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TECHNICAL ANALYSIS OF THE AGRICULTURAL COMPONENT

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3.1. TECHNICAL ANALYSIS OF THE IDP AGRICULTURAL COMPONENT

3.1.1. Project Objectives

The major objective of the governments of the three countries involved in this project is to achieve food self-sufficiency by increasing agricultural and particularly cereals production in the Senegal River Basin. Present yields for rainfed dryland crops including maize, millet, and sorghum average one-half ton per hectare, while rice yields average 4 to 4.5 tons per hectare: in contrast, experimental station trials have yielded 2.5 to 3.0 tons per hectare for dryland crops and 8 to 10 tons per hectare for rice.

Finding a means of making agricultural production more secure and crop yields more stable in the face of capricious rainfall and drought in the SRB is another important objective for the three countries. The IDP favors a mixed farming strategy based on improving dryland and irrigated agriculture in Kaedi, Gouraye, Bakel, and Kayes.

Another key project aim is to improve living conditions and increase agricultural incomes in the villages in order to stem rural exodus to the cities. The project proposes to increase productivity by encouraging the adoption of modern techniques, improved materials, equipment, storage and marketing.

Finally, the IDP aims to progressively develop agricultural production support systems, including a credit system, privately-owned input supply systems, animal traction, and an equipment and maintenance repair system. These measures should help farmers to sustain food production once project assistance comes to an end.

Specific goals of the project include developed irrigated perimeters; establishing service input distribution marketing and credit infrastructures; and promoting the use of improved technology at the farm level.

3.1.2. Approach to Development

Three approaches to developing irrigated agriculture are outlined below.

3.1.2.1. Rehabilitating Existing Perimeters

This approach entails improving existing canals, managing water systems more effectively, protecting perimeters against floods, and ensuring a more efficient drainage system. Other measures to rehabilitate perimeters will include improving and developing lands through leveling; eliminating perennial grasses developing a road system within the perimeter for animal drawn carts; and diversifying agricultural activities by introducing orchards, fish ponds, and other income producing enterprises.

3.1.2.2. Expanding Existing Perimeters

This approach is based on a rational use of pumping whereby pump capacity would be matched to the size of the plot to be worked. For example, the diesel powered pumping system presently in use in Bakel can irrigate up to 25 hectares. Increases in hectarage above 25 hectares are obtained by the replication of the pumping units thereby increasing the hectarage and spreading the risk of mechanical failure over an increasing number of machines as the hectarage increases.

3.1.2.3. Developing New Perimeters

The IDP will develop approximately 1,000 gross hectares of land in the Podor region of the middle valley; 1,000 gross hectares of upgraded and expanded perimeters in the Bakel region of the upper valley; 2,250 hectares in the Gouraye and Kaedi sectors of Mauritania in the upper and middle valley; and 750 hectares in Mali in the Kayes region of the upper valley.

3.1.2.4. Large, Small and Medium Perimeter Strategies

A large perimeter can be defined as a group of small perimeters sharing common irrigation, drainage, and canal systems controlled by a central service. The biggest disadvantage of large perimeters is the high overhead cost of the centralized management of a common structure. Cultivation costs are also high, as most operations, including harvesting, are mechanized.

The medium perimeter is defined as a group of small perimeters sharing a common irrigation and drainage structure, as in the case of large perimeters. These perimeters can be managed by farmers associations however, and thus do not rely on a heavily centralized management system.

A small perimeter is an irrigation unit comprised of a net irrigated acreage of about 15 hectares of land distributed among a group of farmers who join into a producers' association responsible for perimeter management. The greatest advantage of small perimeters is that they are an autonomous unit managed by farmers who do not rely on a large irrigation drainage infrastructure. Each farmer manages and cultivates his land, employing mainly family and occasionally hired labor and working with or without animal traction. Only the perimeter's water pump is jointly owned and managed. More cohesion and understanding between farmers and with RDA's exists on small perimeters, and problems and management issues can be resolved more effectively in a smaller unit.

The small perimeter has proven more profitable to farmers than the medium or large perimeter, as it does not have to bear the heavy costs of centralized infrastructure, maintenance, management, and operations.

The relative success of small perimeters in Senegal and Mauritania has led the RDA's (SAED and SONADER) to consider applying small perimeter management strategies to large and medium-sized perimeters. For example, large perimeters can be restructured into "autonomous irrigated units" with farmers' groups (groupements) primarily responsible for managing the perimeters.

3.1.2.5. Building Structures to Serve Farmers

During the last two cropping seasons, only 60 percent of the area in the irrigated perimeters was cultivated in the Bakel region and 25 percent in the Kayes region. A lack of support structures such as a credit system, pump repair maintenance services, and quality extension services contributed to significantly to the failure to cultivate a larger proportion of land. Introducing irrigation infrastructure can lead to substantial production increases, but only if adequate supply and distribution systems, marketing organizations, credit, and technical services can be set up to support irrigation efforts.

3.1.2.6. Improving Extension Services

As part of the transfer of agricultural and irrigation technology to farmers, extension services will provide training for village technicians in pump, maintenance, agricultural machinery repair, water management, bookkeeping and cooperative management. An important aim of the improved extension services will be to train field agents to understand and be able to work within the socioeconomic context of the village. A major concern of each RDA will be to improve communication and linkages between research and extension services. For more details on the IDP training component, see "Technical Analysis of the Training Component", Volume III, Section 3.3.

3.1.2.7. Developing Input-Supply Systems

Farmers will not commit themselves to irrigated agriculture efforts unless they can be assured sufficient access to inputs to make the venture profitable--including fuel for the complete crop cycle, fertilizers and improved seeds, and pesticides and fungicides. Farmers have no such access in Mali and Mauritania and only partial access in Senegal. Reintroducing a system of agricultural credit in Mali and Mauritania and expanding credit access in Senegal will be an important step toward increasing farmers' access to inputs. For more details on credit-related activities, see the "Private Sector Analysis," Volume II, Section 3.10.

3.1.3. Promoting Technical Progress at the Farm Level

By the end of the project, a large number of farmers should be using several recommended technologies that contribute to increased production.

3.1.3.1. Current Status of Farm-Level Technology

The level of technology practiced by farmers in the project area is generally low. Farmers use animal traction, fertilizers and plant protection techniques sporadically; there have been no sustained and concentrated efforts to upgrade traditional techniques. For example, research institutions have been slow in identifying suitable varieties of seeds for major crops and making recommendations.

Introducing certain "intermediate" crop production technologies with proven track records and requiring minimum risk interventions and limited investment could increase farmers' yields by up to 30 percent. One advantage of these intermediate technologies over high-technology seed-based packages is that they can be adapted easily to a wide range of farming.

3.1.3.2. Technological Intervention Proposed

The IDP will promote a range of yield-increasing and labor-saving technologies in the project area. These include the following:

1. Irrigation techniques: bed and furrow irrigation (depending on the types of crops);

2. Land preparation techniques: optimum size of plots, furrows, ploughing against the slope, etc.

3. Seed selection, improvement and use;

4. Systematic crop rotation;

5. Optimal fertilization: economical use of fertilizers; composting (using harvest residues); and green manuring rice fields with nitrogen fixing leguminous plants;

6. Preventive crop protection measures (including seed treatment);

7. Improved cultural practices: raising nurseries (rice; vegetables); optimum plant density, planting depth; optimum time of planting; and optimum weeding/interculture (line sowing);

8. Diversification of rural enterprises to include poultry farming and small scale animal husbandry to supplement incomes of farmers and productivity of perimeters;

9. Introduction of animal traction;

10. Introduction of labor-saving equipment, such as the following:

- mechanized weeders for rice cultivation;
- mechanized rice threshers (manual or diesel operated);
- mechanized corn and millet threshers (diesel or manual);
- peanut decorticators;
- animal drawn weeding equipment.

11. Establishment of wind breaks around perimeters using eucalyptus or other suitable species to reduce evaporation and wind damage to crops.

3.1.3.3. Feasibility of Proposed Interventions

The proposed interventions are technically sound and economically feasible. Certain of the interventions, specifically an animal traction program supported by an adequate credit system as well as improved extension services, have a high potential for acceptance by farmers. Animal traction leads to more timely sowing and weeding operations and enables farmers to overcome the constraint of labor shortages at critical periods. It can also promote better tillage and weed control and produce barnyard manure for fertilizer.

The feasibility of the improved cultivation practices is discussed in the following section on major crops in the project zones.

A. Feasibility of Animal Traction

1. Availability of Oxen in the Senegal River Basin

Herding is a traditional occupation in the SRB. According to the latest cattle census taken in 1977, the cattle herd in the three countries totaled 645,000 heads in Mali; 645,485 in Senegal and approximately 500,000 in Mauritania. Since more than three-fourths of the herds go through seasonal transhumance, they are absent from the river regions for long periods during the year.

The heards of that region are primarily of the Zebu-Cobra breed. In regions infested by the sleeping sickness fly, they are crossed with the native N'Dama breed which is trypano-resistant. The Zebu-Cobra is a large animal measuring 1.25 to 1.45 m and weighing between 350 to 450 kg (adult males) and 250 to 350 kg (adult females). It is the work oxen best adapted to the Sahelian environment.* The trypano-resistant hybrid of the Zebu-Cobra and the N'Dama is called "Diakoré", an averaged sized animal which has the strength of the Zebu-Cobra and the resistance of the N'Dama. The

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* "Mémento de l'Agronomie - Techniques Rurales en Afriques", Ministère de la Coopération, France.

Diakoré is much in demand for animal traction and will be used within the context of the IDP to introduce it to the farmers participating in the project. In addtion to cattle, horses and donkeys which are abundant in the River Valley, particularly in Mauritania, should be considered as other resources for animal traction.

The success of introducing animal traction on a large scale in the SRB would depend a great deal on the infrastructure available to support it. Therefore, an animal health care system should be incorporated into the animal traction program of the IDP with local agencies already working in the area. The health system should include regular internal and external disinfestation; immunizations against bovine plague, rinder pest and hoof and mouth disease as well as veterinary follow-up of diseases and accidents thay may handicap the animals or threaten their lives.

B. Establishment of a Training Center

1. Description

The goal of the animal traction training center proposed under the IDP would be to train animals for traction; to train farmhands selected by farm owners; and to promote animal traction among the farmers of the area. The training center would train village-level extension agents as well as selected farmers designated from each village as "master trainers", who could in turn train other farmers. Training received by these farmers would be considered as compensation for training other farmers. One criteria for selecting farmers for training should be their willingness to help other farmers in the village learn animal traction techniques.

Training subjects would include choice and selection of animals; techniques of animal training; use and maintenance of equipment; construction of inexpensive housing for animals; feeding, care, and management of animals; common diseases and prevention; first aid; and composting.

Two centers each would be set up in Podor, Bakel, Kaedi, Gouraye, and Kayes. One center would be established at the beginning of project activity and the other later, if need be. About 15 trainees would attend each 21-day session. In addition a certain number of extension agents should attend the sessions in order to learn new training skills, develop insights into farmers' needs, and build a working relationship with farmers. The training centers should be in relatively large, centrally-located villages to ease transportation for farmers attending the sessions. Training sites should have adequate facilities to familiarize farmers with animal care, housing, feeding, and management as well as operation and maintenance of animal traction equipment.

