cultivator	Cattle Plowing Arara-10" plow Hoe Sine-8 or 10" plow; Ariana-one or two 10" plows polyculteur "Baol" 10" plow Ridging Arara, Hoe Sine, Ariana polyculteur-2 ridgers Scarification & weeding Arara/Sine-3 or 5 tine cultivator Ariana-6 or 8 tine cultivator polyculteur-8 or 12 tine cultivator G.nut harvest Arara/Sine & Ariana-3-blade g.nut lifter polyculteur two 3-blade g.nut lifters Seeding Arara/Sine-2 Super Eco seeders polyculteur-3 Super Eco seeders Transport 2-wheel cart or bed attachment to polyculteur Donkey & Horse Plowing Western Hoe-6" plow Ridging Western Hoe Scarification & weeding Western Hoe-3 or 5 tine cultivator G.nut harvest Western Hoe-1 blade g.nut lifter Seeding Super Eco seeder Transport 2-wheel donkey or 2-wheel horse cart	Plowing (10%) Arara-10" plow Hoe Sine 8 or 10" plow; Ariana one or two 10" plows polyculteur "Baol"-10" plow Ridging Arara, Hoe Sine, Ariana polyculteur-2 ridgers Scarification (70%) and weed. (87%) Arara/Sine-3 or 5 tine cultivator Ariana-6 or 8 tine cultivator polyculteur-8 or 12 tine cultivator G.nut harvest (80%) Arara/Sine & Ariana-3-blade g.nut lifter polyculteur, two 3-blade g.nut lifters Seeding (87%) Arara/Sine-2 Super Eco seeders polyculteur-3 Super Eco seeders Transport 2-wheel cart or bed attachment to polyculteur Donkey & Horse Plowing Western Hoe-6" plow Ridging Western Hoe Scarification Western Hoe-3 or 5 tine cultivator G.nut harvest Western Hoe-1 blade g.nut lifter Seeding Super Eco seeder Transport 2-wheel donkey or 2-wheel horse cart

Crops			
a. Crops Grown	Rice, Tomatoes	Groundnuts, millet, sorghum, maize cotton	Groundnuts, millet, sorghum, maize, cotton, rice
b. Rotation Advised		Maize, cotton, sorghum, grounduts or cereal, groundnuts, sorghum	50% groundnuts and cotton 25% cereals 25% fallow
c. Rotation Practiced		Grounduts, sorghum, groundnuts	Groundnuts, cereal
Credit System			
a. Credit Coverage	Equipment and animals and house	Equipment and animals	Equipment and animals
b. Terms	No downpayment, 1 yr. grace, 4 equal annual payments at 5% int.	No grace, 5 annual payments	No grace, 5 annual payments
c. Repayment		45% by farmers, coops add rebates to achieve 84% rate	
d. Animal Insurance	None		
Animal Maintenance		Pasture, crop residues, salt/ mineral	Pasture, crop residues, groundnut hay, salt/mineral
Veterinary Services			
a. Vaccines		RPAP	RPAP
b. Parasite Control		Internal and external	Internal and external
c. Trypanosomiasis Control		Suppressant	Suppressant
Extension Service			
a. Administration	Extension agent responsible for credit, equip. & other input deliveries & water distribution	Extension agent responsible for credit, equip. & other input deliveries	Extension agent responsible for credit, equip. & other input deliveries & marketing
b. Training	Limited on-farm extension, not oriented towards animal traction	Strong on-farm extension & participation in farm management	Limited on-farm extension, no animal-equipment training
Artisan Programs			Training & credit for blacksmiths observed
Income Effects			
a. Area	Planned: 1 ha.-2 crops/year Observed: many families working larger area	Pre-determined	Farmers adopting the oxen package cultivate 150% to 200% more area than the average, but area per worker increases only 9%.
b. Yields	4 to 6 ton per ha. achieved but have fallen to 2-3 ton/ha. due to water control & salinity problems	Groundnuts 40% increase Cotton 36% increase Cereals 73% increase	No change
c. Custom Work	4000-4500 FCFA/ha. plowing		
d. Income	Net income of 250,000 FCFA/yr. achieved but has fallen w/yields		
Adoption Rates			
a. Adoption		1970-73: 155 oxen package adoptors	1968-1977: 16,750 oxen traction adoptors, following nearly uniform use of donkey & horse traction
b. Attrition Rates	High		
Comments	Migrants often stayed only a few yrs. when incomes were high. Lower incomes has caused problem maintaining pop., & allowed area expansion by those who stayed. Settlers suffer severe social displacement.	Operations performed and equipment purchased much more restricted than equip. available would suggest.	