The following equipment should be supplied at training sites:

- a shaded wooden corral for each pair of oxen (to be constructed by the farmers under the direction of the trainer);

- 15 feeding troughs for 15 pairs of oxen made of local wood or used oil barrel (cost: 20,000 CFA);

- a store room for storing salt and minerals (maximum 300 kg per training cycles for 15 pairs) and training equipment;

- a 50 m^2 hut: (cost: 500,000 CFA);

- an 1-hectare enclosed field for exercise. (Cost: 50,000 CFA).

Traction equipment:

- 15 yokes plus cords and chains. (Cost: 105,000 CFA)

- 5 reversible plows, and tillage equipment. (Cost: 300,000 CFA).

Tillage operations and animal power requirements are detailed further in Tables 3.1.A. and 3.1.B, Appendix A.

2. Staffing of the Centers

Each training center would be staffed by a supervisor chosen from among the extension agents in the area where the center is located; a herder, a trainer and assistant trainer, both to be detached from an agency such as SODEVA in Senegal for the duration of training. No additional staff would be hired except for an animal driver. At the end of the project, the training center could be disbanded, eliminating recurrent costs to be borne by local governments. Trainers provided by organizations such as SODEVA would be paid per diem and other expenses for the duration of the training. The extension agent placed in charge of the center would supervise training on a day to day basis.

Each farmer recruited for training would bring to the training center a pair of oxen and a yoke. The center would provide shelter and food during the period of training. As part of the project, participating trainee-farmers would construct a hangar (shed) for the oxen using local material and would take part in all training operations, including feeding and caring for the animals during the training.

C. Training of Blacksmiths

The project will set up a training and spare part supply program contracted to an implement manufacturer, like SISMAR* or a specialized national training institution. This program will provide training for about 30 blacksmiths form the various project areas. The training session would last 15 days, of which 2 days would be devoted to the subject of stock management. The estimated cost of the training is 2,700,000 CFA.

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* Société Industrielle Sahélienne de Matériel Agricole.

Blacksmiths should be equipped with a start-up kit for routine repairs and an initial stock of spare parts. Each tool set would cost up to 300,000 CFA initially or 9,000,000 for all the blacksmiths.

SISMAR would finance supervision of the blacksmiths as this activity is considered to fall in the framework of developing their marketing network.

D. Cost of Establishing Training Centers

I. Initial Cost:

1.	Land	- 0 -
2.	Physical facilities	200,000 CFA
3.	Equipment - (6 units each) ploughs and tillers	500,000 "
4.	2 pairs of oxen (60,000 FCFA/pair)	150,000 "
5.	Herder (1) salary 20,000 FCFA per month	250,000 "
6.	Animal Care	250,000 "

II. Operational Cost (per session of 21 days)

1.	15 trainees at 1,000 CFA/day	315,000 CFA
2.	Trainer salary 60,000 CFA Per Month	60,000 "
	Per diem 6,000 CFA Per Day	180,000 "
	Travel Expenses	50,000 "
3.	Assistant-Trainer: Salary 50,000 CFA Per Month	50,000 "
	Per diem 3,000 CFA Per Day	90,000 "
	Travel	50,000 "
4.	Food and Medication for 8 pairs of oxen	
	- Concentrates/minerals 700kg/50 CFA	350,000 "
	- Medication	48,000 "

III. Facilities:

1. Shelter canals using local material.
2. Storage Shed for equipment and food.
3. Car or Mobylette for Animal Dressers.
4. Enclosed area for exercise.

Equipment: Yokes, chains
Ploughs, cultivator equipment
Feeder troughs, etc.

3.1.4. Major Crops: Agro-Climatic Constraints and Production Techniques

3.1.4.1. Introduction

This section describes the major crops to be grown under the project, the soil, water, and climatic constraints as well as production techniques that will be introduced to the participating farmers. In all three countries, farmers face a critical lack of improved varieties of seeds for major crops, with the exception of rice. Yields of major food crops (rice, sorghum, millet and corn) are dismally low, often less than 30 percent of that obtained at the research stations. In the short term, improvements in yields (15 to 20%) could be obtained by introducing improved cultivation methods.

3.1.4.2. Rice

3.1.4.2.1. Climatic Constraints

A. Temperature

The lowest temperature tolerated by rice plants is 15°C. Below that level, their growth is dwarfed and their vegetative cycle lengthens and may even stop. Because temperatures drop below 15°C during December, January and February all over the Senegal River Basin, a June-November crop is recommended because it would give higher yields.

B. Winds

Rice is sensitive to dry and hot winds of the Harmattan from March to June which come during its flowering season (4 to 6 days per cycle). The probability of Harmattan occurring during the most critical months for growth is one year out of five in May and one year out ten in June. A cropping calendar based on second season rice crop flowering in March-April would significantly reduce the chances of low yields. In addition, establishing windbreaks would introduce effective protection and help conserve irrigation water by approximately 20 percent.

C. Insolation

Decreased insolation combined with low temperatures in November and December reduces photosynthesis. It would be wise to prevent this season from coinciding with the stage of grain development. An ideal cropping calendar is as follows:

Double cropping: June-November Rainy Season first crop
January-April: Off-season second crop
or
March-June.

During the rainy season, medium duration varieties of 110-120 days should be flooded from June 1st to the 15th; replanted or seeded from June 15th through July 15th; and harvested from October 15th through November 30th. This cropping calendar is useful only if water is available for irrigation in June (this will no longer be a problem after construction of the Manantali dam). Delayed planting should be used for short duration varieties of 90 to 100 days if necessary. The plants should be transplanted around August 15th or later and harvesting should occur from November 15th to December 15th. During the second season, medium duration varieties of 110-120 days should be transplanted from January 15th to the 30th and harvested from May 1st to the 30th.

Seedling nurseries should be raised from December to January. Protecting nurseries with plastic screening or using the dao-poag method would reduce nursery stage duration by 15 to 20 days.

D. Varieties

The most commonly used rice varieties are:

- Jaya: A 130 to 140 days long-grain variety with good yield and organoleptic qualities. It has no serious disease problems.

- I King-Pao: A short duration (110-120 days) short grain variety with lesser organoleptic quality and vulnerable to piriculariosis and helmintosporiasis but resistant to drought.

- KSS short cycle, short grain variety believed to have low resistance to fungus diseases and insects.

At present, WARDA is carrying out research to identify new and temperature resistant varieties that would have high ratooning and resistance to stem borers. Their on-farm trials have given the following results:

Variety	Cycle/days	Yields Kg/ha
SRIMALAYSIS	110	7184
IR 1820-210-3	125	7220
IR 2823-399-6-6	103	6380
KN-1 - 351	130	8890
IR 3941-86-2	122	10630
KH-998	124	7663
FM-109	119	7340
BG-90-2	122	5980
IR 2061-628-1-6-4-3	105	6410
C-168	121	6930
SORACHI	116	4912
TATSUMI MOCHI	116	4378

This list indicates several potentially good varieties. During project implementation, the technical assistance teams in the three countries will, in consultation with the research stations and extension staff, select approximately three varieties for promotion. The varieties identified by the IDP TA teams for promotion should be selected on the basis of cooking quality, consumer tastes and yield characteristics. Selection will be facilitated by the fact that on-station trials have been conducted and data is available for several varieties for which yields of 8 to 10 tons per hectare have been recorded. Lack of facilities for seed diffusion remains a major obstacle for farmers in the Senegal River Basin.

E. Production Techniques

Clay, clayish loams or silty clay soils are the most favorable for rice cultivation. A 40-50 percent clay content in top layers would be ideal. Top soil must be loose for approximately 15cm while the bottom soil should be compacted. The soil must have little porosity; percolation of 4mm per day should be considered maximal because of the high cost of pumping water. The level of resistance of rice to salinity is approximately 6 millitios (cm/level) which is found only in the Delta.

Rice plants should be treated with a carbofuran (15 kg granules per ha) against borers. In the case of serious infestation, a curative treatment should be applied. During the second season, Deltametrine should be used against mites during the first cycle: 0.50 kg of the commercial product at 50 percent per hectare and a follow-up treatment with the same product is recommended (1,51 kg per hectare).

The harvesting techniques considered under the IDP are essentially manual, and include reaping with a sickle, sheaving, stacking, threshing, winnowing, transporting and drying. Mechanized threshing will be introduced during the project as a labor-saving technique for the month of June and December when demands on manpower are higher.

F. Yields

Rainy season yields should reach 5.5. tons per ha. while off-season yields should reach 6 tons per hectare. Part of the harvest should be stored in traditional granaries for family consumption. The surplus should be hulled locally for sale.

G. Research

Research is underway at the Richard Toll and Fanaye stations under the aegis of WARDA on the fertilization and selection of high yielding rice varieties. Work is being conducted to identify the most appropriate dosages of fertilizers for each soil type. For example, phosphoric acid and potash inputs can be reduced while nitrogen inputs in the form of urea coated granules to allow slower absorption into the soil can be increased. Research efforts are also being focused on substituting leguminous, nitrogen fixing intercrops. One of these is Sesbania Rostrata which can

be used as fodder and is capable of fixing 40 to 60 units of nitrogen into the soil in 50 to 60 days. Finally, work is also underway to select high yielding varieties that are resistant to cold weather.

3.1.4.3. Corn

A corn market is beginning to develop in the SRB, as consumption of corn served either fresh, or as farina or semolina continues to increase. While corn yields have been excellent in light of the level of cropping techniques, the future of this crop in the SRB region will depend on the rapid introduction of high yielding varieties such as composites and hybrids. A climatic constraint of corn is that it does not tolerate temperatures of over 35°C at flowering time. However, corn does have certain advantages over rice in terms of its low labor and limited water requirements. Up to now, the only high yield potential of rice puts it ahead of corn. For the future, however, research is likely to lead tc the identification of high yielding varieties well adapted to local conditions.

A. Crop Calendar

Crops can be cultivated in both rainy and off seasons, but those grown in the latter period will achieve better results. During the rainy season, crops of 75 to 90 days should be sowed from June 15 ot July 1 and harvested from September 15-30. During the off season, crops of 120 to 140 days should be sowed from October 15-November 15 and harvested from February 15 to March 15. November 15 should be considered the deadline for planting.

The varieties include C.J. Bouaké; Early thai composite, yielding 5.4 tons per hectare; Penjalinen at 5 tons per hectare; Kisan; Hunis; SC1-2-3; Diara; and A-51-53, and 53-54, at 4.34 tons per hectare.

The main hybrid varieties tested by ISRA include HBV1 and HBV2. SAED is planning to introduce these hybrids following training in hybrid see production.

B. Production Techniques

Corn grows best in well drained, deep soils, rich in organic matter and with good physical characteristics. It is very sensitive to salinity.

Ploughing depth for corn should be 20 to 25 cm. Cross ploughing should be used with animal traction and the crop should be planted on ridges with 75 cm spacing between peaks.

Seeds should be treated with TMDT (200 g/100kg dry) and should be planted at a rate of 25 kg per hectare with a spacing of 75 x 30 cm (on ridges) and 2 seeds per hole with holes 2 to 4 cm deep. Thinning to less than 10 cm 15 to 20 days after germination should be done.

Two weeding operations must be carried out early to prevent weeds from competing with corn. Chemical weeding is not recommended because of its high cost.

Organic manure should be used for fertilizer, if possible, at a rate of 10 to 20 tons of manure per hectare. Fertilizer should be applied as follows:

	Level* 1	Level* 2
Basal dose:		
Tricalcum Phosphate	150	150
Potassium Chloride	100	50
Urea	100	50
Top Dressing (Urea)		
1 month after seeding	75	50
2 " " "	75	50

Irrigation should occur once every 8 days, while drainage should take place 12 hours after each irrigation as needed.