	Project	Project	Project
	(19) Integrated Rural Development Chad	(20) BDPA-Bokoro Chad	(21) Sategui-Deressia Chad
Region	Southern Chad	Central Chad	Southern Chad
Years	1972-	1962-1967	1976-
Funding Sources	IBRD, FAC, FED, U.S. AID	FAC	IBRD, U.S. AID
Physical Environment			
Rainfall	900-1100 mm	400-600 mm	
Scope of Project	1,117,000 ha. cultivated		5,000 ha. irrigated cultivation
Population Affected/Pop. Density	1-25/km^2	50,000 4-6/km^2	9,300 14-18/km^2
Number of Farms/Ave. Farm Size	277,000 4 ha.	10,000	1900-2400 2 ha. irrigated project rice, & dryland
Average Number of Workers per Farm	2-3 workers		2-3 workers
Power Source	Cattle	Donkey and horse, cattle	Cattle
Equipment Package and	Ridging: Bourguignon BP4, Tropic at 38 or Sine Scarification: Hoe Sine-tine cultivator Transport: 2-wheel cart with steel wheels dominant, lighter rubber tired carts being introduced	Donkey and Horse Scarification: Western Hoe or Hoe Allouette Weeding: Western Hoe or Hoe Allouette-tine cultivator G.nut harvest: Western Hoe or Hoe Allouette-g.nut lifter Seeder: Super Eco and Ebra seeders One Ox Scarification: Hoe Manga Weeding: Hoe Manga Seeding: Super Eco or Ebra seeders Two Oxen Ridging: Arara Scarification: Arara-3 or 5 tine cultivator Weeding: Arara-3 or 5 tine cultivator Seeding: Super Eco seeder G.nut harvest: Arara g.nut lifter G.nut shelling: Cathala sheller Transport: 2-wheel cart with steel wheels dominant	Plowing: Traditional in region Harrowing: SATEC SODIA-harrow Seeding: SATEC SODIA-seeder Weeding: SATEC SODIA-tine cultivator
Crops			
a. Crops Grown	Cotton, millet, sorghum, groundnuts, fonio	Millet, sorghum, groundnuts, rice	
b. Rotation Advised			
c. Rotation Practiced	Millet, cotton, millet		

Credit System a. Credit Coverage b. Terms c. Repayment d. Animal Insurance	None	None	None
Animal Maintenance			
Veterinary Services a. Vaccines b. Parasite Control c. Trypanosomiasis Control	Large livestock project to accompnay 1977-81.		
Extension Services a. Administration b. Training	Extension agent responsible for equip. & other input deliveries & marketing. Limited on-farm extension.	Extension agent responsible for equip. & other input deliveries. Agents placed in & work with a village coop.	Extension agent responsible for equip. & other input deliveries, marketing & water control. Strong on-farm extension.
Artisan Programs	Equipment production facility planned will also train 5-8 blacksmiths per year.	No trained blacksmiths.	
Income Effects a. Area b. Yields c. Custom Work d. Income	Observed cotton area increase attributed to animal traction. Farmers claim ridging improves cereal yields, even if it requires a slight delay in planting. Ridging-3000-5000 FCFA/ha. Net cash income increase 17,760-16,260 FCFA	Seeder allows increased groundnut area. Increased density with seeder. Increases groundnut yields 20-25%	Expected: revenue 75,000 FCFA/ha. expenses 7,500 FCFA/ha. 67,500 FCFA/ha.
Adoption Rates a. Adoption b. Attrition Rates	63,000 animal traction units		
Comments	1. FED provides nearly 50% equip. subsidy. 2. 4 ha. ave. farm can't support full cost of animal traction unit. 3. Cotton prod. remains main focus of project activities. 4. Extension services-badly understaffed-farmer/agent ratio twice as high as most projects	1. Marketing structure poorly developed. 2. No blacksmiths & delays of 1 yr. to get parts. 3. Groundnut planting & millet weeding compete for labor-option to use seeder rather than weeder	1. SATEC SODIA equipment is experimental.

	Project	Project	Project
	(22) Niamey Productivity Project Niger	(23) Maradi Rural Development Niger	(24) Zinder Rural Development Niger
Region Years Funding Sources	Western Niger 1977- U.S. AID	South Central Niger 1977- IBRD	South Central Niger 1973- FED
Physical Environment			
Rainfall	300-700 mm	500-700 mm	300-700 mm
Scope of Project	918,750 ha. cultivated	86,000 ha.	12,000 km^2
Population Affected/Pop. Density	320,000 15-25/km^2	105,000 30-35/km^2	500,000 10-60/km^2
Number of Farms/Ave. Farm Size	57,000 6 ha.	7-12 ha.	4-5 ha.
Ave. Number of Workers per Farm	3 workers	7 workers	3-4 workers
Power Source	Donkey	Cattle	Cattle and donkey
Equipment Package and Operations Performed	Scarification: Western Hoe-tine cultivator Weeding: Western Hoe-tine cultivator Seeding: Super Eco (being considered)	Scarification: Arara-tine cultivator Weeding: Arara-tine cultivator G.nut harvest: Arara-g.nut lifter Seeding: Seeder not available Transport: 2-wheel cart Plow and ridger frequently requested, but discouraged.	Cattle Plowing: Arara-10" plow Scarification: Arara-tine cultivator Weeding: Arara-tine cultivator G.nut harvest: Arara-g.nut lifter Seeder: Fabre seeder Transport: SISCOMA 2-wheel cart Donkey Scarification: Hoe Fabre-tine cultivator Weeding: Hoe Fabre-tine cultivator Seeding: Fabre seeder Transport: SISCOMA 2-wheel cart
Crops			
a. Crops Grown	Millet, cowpeas, sorghum	Millet, sorghum, groundnuts, cowpeas	Millet, sorghum, groundnuts, cowpeas
b. Rotation Advised	Cowpeas, millet		
c. Rotation Practiced			
Credit System			
a. Credit Coverage	Equipment and animals	Equipment and animals	Equipment and animals
b. Terms	10% downpayment, no grace, 4 equal annual payments at 6.5% interest	No downpayment, no grace except for animals in herd reconstitution program, 3 or 4 payments at 6.5% interest	No downpayment, no grace, 3 equal annual payments at 6.5% interest
c. Repayment			
d. Animal Insurance	To begin 2nd year using health books		

Animal Maintenance			
Veterinary Services a. Vaccines b. Parasite Control c. Trypanosomiasis Control			
Extension Services a. Administration b. Training	Extension agent responsible for equip. & other input deliveries Limited on-farm extension	Extension agent responsible for equip. & other input deliveries Centers to train young farmers & farm families for 5 months--trained farmers serve as village extension agents	Extension agents responsible for credit, equip. & other input deliveries & marketing Farmers trained to serve as village extension agents
Artisan Programs	Training program to begin 2nd yr.	Blacksmiths trained in young farmer training centers and receive 200,000 FCFA credit for 5 yrs. at 10% interest	
Income Effects a. Area b. Yields c. Custom Work		Anticipated effects: Groundnuts 55% increase Cowpeas 20-35% increase Millet 100% increase Anticipated 67,200 FCFA increase in gross revenue of which 60,000 FCFA is due to 100% increase in millet production. This increase must cover 30,000 FCFA annual loan payments, plus other inputs.	Anticipated 35,100 FCFA increase in gross revenue of which 30,000 FCFA required to cover annual loan payment & variable input costs not considered.
Adoption Rates a. Adoption b. Attrition Rates		1977: 1115	1976-77: 365 units placed
Comments	1. Technical package design requires 100% prod. (yield) increase to cover loan payments	1. 50% of equip. unused due to need for repair. 2. Effect of plowing on desertification in question. 3. Credit repayment depends on 100% increase in millet yields & marketing that increase. 4. Loan agents separate from extension agents.	1. Land clearing for mechanization may contribute to desertification. 2. Increased revenue won't cover loan payments & other input costs. 3. Project can't get enough equip. to meet demand. 4. Loan agents separate from extension agents, but credit agency implementing project.