Diazionon spray should be applied during shooting to prevent infestations of SESAMIA, NEPHOTETTIX, CIRPHIS, and CANTARIDE.

In case of infestation by AMACTA LOREYI (caterpillar) or SODOPTERA, an endosulfan treatment could be applied (Thimul 35) as a solution of 3 liters diluted in 600 to 1000 liter of water for each hectare.

After the corn is picked, it must be sun-dried for four to five days to reduce its 25-30 percent moisture level to 15-17 percent.

Level 1, intensive cultivation, should yield 3.5 tons of corn per hectare, and level 2, improved cultivation, 2.5 tons per hectare.

C. Research

Yields of existing composite corn varieties are low in comparison with those that could be achieved if hybrids adapted to local conditions were introduced.

It should be noted that recent corn trials at Bakel have yielded good results using much less water than has been recommended in this analysis. In these trials, soils were kept near field capacity and not allowed to stagnate. Continuing trials should prove the effectiveness of this system as well as highlight possible problems with weeds.

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* Source: USAID-OMVS, Agricultural Research II. Project.

Water conservation can be achieved as follows for the varieties listed below

*Varieties:

Senegal	Penjalinen	5 /ha
	Kisan	4.3 /ha
	Early Thai	5.4 /ha
	C.P.T. Bouaké	
Mauritania (Kaedi)	Z.M. 10	
	Bouaké C.P.T.	1 /ha
	Diara	35/ha
	Makka	06-08t/ha

3.1.4.4. Sorghum

Sorghum has traditionally been grown in the Fleuve Region as a recessive flood crop in the middle and lower valley and as a dryland crop in the upper valley. It is widely consumed in the area.

Low yielding local varieties are remarkably well adapted to low and high temperatures, heavy soils, and drought. Compared to corn, sorghum allows a 20 percent water savings at similar production levels. Varieties introduced with higher yield potential are more vulnerable to temperature and drought and do not have the same taste quality as local varieties. Sorghum is vulnerable to attacks by birds (especially off-season) and has relative immunity to soil salinity (tolerance levels 5 mmhos/cm).

A. Crop Calendar

This crop grows in all seasons, with particularly good potential for high yields in the off season from October-February, in spite of exposure to birds. During the rainy season, seeding should be done at the beginning of June, and the crop should be harvested from September-October. During the cold period of the off season, seeding should occur at the beginning of October and harvesting from February to March. During the warn period of this season, seeding should be in mid-February and harvesting from May to June.

Varieties recommended by ISRA include:

- 90-110 days cycle: Hybrid 6 12 A x 68 29
  612 A x 73208
  lines 73 0 185

- 110-115 days Cycle: Line 73-13 (disseminated in Bakel).

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* Source: USAID-OMVS Agricultural Research II Project.

B. Production Techniques

Sorghum can be grown in various types of soils, but grows best in clayish soils that have been well drained.

Ploughing depth for sorghum should be 20 to 25 cm. Cross ploughing should be used with animal traction. The crop should be planted with spacing between lines of 1.20 m.

Seeds should be treated with TMTD (200g/100kg dry) and sowing conducted in line on each side of the ridge with 15 cm between plants. From 7 to 10 kg of seed should be planted per hectare, and thinning should be done early, at a rate of two plants per hole.

C. Varieties under experimentation*

Senegal:	Hybrids:	P8416 Bt x P-7822	5.12t/ha
		P8307 x 5915	5.10 "
		P8325t x P7812	5.05 "
	Composites	2450	5.14t/ha
	"	75.14	5.68t/ha
	Gabiada de Nara		
	137-62 Niger		
	96-1217A U.V.		
	C.E. 90		
Mali:	Samé 600	0.8t/ha	
	M'Dabiri	0.6-0.8t/ha	
	RT 13	15/ha	
	SD 10	0.6-0.8t/ha	

The first hoeing should be done 15 days after germination, and 2nd and 3rd hoeings should be conducted a month apart.

Fertilizer should be applied as follows:

	Level 1	Level 2
Basal Dose		
Tricalcium Phosphate	150 kg	150 kg
Potassium Chloride	100 kg	50 kg
Urea	100 kg	50 kg
Top Dressing		
after 1sr hoeing	75 kg	50 kg
at nettling	75 kg	50 kg

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* Source: USAID-OMVS Agricultural Research II Project.

Irrigation should be carried out at an average frequency of 1 watering every 8 days, with drainage 12 hours after each irrigation, depending on need. At present we do not recommend plant protection measures, but the following treatments could be considered: Thimul-35 (endosulphan) 1.4 to 3L/ha for AMSACTA LOREY 1 or Basudin 10G (Diazinon) 5 to 10 kg/ha.

Sorghum should yield 3.5 tons per hectare under intensive cultivation and 2.5 tons per hectare under improved cultivation.

3.1.4.5. Tomatoes

In 1980-81, canned tomatoes accounted for 30 percent of total consumption in the SRB. Two processing plants for tomato paste have been established in the Fleuve Region of Senegal, one at Savogne (SOCAS) and one at Dagana (SNTI). These plants are operating at only 50 percent of capacity due to the low level of tomato production.

Bacterial proliferation and other diseases prohibit the cultivation of this crop during the rainy season with existing varieties. Temperatures over 35°C inhibit pollination, and the dry north-east winds aggravate this situation further.

A. Crop Calendar

Seeds should be planted in nursery in September. Transplanting should take place in October, and harvesting from January to the end of April.

Recommended varieties include Roma V.F. and Super Roma for processing and Indiana for fresh tomato consumption.

B. Production Techniques

Tomatoes prefer well drained, deep soils; risk of nematod attacks is higher in light soils. High proliferation of parasites prevents successive planting of tomato crops on the same soils. Tomatoes are quite sensitive to soil salinity; conductivity of higher than 3.5. mm ds/cm adversely affects yields.

Soil should be prepared using deep tilling (20 - 30 cm) and cros ploughing with 120 cm spacing between rows.

Seeding should be done in the nursery in September and stretched out over a month so to prolong harvest.

The distance between seed line should be 10 cm in nursery, with 35 grm of seeds / 10 m^2 seedbed; 10 seedbeds/ha of esop. Soils should be treated with Furadan at a rate of 30 grm/10 m^2. In strawing seed beds, straw should be treated with Benlate 6 gnm for 15 cm^2; and with Thimul 3.5 liters to 10 liters of water must be removed one weed after sprouting. Second Benlate treatment 6 grm for 15 cm^3/and Thimul - same dosage for Thimul.

Tomatoes should be transplanted on ridges with 120 cm spacing between lines and 40 cm between plants. There should be about 20,833 plants per hectare.

Fertilizer should be applied as follows:

Basal Dose	Level 1	Level 2
Tricalcuium Phosphate	200 kg	100 kg
Potassium Chloride	150 kg	100 kg
Urea	50 kg	50 kg
Top Dressing		
30 days after replanting		
Potassium Chloride	100 kg	50 kg
Urea	100 kg	50 kg
About 10 days after planting		
Potassium Chloride	100 kg	50 kg
Urea	100 kg	50 kg

Irrigation techniques should include frequent watering of seedbeds, irrigation and drainage on the eve of replanting, and irrigation of crop five days prior to treatment and one day after.

C. Treatments

The plant protection treatments being considered are basically pesticides. The dry microclimate during off season reduces mildew attacks. However, a fungicide called Manébé should be added to the two insecticide treatments.

The main treatments suggested are indicated in the following table:

Pesticide Treatments for Tomatoes

			Application Methods and Dosage			
Insects	Active Ingredients	Formula	Prevention	Dosage	Cure	Dosage
Heliothis	Endosulfan	Thimul	at flowering	3.51	as needed	
Bemisa	Penithothium Cypermethrine	12g/1	Application every 15/20 days	1.51	as needed	
Acridians	Endosulfan	Thimul			as needed	3,5
Sodoptera	Endosulfan	Thimul			as needed	3,5

A systematic treatment program for 10-15 interval is being considered by SAED, as follows:

- 1st treatment : 7 days after replaning;
- 2nd " : 15 days after 1st treatment;
- 3rd " : 10 " " 2nd treatment;
- 4th " : 10 " " preceding treatment;
- 5th " : 10 " " " "
- 6th " : 10 " " " "
- 7th " : 10 " " " "

This systematic program is associated with level 1 of intensive tomato farming. For level 2, only curative treatments should be done in the form of five endosulfan treatments.

Tomatoes can be harvested from January to the beginning of April with one picking every eight days.

At level 1, intensified tomato farming, the crop should yield 25 tons, while at level 2, improved farming, the yield will be 18 tons.

Status of Research:

Research on tomatoes is underway at the Cambérène Horticulture Center near Dakar, Senegal and at the Kaédi Research Center in Mauritania. Progress is being achieved in increasing production potentials following varietal trials and production techniques, and in cultivating new varieties of industrial tomatoes during the rainy season, to allow for a more rational use of existing industrial plants (such plants are not considered in the analysis).

3.1.4.6. Niébé (Cowpeas)

Niébé or cowpeas is a leguminous plant and a staple in the diet of most people in the SRB. The beans and leaves are eaten by people and the stems after harvesting, are used as fodder.

A. Crop Calendar

Niébé is resistent to drought and high temperatures. It can be cultivated during the rainy as well as during the off season; particularly local varieties, which are not very sensitive to photoperiodism. Rainy season crop should be planted the first fortnight in July and harvested from September 15 - October 15. The off season crop should be planted from October 15 to November 15 and harvested from January to February.

Local varieties include crops of 90 to 100 day duration, while improved varieties are of less than 90 day duration. Varieties TV x 1841 - OIE - TV x 1576 OIE and TV x 7-5 have achieved good results at the Guédé station.

B. Production Techniques

Niébé's roots are sensitive to soil compactness. The crop grows better on light, sandy soils. Niébé should be planted with moderate tilling at a depth of 20 cm. A basal dose of fertilizers should be applied at the time of tillage.

Cross tilling should be done with a plough; and furrowing should be done with ridges 60 cm apart.

Although they are often grown in association with corn or sorghum, new varieties of niébé can be grown as pure or mono crops. Seeding density for the crop is 40,000 plants; 3 seeds/hill; approximately 35 kg per hectare. Seeds can be planted in two rows, on either side of the ridges.

Fertilizer should be applied as follows:

	Level 1	Level 2
Only one fertilizer application during tilling.		
Urea	60 kg	
Tricalcium Phosphate	200 kg	100 kg
Potassium Chloride	150 kg	100 kg

Abundant irrigation should be applied before seeding to impregnate soil, while less watering will be required later because of niébé's resistance to drought.

Irrigation should take place at a frequency of one watering every eight days for light soils.

When niébé is cultivated as mono crop, its flowers are vulnerable to insects. An Endosulfan (Thimul) treatment is recommended during flowering for intensive cultivation of the crop.

Harvest of leaves and beans should stretch out over a month-long period, ending with the picking of husks and dry fodder. Yields for niébé beans should be 2.5 tons per hectare at level 1 and 1.8 tons per hectare at level 2. Yields for dry fodder should be 2.5 tons per hectare for level 1 and 1.0 ton per hectare for level 2.