	Project	Project	Project
	(25) Badiguicheri Niger	(26) Operation Charrue Mauritania	(27) Culture Attelée Benin
Region	Western	Southeast Mauritania	Borgou and Atakora
Years	1972-	1961-67	1966-
Funding Sources	FED	FAC	UNDP, FAO, CIDR, Peace Corps
Physical Environment			
Rainfall	400-600 mm	300-600 mm	1000-1200 mm
Scope of Project	1415 km^2 70,000 ha. cultivated	95,000 km^2	82,200 km^2
Population Affected/Pop. Density	100,000 10-30 km^2		741,000 5-14/km^2
Number of Farms/Ave. Farm Size	4 ha. dryland + 1 ha. bas-fond	10,000 3 ha.	
Ave. Number of Workers per Farm		3-8 workers	
Power Source	Cattle and donkey	Cattle	Cattle
Equipment Package and Operations Performed	Cattle Plowing: Arara 10" plow Scarification: Arara-tine cultivator Weeding: Arara-tine cultivator Transport: 2-wheel cart--iron wheels Ridging: Arara Donkey Plowing: Hoe Fabre-8" plow Scarification: Hoe Fabre-tine cultivator Weeding: Hoe Fabre-tine cultivator Transport: 2-wheel SISCOMA cart	Plowing: Bajac plow SISCOMA CFCOOP plow Ebra T33 plow	Plowing: Arara-10" plow Ridging: Arara Scarification: Arara-5 tine cultivator Weeding: Arara-5 tine cultivator G.nut harvest: Arara-2 blade g.nut lifter Transport: 2-wheel cart-wooden bed
Crops			
a. Crops Grown	Rice, cotton, sorghum, millet, cowpeas, groundnuts	Sorghum, millet, groundnuts, cowpeas	Sorghum, yams, millet, groundnuts, cowpeas, fonio, bambara nuts, cassava, maize, rice, cotton
b. Rotation Advised			Groundnuts, cotton, cotton, sorghum, OR groundnuts, cotton, sorghum, cotton, sorghum
c. Rotation Practiced			4-6 years alternate yams or cassava with cereals followed by 2-5 years fallow, OR cotton, cotton, cereal, groundnuts, groundnuts, 5 years fallow

Credit Systems a. Credit Coverage b. Terms c. Repayment d. Animal Insurance	Equipment and animals 4 annual payments	Equipment and animals No downpayment, no grace, 3 annual payments	Equipment only 5000 FCFA downpayment, no grace, 5 annual payments at 5-7% interest High but falling None
Animal Maintenance			Pasture and salt
Veterinary Services a. Vaccines b. Parasite Control c. Trypanosomiasis Control			RPAP Internal Suppressant and resistant breeds
Extension Services a. Administration b. Training	Extension agent responsible for equip. & other input deliveries Weak on-farm extension, but have program to train animals & to train farmers in animal traction use	Extension agent responsible for credit, equip. & other input deliveries & marketing Very weak extension effort--only 8 agents	Extension agent responsible for credit, equip. & other input deliveries & marketing Limited on-farm extension, animal training & training of farmer in use of animal traction provided
Artisan Programs	10 blacksmiths sent for training	Blacksmiths not organized	Blacksmith training and credit program to equip. blacksmiths observed
Income Effects a. Area b. Yields c. Custom Work d. Income		30% increase 14% increase	Observed area expansion Observed income increase
Adoption Rates a. Adoption b. Attrition Rates	1977: 175 oxen traction units	1961-67: 2,397 plows sold	1966-75: 10,889
Comments	1. Equip. receives direct subsidy from FED. 2. Severe logistics problems, especially with equip. delivery from SISCOMA. 3. Separate loan & extension agents.	1. Severe logistics problems affecting equip., parts, other inputs & marketing.	1. Logistics problems affecting equip. delivery. 2. Lack national equip. manufacturing facility. 3. Inadequate credit administration structure.

APPENDIX II:

LIST OF 125 PROJECTS WITH ANIMAL TRACTION COMPONENTS

This list presents those projects in which animal traction is a major component. Other projects were reviewed but not listed because the implementation of animal traction could not be substantiated.

NOTE: In the column "Ending Date," the parentheses indicate the projected termination date of a current phase of the project.

PROJECT TITLE	REGION	DONOR	BEGINNING DATE	ENDING DATE
Gambia				
Irrigated Cereal Crops		Holland	1979	(82)
Provisions of Agricultural Supplies and Equipment	McCarthy Is. & Upper River	FED	1977	(82)
Gambia Rural Development	Eastern	IBRD, UK BADEA, USAID	1976	(81)
Project Cotton	National	ADB	1975	(78)
Gambia Agricultural Development	Western	IBRD	1972	
2nd Phase		IBRD	1977	(80)
McCarthy Island Division	McCarthy Is. Div.	Taiwan	1966	
2nd Phase	"	IBRD	1974	
3rd Phase	"	Mainland China	1976	(80)
Mixed Farming Centers	National	UK	1956	
Mixed Farming and Resource Management	"	UK	1979	(86)
Chad				
Irrigated Crop Production		USAID	1976	(79)
Lake Chad Polders	Lake Chad	IBRD, ADR, USAID	1976	(80)
Polder of Mamdi	Lake Chad	USAID	1976	(81)
Sategui Deressia Irrigation	Southern	IBRD	1974	
2nd Phase	"	IBRD, ADF	1976	(80)
Mandoul Valley Development	Doumra	FAC	1960's	early 1970's
BDPA-Bokoro	Central	FAC	1962	1967
LCBC-Livestock and Mixed Farming	Lake Chad			

PROJECT TITLE	REGION	DONOR	BEGINNING DATE	ENDING DATE
Mali				
Action Blé	Mopti	USAID	1979	(83)
Farming Systems Research-Mali Sud	Southern	IDRC, USAID	1979	(83)
Opération Haute Vallée	Southwest	USAID	1979	(85)
Selingue Irrigated Perimeter	Western	ADF	1979	(83)
Integrated Rural Development-Kaarta	Keyes	CIDA, Netherlands	1977	(82)
Centres d'Animation Rurale	National	--	1960's	
CMDT-Mali Sud	Southern	France, CFDT	1952	
Recent Phase		IBRD, FAC, BADEA	1977	(81)
Operation Riz-Sikasso	Sikasso	FED	1977	(80)
Action Riz-Sorgho	GAO	USAID	1976	(81)
Operation Mil-Mopti	Mopti	USAID	1976	(81)
Mali Livestock I	Dougou Kolomba Banamba	USAID	1975	(80)
Bagaineda	Bamako	FAC	1972	
2nd Phase	"		1976	(80)
OACV Integrated Rural Development	Central	FAC	1970	
2nd Phase	"	IBRD	1974	
3rd Phase	"	IBRD	1979	(84)
Operation Riz Mopti	Mopti	IBRD	1972	
2nd Phase	"	IBRD, FAC	1978	(83)
Operation Riz-Segou	Segou	FED	1972	
2nd Phase	"	FED	1976	(82)
Centre d'Experimentation and Enseignement	?	FAC	1970	
Centres Cooperatifs d'Essais de Machines Agricoles	?	French	1959	terminated
Centre d'Encodrement Rurale				
Konosso	San	FIDES	1957	1963
Lac Horo	Goundam	FIDES	1957	terminated
Logo	Kayes	FIDES	1957	terminated
Sirakoro	Kita	FIDES	1957	1961