Post harvest loss will present a problem for the niébé crop, unless minimum precaution against insects can be ensured. Dressing with DELTAMETHRINE powder (400-500 kg/ton) is recommended. An alternative dressing with peanut oil is recommended against weevil attack (Moscal).

C. Research

Limited progress can be expected from the research currently conducted on niébé. IITA scientists at Ibadan and Ouagadougou are working on high yielding varieties resistant to insect attack.

3.1.4.7. Onions

Senegal consumes annually nearly 50,000 tons of onions of which some 25,000 tons are imported. Current production in the Fleuve region is about 20,000 tons per year.

A. Crop Calendar

Sowing and transplanting can be done from October to January, while harvesting should be from March to June. Immature bulbs can be planted in October for a January-February harvest. It is suggested that nursery seedings be cultivated from the end of October to early December and harvested in April.

The Galnit Purple and Golden Creole varieties have been selected for good taste and preservation quality.

B. Production Techniques

Onions prefer light clayish loams with good drainage. Ploughing depth should be up to 20 cm. Ridges and furrows should be planted 50 cm. apart.

Sowing should be done in nursery at the end of October, at 400 m² nursery per hectare with 2.5 kg of seeds for 400 m² nursery. Seedings should be transplanted when they are about the size of a pencil, and transplanted on either side of the ridges at a distance of 10 cm. 400,000 plants/ha.

Fertilizer should be applied as follows:

- Manure: 20 tons per ha if possible. Basal dressing should be incorporated into soil at ploughing.

Chemical fertilizers:

	Level 1	Level 2
Basal Dose		
Urea	100 kg	50 kg
Tricalcium Phosphate	350 kg	250 kg
Potassium Chloride	100 kg	50 kg
Top Dressing		
20 days after transplanting		
Urea	100 kg	50 kg
Potassium Sulfate	100 kg	50 kg
50 days after transplanting		
Urea	50 kg	50 kg
Potassium chloride	50 kg	50 kg

Row irrigation should be used. Water requirements are estimated at 9,600 m^3 per hectare in the Bakel region. The nursery should be seeded to 15 days and watered twice a day. From 15 days to 5 weeks, it should be watered once a day. The crop should be irrigated once every 5 to 10 days up to 15 days before harvesting.

Plants should be treated against Thrips Tabaci, insects that suck on leaves. A diazinon solution 3.5/liter to 1,000 liters of water should be applied.

Fresh onions can be picked for immediate consumption or the crop can be dried. Onions should yield 30 tons per hectare at level 1 and 20 tons per hectare at level 2. Onions (Galmi Purple) can be kept fresh in a well areated area from 5 to 6 months with less than 20 percent post harvest loss.

C. Research

Current research on onions has been directed towards variety selection for culinary quality, good preservation, and a rainy season crop. The rainy season crop would allow for a permanent supply of the regional market and reduce the need for imported onions.

3.1.4.8. Okra

For local consumption and neighboring markets after drying.

A. Crop Calendar

Rainy season okra can be sowed in July and harvested beginning at the end of September, with continuous picking until the end of November. Okra can also be grown during the dry season under irrigation.

Recommended early varieties include: USO (from CDH/ISRA), clemson spineless, green velvet, long green, and long fodded.

B. Production Techniques

Okra can grow in a variety of soils provided they are well drained and deeply ploughed soils should be prepared with tillage at a depth of 20 cm. Ridges should be spaced at 60 cm. Plants should be seeded at the rate of 2 to 3 seeds per hole, with 30 to 40 cm spacing between plants (for quick okra). Seeding depth should be 12 mm, and seeds should be planted at a rate of 5 kg per hectare. They will need to be soaked 24 hours in water to hasten germination.

Fertilizer should be applied as follows:

Chemical Fertilizers	Level 1	Level 2
Basal Dose		
Urea	100 kg	50 kg
Tricalcium Phosphate	250 kg	150 kg
Potassium Chloride	100 kg	50 kg
Top Dressing 40 days after sowing		
Urea	80 kg	50 kg
Potassium Chloride	50 kg	50 kg

Irrigation should generally be applied in Bakel at 1661 m^3 per hectare.

Only curative plant protection measures are recommended[1]. In case of caterpillar attacks on the leaves (xanthodes) and the fruits (heliothis), crops should be treated as soon as caterpillars appear, with the following:

		Brand name	
	- Cypermethrine	: Cybush 10-5cc	10 liter water
		: Ripcord 5-10cc	10 liters water
or	- Decamethrine	: Decis 2.5.-6cc	10 " "

In case of borer attack by jassidus, ocycarenus, etc, the following solutions can be used:

- Dimethoate

or	- Systoate 40-10cc	10 liters of water
or	- Astoate 40 -	" " " "
or	- Perfecthion -	" " " "
or	- Daphene Fort - 1Pcc	" " " "

Generally only one application is sufficient. Seven days should elapse between treatment and picking of the pods.

Early okra can be picked two to two and a half months after sowing, and harvesting can extend over approximately 2 months. Pods should be picked when they are tender and friable, every 4 to 5 days.

Pods should yield 5 tons per hectare under level 1 and 3.5 tons per hectare under level 2. Leaves are also consumed locally in limited quantities.

Okra is cut and dried for preservation and easy transportation. The solar drying process takes about a day.

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(1) CDH Technical Data Sheet (Cambérène Horticultural Development Center, Dakar, Senegal).

C. Research

Rattoon okra crops cultivated with appropriate pruning and fertilizing have achieved good results at the Kaédi Research Center after the first harvest.

3.1.4.9. Sweet Potatoes

Sweet potatoes are grown for local marketing and can also be sun dried in slices, transported, and sold in neighboring markets.

A. Crop Calendar

Sweet potatoes can be grown in the rainy season only in Bakel and Kayes because of high water requirements. Planting should take place from June - July and harvesting from October - November.

Recommended varieties include Ndargu (from CHD/ISRA) and local varieties.

B. Production Techniques

Sweet potatoes grow well in humid soils. Soil can be clayish but must be well drained as potatoes are grown in mounds. Soil should be prepared using 15 to 20 cm deep tilling for clayish soils, with 60 cm wide ridges spaced at 30 cm.

Plants should be spaced at one meter between rows and 0.40 m between plants, with two plantings per hole. There should be about 50,000 plants per hectare.

Fertilizer should be applied as follows:

Chemical Fertilizers	Level 1	Level 2
Basal Dose		
Tricalcium Phosphate	300 kg	200 kg
Top dressing		
25 days after planting	150 kg	100 kg
Potassium Chloride	200 kg	100 kg

Water requirements for irrigation will be high, especially at the beginning of vegatation. The watering formula in the Bakel region should be 2,100 m^3 during the rainy season. The crop should be harvested 100 to 120 days after planting for NARDU variety and for local varieties not listed in the technical data sheet. Harvest should be extended over a 5-month period.

Tubes will yield 18 tons per hectare unde level 1 and 14 tons per hectare under level 2. (Leaves for animal feed: 3% of dry fodder).

Fresh sweet potatoes can be stored for one month under SRD conditions. Sun-dried sweet potatoes can be dehydrated in one day and preserved for six months.

3.1.4.10. Peanuts

Peanut crops, as opposed to groundnuts, has recently been introduced in Senegal. Peanut prices are slightly higher on the local market than those for groundnuts. If export marketing to European countries were to be organized, it would certainly open up important opportunities with much better prices than for groundnuts.

Peanuts require relatively hot weather. Ideal temperatures range between 15°C to 45°C. Above and below this range, germination is inhibited. 1/ To complete its vegetative cycle, the peanut plant needs between 400 and 1,200 mm of water. To facilitate maturation and harvesting, the latter part of the cycle should be direr.2/

A. Crop Calendar

Peanuts should be seeded in July and harvested at the end of October.

Recommended varieties include: Early Valencia, Loudima Red (A 1246); Valencia 247, and Late Virginia Type GH 119-20, Bunch 210.

B. Production Techniques

Light soils are appropriate for the peanut crop, which is cultivated mainly in the Basin's fondé soils. Ploughing depth for peanuts should be up to 20 cm. A basal dose of fertilizers and manures should be incorporated in the soil. The soil should be prepared using cross tilling with a plough, with small ridges tightly spaced. Seeds should be hulled 10 to 15 days prior to sowing and sorted to select only good ones. Seeds should be dressed with a powder solution of TMTD and Aldrine at 3 percent: 500g/100g of seeds. Sowing density should be at 1 seed per hole, with 15 cm on twin rows with 60 cm spacing, 170,000 plants per hectare, and 80 kg of seeds per hectare.

1/ P. Gillier and P. Sylvestre, Peanut, Maison Neuve and Larose Ed. Paris 1969.

2/ Ministry for Cooperation, Agronomy Handbook, Paris 1975.

Fertilizer should be applied as follows:

	Level 1	Level 2
A single fertilizer application during soil preparation		
Urea	50 kg	
Tricalcium Phosphate	100 kg	100 kg
Potassium Chloride	200 kg	50 kg

Irrigation should be adapted to rainfall patterns, with abundant watering before seeding to imbibe the soil fully. Watering can be reduced progressively, and eventually can be applied only to compensate for rainfall deficiencies. All watering should cease three weeks prior to harvesting.

As the peanut crop is remarkably immune to insect infestation, no special plant protection treatment is suggested. Weeding will be essentially manual after the first month of vegetative cycle.

As soon as the plant matures, it is pulled and dried upside down with pods exposed to the sun for 2 to 3 days. Pods should be separated from the plant through pulling by hand. They should be stored immediately to protect them from the rain, which causes the shells to turn black. The pods should be stored in a dry place protected from insects.

3.1.5. Summary of Water Requirements for Rice and Corn in the IDP Zone

The following tables summarize water requirements for two key crops -- rice and corn. Water requirements of these crops during the summer are two or three times the quantity required during the rainy season. Increased yields of 5-6 tons per hectare of rice and 4 to 5 tons per hectare of corn (hybrid varieties) should make growing of these crops economically feasible, however.

3.1.5.1. Rice: Water Requirements

	RAINY SEASON			DRY SEASON		
	Water App.	Fuel Cons.	Pump Cost	Wat. App.	Fuel Cons.	Pump Cost
BAKEL	8,800m^3	135 l	22,000CFA	22,800m^3	315 l	52,000CFA
PODOR	12,600m^3	200 l	31,500CFA	18,100m^3	270 l	45,250CFA
KAEDI	10,750m^3	162 l	26,875CFA	20,000m^3	300 l	50,000CFA
KAYES	10,200m^3	150 l	25,500CFA	22,280m^3	334 l	55,700CFA

3.1.5.2. Corn: Water Requirements

	RAINY SEASON			DRY SEASON		
	Water App.	Fuel Cons.	Pump Cost	Wat. App.	Fuel Cons.	Pump Cost
BAKEL	1,660m^3	25 l	4,150CFA	11,530m^3	171 l	28,825CFA
PODOR	4,950m^3	74 l	12,375CFA	9,270m^3	135 l	23,175CFA
KAEDI	3,300m^3	50 l	8,250CFA	10,300m^3	153 l	25,750CFA
KAYES	1,170m^3	18 l	2,925CFA	12,100m^3	180 l	30,250CFA

3.1.6. Agricultural Research

3.1.6.1. Linking the Agricultural Research II Project and the IDP

Agricultural research results that will be applied by the IDP will be produced under a separate USAID financed project, Agricultural Research II (Project No. 685-0605). The goal of coordinating these two projects is to encourage the IDP staff and research personnel to work together to integrate research and development efforts within each country and between the three countries.

3.1.6.2. Agricultural Research Agencies in the Senegal River Basin

Agricultural research in the Senegal River Basin is conducted by the following organizations:

- In Senegal:
  - ISRA (Senegalese Institute of Agricultural Research) in three stations, at Richard Toll and Fanaye and Guede;
  - WARDA (West African Rice Development Association) at 2 stations, at Richard Toll and Fanaye.
- In Mauritania
  - CNRADA (National Agricultural Research and Development Center) at Kaedi.
- In Mali:
  - I.E.R. (Institute of Rural Economy) at the Same station near Kayes.

3.1.6.3. Regional Problems in the Integration of Research Efforts

Agricultural research in the SRB has been characterized by a failure to coordinate research efforts, a lack of clearcut procedures for selecting research topics, a weak management structure, and an isolation from actual farm conditions. Each of these deficiencies is examined below.

A. Failure to Coordinate Research Efforts

Regional integration is particularly lacking in the selection of research topics and in the transfer of findings from one station to another. Consultations between research workers in related fields have not been well coordinated up to now. Stations within the same country have no formal channels of communication, and communication between the three member States even more limited. The OMVS, working through CIERDA (the Inter-State Committee for Agricultural Research and Development), has initiated a process of consultations and coordination. In the same vein, international agencies, called upon to underwrite the research effort, are insisting that the different stations specialize in complementary areas of research, in cooperation with the international agricultural research centers.

B. Selection of Research Topics

The Member States all have established procedures for determining the research priorities of their respective countries. In Senegal, for example, research topics are, in theory, selected in accordance with the following process:

1) The National Master Plan for Agricultural Research designed by the SERST *, in which agencies indicate guidelines and set priority criteria for agricultural research.

2) Regional Development Committees, working with questionnaires sent by SERST to all regional administrations concerned, help the regional authorities to specify their research requirements.

3) The National Consultative Commission on Agricultural and Agro-Industrial Research, defines research priorities on the basis of preparatory work done by the Conference of six specialized Technical Committes.

4) The combined National Conference on Agricultural Research provides an opportunity for a final consultative meeting between research organizations and development agencies to discuss research guidelines and priorities for the year.

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* State Secretariat for Scientific and Technical Research (Ministry of Higher Education).

5) Finally, the governing Board of the Research Institute, ISRA, decides on annual programs and budgets.

While this procedure for selecting research topics does require a certain degree of consultation between research and development agencies, in practice, it is market by several shortcomings.

Consultative arrangements between research and development institutions are rather poor in the sectors of agriculture and animal husbandry. Although the chairman of ISRA's Board of Governors is the Director General of Agricultural Production in the Ministry of Rural Development, there is little coordination in committee and commission proceedings on the one hand and the selection of subjects proposed by research workers by ISRA's governing board on the other hand.

Inequities are noted between researchers and development workers in terms of educational background, access to resources, and privileges related to salary, housing, and transportation. These inequalities in status widen the gap between researchers and the RDA staff. For example, researchers often publish papers that are clearly intended for other research scholars, and do not relate to RDA staff efforts. As a result, development personnel do not expect much from their counterparts in the research establishment and feel powerless to influence research efforts so that they reflect and address the practical problems they face. For this reason, extension personnel often hesitate when asked to play any role on the committees and commissions organized to monitor consultation and exchange in agricultural research.

Because agricultural research falls under the administrative supervision of the SERST and the RDA's under the Ministry of Rural Development, liaison between the research and development sectors is difficult at the institutional level. Until quite recently, the initiative in research work has invariably been left to the research sector. Athe same time, RDA's have taken little initiative, even though research is of vital importance to their future.

The following procedure should be applied for selection of research topics. As a first step, the OMVS agricultural research personnel should prepare a master-plan for agronomic research in the Senegal River Basin in collaboration with the IDP implementing agencies in the three countries. This master plan should define research priorities and identify specific problem areas in each of the three zones. Once the master plan is developed it should be submitted to the Council of Ministers of OMVS for approval. Based on this mater plan, researchers at the three locations should formulate their research programs, which should be coordinated with the overall research strategy within the country (for example, in many countries research coordinating committies/technical commissions exist to plan and coordinate agricultural research within each country.).

C. Research Management Structure

The main weakness of research management is that no workable system has been established for checking and controlling ongoing research. For the past year, ISRA has been trying to set up a research supervision system, but the lukewarm response of research workers has slowed progress to date.

Research results are still essentially dependent on the good will and professional integrity of individual researchers. There is no mechanism for imposing discipline, standards, or a definite methodology on researchers. Once a project is approved, it progresses solely according to the initiative of the particular researcher involved, until the resources allocated are exhausted. A lack of regulatory controls and discipline result in wastes of energy and resources.

D. Relative Isolation of Research Efforts from Realities of Farm Conditions

In the past few years, some progress has been made towards linking agricultural research to farmers' needs and thus integrating local agro-socioeconomic realities into the design of new research strategies.

In Senegal, efforts in this direction have included the following:

- An agreement on Multilocal Experimentation between the Agricultural Production Head Office (DGPA), the Rural Development Mutual Fund (FMDR) and the National Center for Agricultural Research (CNRA), aimed to pool research findings on a regional level and to stimulate experimental work in the rural areas. The scheme works through 30 support stations to conduct multilocal experiments under the supervision of the Department for the Extension of Applied Research.

- A Research Support Liaison Unit operating to link ISRA and SAED (dating from 1978).

- The transfer of techniques to one or several villages; four villages have been selected for study over the past 15 to 20 years, yet none of these are from the River Basin region.

- A study of an experiemental herd conducted in collaboration with SAED, aimed at upgrading animal husbandry techniques through the improved integration of animal traction with other farming methods.

The entry of the researcher to the rural milieu has been a gradual process, generally affecting isolated research workers or extension staff. Research stations often operate under conditions that are unrealistic and/or at variance with conditions prevailing at the farmers' level.

The researchers have little incentive to aim their efforts at the farmer's level; too often they conduct their research with little concern about the probability of their findings being adopted by the farmers. These researchers fully control the selection of new research topics and are unprepared to integrate concrete developmental realities into their selection criteria.

Nevertheless, a certain amount of progress is discernable, especially in Senegal. This forward movement has brought about the following changes:

- the regionalization of research institutions, bringing them closer to regional development agencies;

- the orientation of the research, toward farming systems research - a development which brings them to take the farmers' realities into account;

- the organization of multidisciplinary teams, which ensures that the technical, social and economic aspects of problems are taken into account simultaneously.

3.1.6.4. Intervention of the Agricultural Research II Project

The Agricultural Research II Project will introduce a number of corrective measures into the existing research systems to remediate the problems outlined above; including:

A. Improved coordination of regional research (partly through CIERDA, partly through the introduction of mechanisms for coordinated funding).

B. Reorientation of Agricultural Research toward subjects that are relevant to the region, including:

- the extension of research on farming systems;
- the orientation of crop research (cereals, rice, vegetables for local markets, etc.); and
- the integration of animal husbandry research into agricultural research activities.

C. A new orientation of research work to improve the profitability of agricultural activities by reducing production costs through cost-effective use of inputs such as water for irrigation, improving labor productivity through incentives, and developing production techniques suited to the environment such as the combination of farming and husbandry and animal traction.

D. A functional relationship between research and development, encouraging research and experimentation at the farm level and linkages between research structures and the RDA's to introduce a research support component into development activities and organizing liaison efforts linking the research effort with the RDA's activities.

E. Reinforcing research capabilities of Senegal, Mauritania, and Mali to provide effective technological support for agricultural development operations in the Basin.

3.1.6.5. Objectives of Agricultural Research in the SRB

Technical objectives of research efforts include increasing agricultural production and increasing the productivity of soil, labor, and other inputs. Microeconomic objectives including reducing production costs and developing profitable farming systems based on rational use of land, labor and available input factors. Finally, macroeconomic objectives of the research include increasing exports; reducing imports, and integrating agriculture and industry by setting up production - processing circuits.

Senegal, Mauritania and Mali cannot invest for the moment in the type of agricultural research whose results will materialize only in the remote future. Hence research topics should be selected with an eye to their potential short-term and possibly medium-term results. Applied Research seems to be the best method of producing viable results within a maximum period of six years.

3.1.6.6. The Research Program of the OMVS/USAID Agricultural Research II Project

The current research program adopted by the OMVS is designed to achieve four main objectives:

1. Selection and development of farming systems appropriate to each region of the Basin; these systems will be used to intensify the production of cereals and fodder and increase economic returns from irrigated agriculture,

2. Introduction of selected varieties of seeds and farming techniques to improve farm productivity and stimulate crop diversification.

3. Improvement of irrigation and farming techniques in order to achieve a combination of human animal, and mechanical labor systems necessary to speed up rural development.

4. Development of techniques for integrating animal husbandry with irrigated agricultural production.

A. Senegal

The research program implemented at the Fanaye Station will focus on the development and upgrading of farming or production systems, which means identifying and evaluating technical, social and economic problems in the present production systems; testing technological innovations on site for

technical soundness, economical profitability and social acceptability; and providing technical assistance in desseminating tye upgraded technological packages.

B. Mauritania

The program includes on farm trials to increase cereals production; experiments focused on correlations between soils, irrigation, and plant growth; experiments in the integration of new crop varieties and farming practices adapted to local conditions; supervision of technological diffusion among farmers; and the development of a system for the selection of research projects.

C. Mali

The research program in Mali is similar to that in Mauritania, although more limited. It will also be focused on rainfed crops such as sorghum, millet, cowpeas and certain vegetables. The focus will be on adaptive research on cereals and grain legumes including varietal testing and on farm trials of technological package.

3.1.6.7. The Research Program of the Integrated Development Project

3.1.6.7.1. Farming Techniques and Irrigation will include the following:

- Experiments in the use of animal traction on heavy clay soils;

- Irrigated rice farming techniques for relatively porous soils: semi-permanent strips of water;

- Crop rotation;

- Integration of farming and animal husbandry using organic manure, planting of fodder crops and recyclage of harvest wastes.

3.1.6.7.2. Fertilization Techniques will involve the use of locally produced tricalcium phosphate to supply phosphates; a comparative evaluation of superphosphate inputs and development of phosphate-use techniques tailored to the physical and chemical properties of tricalcum phosphate; and the continuation of fertilizer experiments on rice (WARDA-Fanaye) and other cereals to reduce chemical fertilizing to a minimum with resultant savings in foreign exchange.

3.1.6.7.3. Crops will be introduced as follows:

A. Maize and Sorghum - Varieties adapted to River Basin climate and soils will be introduced, and work on the development of palatalbe, high yield in hybrids will continue.

2. Temperature

Average temperatures in the Bakel Zone hover around 30°C. The zone's continental location explains the fact that temperatures are generally almost 2°C higher than those in Podor.

There are two temperature minima:

- in August: a drop temperatrue is associated with the rains. The steepest drops are down to around 33°C.

- in December and January: During the very cold season, maximum temperatures drop to 30°C and minimum temperatures drop below 15°C.

and two temperature maxima:

- in April, May and June: before the start of the rains, maximum temperatures rise appreciably above 40°C, with peaks higher than 45°C.

- in September and October, at the end of the rainy season, average maximum temperatures rise all the way to 35°C.