PROJECT TITLE	REGION	DONOR	BEGINNING DATE	ENDING DATE
Mali (continued)				
Ecoles Saisonnières	National	FIDES	1957	
2nd Phase	"	FAC, FED	1965	
3rd Phase	"	Financed by local Operations	1970's	
Zone d'Extensification Rurale				
Baroueli	Segou	France	1940's	
Zebala	Koutiala	France	1940's	
M'Pesoba	Koutiala	France	1938	
Office du Niger	Niger Delta	France	1934	
2nd Phase	"	Soviet, FAC	1963	
3rd Phase	"	IBRD, FAC, FRG	1979	(81)
Opération Haute Vallee	Southwest	France	1930's	1960's
Mauritania				
Tagant Irrigated Agriculture	Niger Valley	FRG	1980	(84)
Oasis Integrated Rural Development	desert	USAID	1979	(83)
Small Scale Irrigation	Niger Valley	Holland	1979	(82)
Integrated Rural Development-Selibaby	Selibaby	USAID	1977	(81)
Gorgol Rice Perimeter	Niger Valley	FED	1976	(78)
M'Pourie	"	China	1970	
Operation Charrue	Southeast	French	1961	1967
Action BDPA-CER's of Boghet Dar El Barka	Niger Valley	French	1956	1959
Kaedi-Agronomic Station	Niger Valley	French	1961	1967
Niger				
Diffa Integrated Development	?	?	1980's	
Say Rural Development	Say	USAID	1980's	
Tahoua Irrigated Agriculture	Tahoua	FRG	1980's	

PROJECT TITLE	REGION	DONOR	BEGINNING DATE	ENDING DATE
Niger (continued)				
Tillabery Irrigated Agriculture	Tillabery	IBRD, FAC, FRG	1979	(83)
Birni-N'Konai Irrigation	?	ISDB	1978	(82)
Dosso Agricultural Development	Dosso	FAC	1978	(80)
Maggia Valley Irrigation	?	FRG	1978	(82)
Integrated Rural Development-Pollol-Basso-Chiktal	?	USAID	1978	(82)
Naimey Productivity Project	Niamey	USAID	1977	(82)
Maradi Rural Development	Maradi	IBRD	1976	
2nd Phase	"	IBRD	1980	
Integration of Livestock and Agriculture	?	FED	1976	(79)
Tiaguirire-Lossa Rice Production	?	FAC	1976	
Toula Irrigated Rice	?	FED	1975	(79)
Niger Cereals	National	USAID	1975	
2nd Phase	"	USAID	1979	(81)
Zinder Rural Development	Zinder	FED	1975	
2nd Phase	"	FED	1977	(81)
Badeguicheri Rural Development	Badeguicheri	FED	1972	
2nd Phase	"	FED	1976	(80)
Integrated Rural Development-Ag. Credit	?	?	1970	
Kolo-Institut Pratique de Développement Rural	Kolo	UNDP/FAO	1970	
Ibohamane Irrigation	Keita	?	1969	
Senegal				
Casamance Regional Development	Casamance	USAID	1978	(85)
Integrated Rural Development-Senegal Oriental	Eastern	PAM	1978	(80)
Opération Arachides	Sine Saloum	FED	1976	(80)
Cereal Production	Thies-Diourbel	USAID	1975	(79)

PROJECT TITLE	REGION	DONOR	BEGINNING DATE	ENDING DATE
Senegal (continued)				
Promotion Rural du Sine Saloum	Sine Saloum	IBRD, CCCE	1975	(81)
Projet Complémentaire Mais	Haute Casamance Senegal Oriental	FED	1975	(80)
PIDAC	Middle Casamance	FED	1972	(78)
Sedhiou Rural Development	Casamance	IBRD, CCCE	1972	
2nd Phase	"	IBRD, CCCE	1976	(81)
Terres Neuves	Eastern	IBRD	1972	
2nd Phase	"	IBRD	1976	(80)
Casamance Rice Production	Middle & Upper Casamance	China	1970's	terminated
Agricultural Credit	National	IBRD	1969	
2nd Phase	"	IBRD	1973	(78)
Casamance Rice Development	Lower Casamance	USAID	1968	1972
Operation Cotton	Casamance and Eastern	FED	1968	
2nd Phase	"	FED	1972	
3rd Phase	"	FED	1976	(80)
ILACO	Lower Casamance	FED	1964	1968
Operation SATEC	Upper Casamance	FAC	1964	1968
Unites Culturales Types	Darou	?	1964	
	Tivaouane	?		
Action CFDT	Senegal Oriental & Haute Casamance	CFDT, France	1963	1968