During the months of December and January, there is a possibility of damage to the rice crop. The risk is higher than in Podor, but in general the only serious effect has been slower stem growth and budding and yields have not diminished much.

During the months of April, May, and June, there is a particularly high risk of damage to the maize crop at flowering time as well as to temperate vegetables. Thus maize should be planted off-season the beginning of November, making it possible for the crop to flower in February and leading to an early harvest at the beginning of March.

3. Evapotranspiration

Data obtained from the observation of evaporation from class A trough have been used to calculate irrigation water requirements. These data are as follows:

Evaporation from Class A Trough (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Bakel	290	335	435	545	528	440	370	241	223	264	267	258	4198

4. Wind Patterns

Continental north-east trade winds, especially the hot, dry Harmattan blowing from the northeast should be taken into account as an agronomic

B. Tomatoes - Varieties will be tested for high yields and disease and insect resistance to lower the cost of plant protection. These varieties will be introduced for cultivation during the rainy season.

C. Cowpeas - Research will be done on high yielding varieties resistant to insect alters (Aphis, borses).

D. Onions - High-yield, mild tasting varieties will be selected and storage techniques will be developed. Onion production will take place duing the rainy season to supply the November to March market.

E. Sweet Potatoes - Varieties will be tested and planted and storage techniques will be developed.

3.1.7. The Bakel Perimeters

3.1.7.1. Location - The Bakel zone is situated in the upper valley of the Senegal River, 450 kilometers east-south-east of Saint-Louis. Perimeters in the Bakel zone, some 1,592 hectares, are classified into two distinct groups:

1. Bakel-Collenga, a medium-type perimeter that will cover an area of approximately 192 hectares of net irrigated area;

2. the small perimeters currently covering an area of over 600 hectares, to be extended by a further 470 hectares (gross) within the context of this project.

3.1.7.2. Physical Characteristics

A. Climate

1. Rainfall (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Bakel				5	58	83	145	207	141	36	5		660

With annual rainfall totalling 660 mm and a rainy season spread out over four months, from June to October, the Bakel Zone is in a privileged situation in which rainfed crops on dieri land represent a large part of farming.

limiting factor responsible for increased evapotranspiration. The plantation of windbreaks as a protection against northeast and easterly winds could result in a substantial reduction in water consumption on the perimeters, ranging from 10 to 20 percent.

3.1.7.3. Soil Typology

A. Bakel Collenga

The Bakel-Collenga perimeter is presently under construction. No in-depth soil studies have yet been conducted, but provisional estimates have been made for 92 hectares of the perimeter. According to these estimates, 74 hectares or 80 percent of the area has hydromorphic soils with a high (in fact, dominant) clay content. These soils may be classified as hollaldé or false hollaldé soil. They are suited to rice farming. The other 18 hectares or 20 percent of the area is composed of lighter alluvial clay soils that may be classified as fondé soils. These soils are more porous, and are thus not recommended for rice farming. On the other hand, mixed farming would succeed there.

The extension of the Bakel-Collenga perimeter, which is of special interest to the IDP project, will take place on soils that are heavier and of higher clay content than soils on the present perimeter. For the 100 hectare extension, it is estimated that 90 hectares will be set aside for rice farming and 10 hectares will be set aside for mixed crops.

B. Small Perimeters

Analysis of the small perimeters and their extension proposed in Table 7-1 indicates that on the existing perimeters, heavy clay-soils suited to rice farming account for slightly more than 50 percent of the total improved land area, and that on the proposed extensions to these perimeters, about 45 percent of the total area is suitable for rice farming.

For the sake of simplification, we shall assume for this study that 50 percent of the land area on the small perimeters in the Bakel Zone may be set aside for rice farming. That proportion yields the following net figures for the areas involved: 1/

Gross area (Net hectarage under cultivation)

	(ha)	Rice	Mixed Crops	Total
Existing perimeters	230	86	86	172
Proposed extensions	215	81	80	161
Total	445	167	166	333

1/ It is assumed that a perimeter of 20 hectares gross contains a net cultivated area of 15 hectares, i.e., 75 percent. This figure may be substantially higher, especially when intercropping is taken into account.

3.1.7.4. Crop Water Requirements

Appendix A, Table 3.1.7. a. and b. present calculations for water requirements for rice and corn in the Bakel Zone, taking into consideration evapotranspiration and rainfall.

Rice requirements are 8,800 m^3 during the rainy season and 2,080 m^3 during the dry season, while for corn they are 1,660 m^3 at rainy season and 11,530 m^3 at dry season.

3.1.7.5. Family Size

The size of an average farm family in the Bakel Zone is indicated below [1/]:

No. of persons per family	8.0
No. of active persons per family	4.1
No. of active men	1.6
No. of active women	2.5

3.1.7.6. The Existing Farming System

The following estimates for the Bakel region are based on data from the FAO-BIRD study of the Gouraye zone:

average area of family farms	3.2 ha	comprising
crops on dryland:	2.16 ha	"
millet and black-eyed peas:	0.4 ha	
sorghum and black-eyed peas:	1.6 ha	
peanuts	0.16 ha	
crops on walo land:		
flood recession sorghum	1.36 ha	
crops on irrigated land:	0.10 ha	

Traditional cultivation is practiced, with minimum use of fertilizers and chemical treatments. Animal traction is practiced, but only on a negligible number of farms. Yields are low, compatible with the figures put forward in the FAO-BIRD report for the Gouraye Zone.

Appendix A, Table F shows yields and production levels for an average farm.

1/ Irrigated Perimeter Project FAO-BIRD Report, 1981.

3.1.7.7. Proposed Farming System

While no reliable data is presently available to propose a modified farming system for the Bakel area, research is being conducted into various techniques that could serve as a basis for developing new farming systems. These techniques include the following:

1. Multiple cropping techniques to increase the intensity of cropping;

2. Labor saving equiment (animal traction and related implements);

3. New crop sequences (solutions to unemployed or under-employed labor during off-season);

4. Yield-increasing techniques; and

5. Small scale animal husbandry.

The proposed multiple cropping system would be based on a rainy season planting of rice from July to November; an off-season planting of corn and various vegetables from November to February; and a dry season planting of rice form March to June.

Although this system of cropping appears to be feasible for the Bakel area, we lack a clear understanding of potential constraints and operating problems -- especially for farmers who also cultivate dryland crops from June to November. Another system of multiple cropping that has been proposed would be based on a dry season planting of rice from March to June; a rainy season planting of rice from July to November with the ratoon of the dry season crop; and an off-season planting of corn from November to February.

Field trials for rice have yielded 6 to 6.5 tons per hectare for the main crop and 3 to 3.5 tons per hectare for the ratoon crop. It should be noted that these ratoon crop yields were achieved with very little investment of labor and fertilizers. The ratoon crop thus has good potential in terms of the low labor and purchased inputs required. Introducing animal traction should further reduce labor constraints to a great extent.

In developing and implementing these modified farming systems, an understanding of the resource structure of the farms is vital. Research and extension workers must work together in developing these systems.

3.1.8. The Podor Perimeters

3.1.8.1. Location

The Podor zone is situated in the middle valley of the Senegal River, 180 kilometers from Saint Louis in the vicinity of the town of Podor.

3.1.8.2. Physical Characteristics

A. Climate

Average Rainfall and Evaporation Statistics:

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Rainfall					2	8	43	138	79	30	2		310
Evaporation	262	287	362	412	436	401	342	248	279	266	241	235	3771

1. Rainfall

Average total annual rainfall is 310 mm, falling in the period from July to October. Such a low figure offers little potential for rainfed farming in the zone. Worse still, large annual variations have been registered, and this region was particularly hard hit by the drought stretching from 1972 to 1980.

2. Temperatures

The average annual temperature in Podor is around 28°C. Although temperature minima in December, January, and February can drop lower than 15°, there is no great danger of damage to the rice crop, as temperatures rarely fall below 12° and even then, remain at that level for extremely short periods. The rice crop is not seriously affected by low temperatures, although maturation time is delayed.

High temperatures of above 35°C are registered from March to July, yet the temperature range is more restricted than in the upper valley. Nevertheless, off-season maize and vegetables should be planted early to avoid crop damage resulting from a combination of high temperatures and the Harmattan winds from March to June.

3. Evapotranspiration

Water requirements for irrigation on the perimeter have been calculated on the basis of the study of evaporation levels from a class A Trough.

4. Wind Patterns:

From an agronomic viewpoint, the most dangerous winds are the hot, dry ones. The desiccating Harmattan wind, which blows from northeast to southwest from March to June, can wreak havoc on crops, not to mention its impact on water consumption on the perimeters. The planting schedules should thus be adjusted to avoid flowering during this period.

Continental northeast trade winds that prevail in the region should also be taken into account, as they affect evapotranspiration levels.

3.1.8.3. Soil Typology

Soils in the Podor Basin may be classified into three categories:

1. Developed hydromorphic alluvial-clay soils. These are the soils of the high and low levees, known as fondé soils. These soils are earmarked for mixed crop farming.

2. Hydromorphic alluvial-clay soils. These soils have low humus content and substantial vertical depth and are referred to in the local language as fondé water or false hollaldé soils. These soils are earmarked for mixed crop farming and possibly for rice farming, as they are relatively impermeable.

3. Topographic green soils over stilling basin clay soils. These hollaldé soils are earmarked for rice farming.

The sequence of soil types habitually observed along the banks of the Senegal River make it possible to locate the three types of soils with considerable precision. The confluence of the Doué Creek and the Senegal River possibly accounts for the great variety of soil types observed here and for the considerable differences from the typical schema of soils. Appendix A, table 3.1.8.a. gives a rough idea of the location of the three main types of soil.

Appendix A, table 3.1.8.b. indicates the uses for which these soils have been earmarked, according to irrigation zones.

3.1.8.4. Crop Water Requirements:

Crop water requirements in Podor zone as per calculations in Appendix A, tables 3.1.9.c.-e. are indicated below; rice rainy season, 12,600 m^3; rice dry season, 18,100 m^3; corn rainy season, 4,950 m^3; corn dry season, 9,270 m^3.

3.1.8.5. The Existing Farming System

According to available statistics (GERSAR report) the existing farming system is based on the cultivation of two hectares of rainfed crops on dryland and three hectares of flood recessions farming. Table 3.1.8.f. shows labor time distribution within the farming system. This table indicates that average family labor capacity is underused and that the period of peak activity on the farm occurs in the months of May, June, and July.

3.1.8.6. Proposed Farming Systems

An improved farming system would include one-half to one hectare of irrigated land in addition to the two hectares of djeri and three of walo, and would employ animal traction. Multiple cropping would be performed on the irrigated land, with a rainy season rice crop from July to October, an off-season maize/vegetable crop from November to February, and a summer rice crop from March to June.

An alternative multiple cropping system could be based on a July to October rice ratoon crop, a November to February maize /vegetable crop, and a March to June rice crop.

Recommended practices would be adopted under the improved system, and small scale animal husbandry including poultry, would be introduced.

The above suggestions have been made in light of various research approaches currently being tested by researchers in the Bakel area. It is important to note that farm family labor is unemployed or underutilized during the months from November to June, the period between the harvest of rainy season dry crops and the onset of the rainy season. Farming systems should be aimed at exploiting available farm family labor during this period.

We propose that rice be transplanted in this area during the first week of July to coincide with water availability in the river, and that dry crops be planted in June. While this schedule would tax available labor during the June-July period, introducing animal traction and other adjustments in farming operations would help ease that situation.

3.1.9. The Gouraye Perimeters

3.1.9.1. Location:

The zone of Gouraye is located in the administrative district of Guidimaka in Mauritania, in the upper valley of the Senegal River. IDP will affect 16 perimeters located in 12 villages, covering a total irrigated area of 1,164 hectares gross, of which 790 hectares of perimeters are to be constructed and 374 already exist.

Table 3.1.9.a. presents a summary analysis of sites proposed for improvement and crop distribution.

3.1.9.2. Physical Characteristics

A. Climate

Data collected in the Bakel Zone on rainfall, temperatures, evapotranspiration, and prevailing winds apply to this area as well.

B. Soil Types

According to Chapter II of the "SONADER Report" 1/ on sites proposed for improvement, 34 percent of the area proposed is suitable for rice farming and 66 percent is suitable for mixed farming. Soils were classified in this project to encourage the extension of rice farming as far as possible in the region. Soils defined as "heavy fondé", characterized by a combination of alluvium and 20 to 30 percent clay, are used for rice farming in the same way as the clayish "hollaldé" soils of the lower basin.

The project strategy is to recommend rice farming only for plots that can profitably be planted with rice both in the rainy season and in the off-season. In the off-season, the profitability of any rice farm is likely to be markedly compromised by a water percolation rate higher than 4 mm per day. Present percolation rates on alluvial-clay soils rise easily beyond this level. Thus only those soils with a higher clay content should be selected for rice production. On the other hand, maize and sorghum, which thrive on a third less water than rice, produce better results on lighter soils. About 20 percent of the improved land will be devoted to rice farming.

3.1.9.3. Crops and Water Requirements

A. Selected Crops

Because of the low proportion of clayish soils in Gouraye Zone, only 20 percent of improved land will be devoted to rice farming, amounting to a net hectarage of 118.5. The remaining 80 percent of the improved land, an area of 474 net hectares, will be devoted to mixed farming.

A mixed cropping system covering a three-year period has been proposed, with rainy season and off-season cropping as follows:

	Rainy season	Off-season
Year 1	Maize	Cow peas
Year 2	Sorghum	Maize
Year 3	Maize	Vegetables

1/ FAO/World Bank Cooperative Programme
Investment Center, "Projet de Périmètres Irrigués Villageois - Rapport de Préparation".

Tomatoes, onions, cabbage, large-grained peanuts (nematode trap), and okra are among the crops selected for planting. Water requirements should be calculated on the basis of the water consumption of the tomato plant, which, as compared to the other vegetables, consumes more and needs water over a longer stretch of time. For a standard perimeter or a hydraulic sector measuring 15 hectares, the distribution of irrigated land will be as follows:

	Rainy-season	Off-season	Total
Rice	3 ha	3 ha	6 ha
Maize	8	4	12
Sorghum	4	-	4
Black-eyed peas	-	4	4
Vegetables	-	4	4
	15 ha	15 ha	30 ha

3.1.9.4. Water Requirements for Irrigation

Water requirements for irrigation are essentially the same for the various crops as those in the neighboring zone of Bakel. The requirements have been calculated for each crop according to the rate of evapotranspiration, average rainfall, and the specific qualities of each crop.

Table 3.1.10.b gives water requirement figures per hectare of rice and per hectare of mixed crops in the Gouraye Zone.

3.1.9.5. The Agricultural Population

The rural population affected by development of the Gouraye Zone is estimated at approximately 20,000. According to surveys conducted within the framework of the USAID and "War on Want" projects, the population shows the following structural characteristics:

Number of persons per family	: 8
Active members	: 4.1
Active males	: 1.6
Active females	: 2.5

3.1.9.6. The Present Farming System

The FAO-BIRD Study of December 1981 describes the farming system currently in force in Gouraye Zone as follows:

Average size of family farms:	3.62 hectàres
Farms on djeri land:	2.16 ha distributed as follows
millet and cowpeas	0.4
sorghum and cowpeas	1.6
peanuts	0.16
Farms on Walo land:	
flood recession sorghum	1.36
Farms on irrigated and falo land:	0.10

The techniques in use are essentially traditional, with minimum recourse to fertilizers and chemical treatments. Animal traction exists in the area, but is practiced only on a very small number of farms. Yields are low. Statistics compiled from the 1981 FAO-BIRD Report on Gouraye Zone are presented in 3.1.9.c.

3.1.9.7. Proposed Farming Systems

Improved/modern farming systems should be marked by multiple cropping on the irrigated land, intensive agricultural practices, animal traction and other labor saving technology, alternate crop enterprises, and small-scale animal husbandry.

It should be noted that at present there has been no systematic research into the possible cropping systems and their impact on the other segments of the system such as dryland operations. Much is known, however, about the seasonal nature, underemployment of family labor resources, low yields, and lack of modern inputs of present farming systems. Technology tested elsewhere under similar agroclimatic and socioeconomic conditions has provided insights into the potential for developing modern farming systems that could improve yields and overall returns on the traditional farms. Because of similar conditions in the Bakel-Podor Zones of Senegal, multiple cropping has a great potential in these zones. A multiple cropping system in this region might be based on rice-corn/vegetables/peanuts/sorghum-rice sequences on the irrigated lands.

3.1.10. The Kaedi Perimeters

3.1.10.1. Location

The Kaedi Zone is situated in Mauritania, in the middle valley of the Senegal River, about 350 kilometers east of Saint Louis. Following a joint USAID-World Bank field mission, 19 sites for perimetrs were identified and selected on the basis of two reports: the FAO-BIRD Report: The Project for Irrigated Village Perimeters: Preparatory Report, December 1981, and Chapter II of the SONADER Report: Site Identification.

All the improvements proposed by the field mission team involve the creation or the extension of small perimeters. The program of short-term improvement will involve construction of 32 small perimeter irrigation units on a total area of 780 hectares gross. Combined with the already existing 354 hectares of PIV SONADER perimeters, this hectarage will total 1134 hectares of developed small irrigated perimeters in the sector. Table 3.1.11.a. presents the list of proposed sites, each with its intended crop regime, as determined by SONADER.

According to SONADER's specifications, the distribution of crops will be as follows: (Note: The team's agronomist and its soil specialist have not visited the zone).

3.1.10.2. Physical Characteristics

3.1.10.2.1. Climate

A. Rainfall (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
KAEDI					5	27	89	162	85	16	5	2	392

The Kaedi Zone is equidistant from Podor and Bakel, yet shows more similarities with Podor. Precipitation for the months of July, August, and September is slightly heavier than in Podor.

Because total annual rainfall averages 396 mm, dry farming on djeri soils remains a risky proposition. Yields on djeri in this region are extremely low.

B. Temperatures

As in the case of Podor, the average annual temperature hovers around 28°C. Temperature lows occur in December, January, and February, where they

can reach below 15°C; highs of hotter than 35°C occur from March to July.

Planting schedule for maize and rice should be formulated to take into account the risks connected with hot and cold periods in the region. Temperature ranges are lower here than those observed in the upper valley.

C. Evapotranspiration

Data on evapotranspiration gathered from the observation of a Class A Trough have been used for calculating irrigation requirements for crops.

Evapotranspiration in a Class A Trough (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
KAEDI	290	335	398	496	480	440	370	241	223	264	267	258	3962

Source: GERSAR.

D. Wind Patterns

As in the case of Podor, northeast trade winds of continental origin and hot, dry harmattan from the east prevail. Planting of wind-breaks on perimeters should appreciably reduce evapotranspiration, particularly during the hot off-season from March to June.

3.1.10.3. Soil Typology

Green or sub-arid reddish brown soils in the Kaedi region belong to the class of hydromorphic mineral soils with low water content. On the whole, their nutritive content is poor. 1/

According to the established soil classification system, about 80 percent of the sites identified seem suitable for rice farming, while 20 percent seem suitable for mixed crop farming. It should be pointed out, however, that this system automatically set aside heavy fondé soils for rice farming, even though these are also suitable for mixed crop farming. Assuming that the term heavy fondé refers to alluvial soil with a clay content ranging between 20 and 30 percent, this kind of soil has percolation rates higher than 5 mm per day -- a rate that would make it economically unsuitable for rice farming.

1/ FAO-BIRD: The Irrigated Village Perimeters Project: Preparatory Report, Dec. 1981

For the purposes of this study we shall apply the ratio of 70 percent of the soils suitable for rice farming, 30 percent suitable for mixed crop farming as a preliminary approximation to all the proposed perimeters.

3.1.10.4. Crops and Crop Rotation

Assuming no water availability problems, 70 percent of the area of the new perimeters will be devoted to rice farming on the basis of two cycles per year covering 550 hectares.

The remaining 30 percent of the land, totalling 230 hectares, will be devoted to two-cycle mixed crop farming.

For each standard perimeter measuring 15 hectares net, it can be assumed that 10.5 hectares will be devoted to rice farming and 4.5 hectares will be devoted to mixed crops.

We propose the following mixed crop rotation system over a three-year period:

	Rainy season	Cold off-season
Year 1	Cowpeas	Maize
Year 2	Sorghum	Maize
Year 3	Large grained peanuts	Vegetables.

In the rainy season, large grained peanuts, which attract nematode worms, will be planted on soils to be devoted to vegetables in the off-season. On each perimeter, the area reserved for vegetables, identical to the area for large grained peanuts, will be limited to about one and a half hectares, since the local market is small. The main vegetables to be cultivated will be tomatoes, onions, cabbage, okra, sweet potatoes and peppers. Okra, peppers, and even sweet potatoes can be dried for sale throughout the region. Similarly, onions can be marketed outside Kaedi.Zone, provided the price paid to producers makes this effort worthwhile.

3.1.10.5. Water Requirement for Rice (rainy season) is 10,750 m^3, and 20,000 m^3 for dry season. Corresponding figures for corn are 3,300 m^3 and 10,300 m^3 respectively.

3.1.10.6. Average Family Size

For the definition of the family farm unit, we use figures given by the M.I.S.O.E.S. survey concerning the Kaedi region:

Number of persons	5.7
Active members	3.0
Active males	1.2
Active females	1.8.

3.1.10.7. The Existing Farming System

The average area cultivated per farm is presently 3.15 hectares, of which 1.25 are djeri and 1.90 are walo. 1/

Crops and yields of the traditional farming system 2/ are as follows:

Crop	Area	Yield kg/ha	Production kg
Millet	1.25	250	312
Cowpeas		150	187
Flood recession sorgho	1.90	300	375
		450	855

The general practice on all djeri plots is to plant millet together with cowpeas. All planting operations are manual.

3.1.10.8. Proposed Farming Systems

In view of the lack of research findings and research-based farm level recommendations, it is impracticable to propose a specific modern farming system for the area. Moreover, the wide range of agroclimates that prevails in the region makes it difficult to propose a specific farming system. We propose that the rice crop be planted, under irrigation, during the rainy season from July to October; that corn, vegetables, sorghum, and peanuts be grown in the cold part of the off season from November to February; and that rice and peanuts be grown in the warm part of the off-season from March to June.

Practices adopted for the improved system should include animal traction, intensive cultivation, poultry, small scale animal husbandry, and plantation crops like bananas.

Research stations in the area are testing several approaches to multiple cropping using short duration varieties of maize, corn, and sorghum to increase the total food production on the irrigated perimeters. Extension agencies working in close collaboration with the research institutions in the area should be able to aid in developing modern farming systems.