PROJECT TITLE	REGION	DONOR	BEGINNING DATE	ENDING DATE
Senegal (continued)				
Sefa Perimeter	Middle Casamance	CGOT	1963	
Boulel-Modernisation Agricole	Sema	France	1957	
4 Model Villages	?	France	1956	
122 Unites Experimentales	?	FAC	1969	
Upper Volta				
Seguenega	North Central	Africare	1979	(83)
Oncho Freed Areas Village Den Fund	South Central	USAID, FAC	1978	(82)
Amenagement du Plaine-Dionkele	Western		1977	
Artisan Small and Medium Scale		IBRD	1977	(81)
Livestock Development Project	Western	IBRD	1977	(81)
West Volta Ag. Development	Western	IBRD, CIDA	1977	(81)
Rural Dams-Downstream Development		FED	1976	(80)
ORD du Sahel	Northern	USAID	1976	continuing
Bougouriba Ag. Development	Southwest	IBRD	1975	
2nd Phase	"	IBRD	1979	(83)
Eastern ORD-Integrated Rural Development	Eastern	USAID, UNDP	1975	(81)
Karfiguela	Banfora	China	1975	
Irrigation Dams	?	UNCDF, UNDP	1975	(80)
Rural Artisan Workshop	?	UNCDF	1975	
2nd Phase	?	UNCDF	1977	(81)
Farmer Training Center	Tome	Holland	1974	
Frères des Hommes-Piela	Eastern ORD	French	1974	
AVV	South Central	FAC, Holland	1973	
2nd Phase	?	Holland, IBRD, FED, FAC	1973	(81)
Rural Development Fund	National	IBRD, FAC, BADEA	1972	
2nd Phase	"	IBRD, FAC, BADEA	1976	(80)

PROJECT TITLE	REGION	DONOR	BEGINNING DATE	ENDING DATE
Upper Volta (continued)				
Maurice Cola	Fada		1968	1975
Vallée de Cou	Western	Taiwan	1967	
	"	China	1972	
	"	FAC	1978	(81)
Action CFDT	Western	CFDT, FAC	1964	
Projet Coton	"	IBRD	1971	1977
Matourkou Rural Development	Bobo	UNDP/FAO	1963	
2nd Phase	"	UNCDF	1976	(80)
Geres-Ouahigouya	Ouahigouya	GERES	1962	
2nd Phase	"	BDPA	1965	
Bobo ORD	Bobo	?	1960's	continuing
Dedougou ORD	Dedougou	?	1960's	continuing
Koudougou ORD	Koudougou	?	1960's	continuing
Kaya ORD	Kaya	?	1960's	continuing
Koupela ORD	Koupela	?	1960's	continuing
Ouagadougou ORD	Ouagadougou	?	1960's	continuing
Action SATEC Mossi	Central	FAC	1962	1967
Yatenga ORD	Ouahigouya	-	1960's	
2nd Phase	"	-	1973	
3rd Phase	"	FED	1977	(81)
Ferme de Kamouna	Banfora	FAC	1961	terminated
Centres d'Encadrement Rural	National	FIDES	1954	1961
Mission Catholique de Manga	Manga	-	1950's	
Benin				
Culture Attelee	Borgou and Atakora	UNDP/FAO, CIDR	1966	continuing
2nd Phase	Borgou	IBRD	1976	(81)
3rd Phase	Atakora	USAID	1978	(81)

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