1/ Source: The M.I.S.O.E.S. Survey

2/ Source: FAO-BIRD: The Irrigated Village Perimeters Project, Dec. 1981

3.1.11. Kayes Perimeters

3.1.11.1. Location

The Kayes Zone is situated in the upper valley of the Senegal River, 570 kilometers East-South-East of Saint Louis. Perimeters in the Kayes Zone are classified into two distinct categories:

A. Existing perimeters due for rehabilitation

These sites cover 232 hectares divided into ten perimeters. Apart from hydraulic improvements (examined in the irrigation report), the main rehabilitation work to be done here consists of planting windbreaks. All the perimeters requiring rehabilitation are classified as small village perimeters, on which each unit measuring between 10 and 15 hectares is fitted with a pump. Table 3.1.11.a. presents and analysis of these existing small perimeters.

B. New sites proposed for the creation of new perimeters

Covering 932.7 hectares and divided into 9 perimeters of unequal size, these new sites differ fundamentally from the existing perimeters in that they consist mainly of stilling basins that require structural improvement such as runoff water control to facilitate the cultivation of a single rice crop per year. In Goumbaye and Kounta, the addition of an irrigation system based on pumping stations ensures both a rainy season crop and a second crop during the off-season.

Table 3.1.11.b. presents a summary analysis of sites in Kayes Zone requiring improvement.

3.1.11.2. Physical Characteristics

Climate

1. Rainfall (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Annually
Kayes (downstream)				6	43	93	163	232	158	40	6		740
Kayes (upstream)				6	46	101	176	251	171	43	6		800
Kayes (average)				6	44	97	170	241	164	42	6		770

Considering the fact that it is located in the Senegal River Basin, Kayes Zone has a reasonably favorable rainfall situation. Rainfall averages 770 mm a year, distributed over more than four months. This rainfall is sufficient to ensure good harvest of rainfed crops on djeri land. In this region increased cereal production could be achieved through a mixed strategy involving the extension of irrigated land and the achievement of improved productivity on rainfed areas.

2. Temperatures

Because of the continental location of the Kayes Zone, temperature variations are wider than those in Bakel. Maximum temperatures in April, May, and June are often higher than 40 or even 45°C. High temperatures increase the risk of damage to crops such as maize and temperate vegetables. Temperatures in December and January fall below 15°C, which means that the planting schedule for rice has to be more strictly observed and measures must be taken to protect perimeters on which off-season rice is planted. Planting windbreaks will result in an appreciable reduction of temperature variations on the perimeters and thus improve farming conditions.

Planting schedules for the Kayes Zone should devote particular attention to the planting of off-season rice at the end of January, as nursery sown in early January must be protected against cold.

Off-season maize should be planted at the beginning of November and not later than November 15 so it can be harvested at the beginning of March after flowering in February.

3. Evapotranspiration

The following table presents figures for evapotranspiration from a class A Trough, useful for calculating water requirements for crops.

Evapotranspiration from a Class A Trough (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Kayes	304	352	459	572	554	462	388	253	234	277	280	271	4406

4. Wind Patterns

As in the case of Podor and Bakel, the prevailing continental trade winds, blowing from the northeast, and the hot, dry east Harmattan wind increase evapotranspiration. Planting wind-breaks on perimeters will result in substantial savings of water rainging from 10 to 20 percent.

3.1.11.3. Soil Typology

Soil types in the region of Kayes are the same as those observed in the Podor Basin, yet there is a vast difference in range due to the relative narrowness of the alluvial valley upstream. The fondé-type alluvial-clay soils are well situated for irrigation as they are close to the river (high level). They are also suitable for mixed farming with crops such as maize, shorghum, and vegetables. In places, these soils narrow down into strips of only 100 to 200 meters wide.

The stilling basins in which close-packed, clayish hollaldé soils suitable for rice farming have been deposited are often reduced to slight and rather narrow depression. For instance, the Wallinkane and Dramane-Sobokou basins are only 100 to 150 meters wide. Exceptions are the basins of Sobokou and Goumbaye, which are much wider. Because the light soils along the banks have a good texture as well as being deep, they offer a definite agronomic potential. The potential of heavy soils in the basin is less certain. These soils are generally suitable for rice provided that an appropriate drainage system is established together with a fertilization regime tuned to the highly variable richness of the soils.

3.1.11.4. Crop Water Requirements

Crop water requirements for Kayes zone are presented in tables 3.1.11.c., 3.1.11.e. Rice requirements are 10,200 m^3 in rainy season and 22,280 m^3 in dry seasons. For corn the requirements are 1170 m^3 are 12,100 m^3 respectively.

3.1.11.5. Crops

A. Small perimeters due for rehabilitation

Thirty percent of the small perimeters due for rehabilitation will be devoted to rice farming, which amounts to 70 out of a total of 232 hectares. The crop rotation patterns suggested for the irrigated perimeters could be based on the following depending on the specific needs of perimeters, market situations, prices, etc...

Rainy season	Off-season
Cowpeas	Maize
Rice	Large Peanuts
Maize	Vegetables
Large Peanuts	

Large peanuts are introduced into the crop rotation system as a nematode worm trap, with a view to cleansing the soil prior to the planting of vegetables and cowpeas. These large grained peanuts are in great demand on the local and even possibly on the regional markets.

Vegetables would form an important part of off-season crops on the perimeters. Okra and pepper can be dried for sale throughout the region. Sweet potatoes can be similarly treated (sun-drying techniques have to be adapted). Onions might also be sold outside the region of Kayes, provided prices are high enough to cover transportation expenses.

Mostly maize is consumed in the form of green cobs after roasting on cobs. Increased yields resulting from the use of modern techniques and improved seeds make maize more competitive with other cereals on the market.

Cowpeas and sorghum are staples in the local diet. These crops are well suited to conditions in the region and give satisfactory results under sometimes difficult climatic conditions. They are drought resistant, and can survive during long, dry periods.

Rice could be grown in several perimeters during the rainy season with only small quantities of irrigation. Good yields of up to 6 tons per hectare have been obtained on farmer fields. It is technically and economically feasible to grow a second crop (January to April) or a summer crop (March to June). These opportunities need to be explored.

B. New Sites: Improvement of Basins

It is proposed to carry out improvements on an area of 932.7 hectares in the region of Kayes. Of this total, 85 percent or 789.7 hectares will be suitable for rice farming, 373.7 hectares to be double cropped annually, and 416 hectares to be planted only during the rainy season.

Another 143 hectares or 1.5 percent of the land will be suitable for mixed crops. This land could be irrigated and cultivated throughout the year with at least two crops per year.

Farming on the newly improved land is planned to follow the program outlined below:

AREAS CULTIVATED (ha)

Basins	Project Years						End of 6th year
	1	2	3	4	5	6	
Goumbaye 1st Phase				77	155	155	155
Goumbaye 2nd Phase							255
Dioumékon 1st Phase (Soukoutale)				40	40	40	40
Dioumékon 2nd Phase				8	43	43	43
Kounta 1st Phase				8.4	8.4	8.4	8.4
Kounta 2nd Phase (Farakotassou)				15.3	15.3	15.3	15.3
Dakandakpé 1 & 2						11	11
Nalinkane						40	40
Dramané Sobokou						150	150
Gakoura 2						115	115
Sobokou 2						100	100
TOTAL				148.7	216.7	677.7	932.7
Comprising Rice: - one-crop annual cycle						416	416
- two-crop annual cycle				88.2	153.7	153.7	373.7
Mixed crops: - two-crop annual cycle				40	50	53	143

The following crop rotation patterns are suggested for the different areas:

a. Rice: one crop annual cycle (416 hectares): a single rice crop would be planted every year on the same land with no rotation. However, it is technically possible and economically profitable to raise a leguminous fodder cum green manure relay crop using residual moisture. Such a crop could be planted a week before rice harvest. This crop, which uses residual moisture to grow, has two advantages. Firstly, the first flush of the crop (green leaves) can be harvested for use as fodder (for sale or for on-farm livestock consumption). Secondly, after the crop regions residues are sufficiently dried, they can be composted as green manure. Such practice has a beneficial effect on soil improvement and yield of the following rice crop.

b. Rice: two crop annual cycle (153.7 hectares): two crops of rice can be grown on the same land with no rotation, or a second crop of grain legumes or peanuts could be grown to improve the soil fertility.

c. Mixed crops: two crop annual cycle (143 hectares): this land would be suitable for cultivation year round, if water were available. At least two crops per year could be raised on this land. Cropping pattern could be based on the following crops.

Rainy season	Off-season
Maize	Maize
Peanuts	Vegetables
Sweet Potatoes	Peanuts
Sorghum/millets	
Cowpeas	

Farmers tend to concentrate on subsistance crops such as cereals and grain legumes during the off season. The extent of different crops grown during the off season also depends on the availability of markets to sell the produce. Farmers must thus make constant adjustments as to the extent of areas to be cultivated under different crops and would be unlikely to adapt a fixed rotation; thus we can only propose a range of possible rotations.

3.1.11.6. Agricultural Population

Available information on agricultural households in the Kayes Region is relatively unreliable. The socioeconomic survey of Maloum-Kounda region (1978), supplemented with another survey in 1979, provides us

with the following data for 511 farms:

- Percent of the population active; 54.5
- Percent of the population away from homes - migrated to some other part of the country. (migration involves only active males); 6.0
- Percent active persons per farm; 6.94
- Percent women in active population. 56

3.1.11.7. The Percent Farming System

The following conclusions about the existing farming systems in the Kayes Region are based on the socioeconomic survey of Maloum-Kounda, conducted in 1978 and 1979.

- Average size of family farms: 2.59 ha (0.33 ha per active person);
- Principal type of farming is dry farming (Djeri);
- Flow recession farming (Walo) is practiced to a lesser extent in the Kayes region;
- Farming techniques are traditional;
- Cattle breeding is highly developed;
- Farming with animal traction is relatively well developed (142 plow oxen for 511 farms surveyed);
- Nearly 50% of Djeri land is ploughed before planting of each new crop.

Average yields on family farms are indicated in the following table:

Crop	Ha	Yield in kg/ha	Total Produced
Sorghum/millet	1.45	800	1,660
Maize	0.44	950	418
Peanuts	0.57	750	427
Rice	0.80	850	66
Crops along river bank	0.05		
Total	2.59		

3.1.11.8. Proposed Farming Systems

As is true for other project areas, no research findings are available yet for this region to support a proposal for improved farming systems. Any modified farming system must be based on both dry land farming and irrigated farming. Every farmer cultivates two or more hectares of dry land (rainfed). Once existing perimeters are revitalized and new ones are established, several farmers in the area will have irrigated land in quantities of up to one hectare or more in some cases. Proposed farming systems should thus be based on two types of crops in dry land, subsistance crops and irrigated crops (both food and cash crops).

It will not take too many hectares of irrigated vegetable crops in the perimeters to saturate the limited market in the region of Kayes (mainly Kayes town). Crop diversification and introduction of new farming enterprises will thus be essential to increasing the profitability and economic viability of the perimeters. Possible crop diversification includes raising bananas, corn, and peanuts rather than only vegetables and onions, as had been the case in the past. New enterprises could be based on poultry and small-scale animal husbandry, for which great demand exists in the region. In fact, this idea is being tested in one or two of the surviving perimeters. It will be up to the technical assistance team and its counterparts to design and promote suitable farming systems and new technologies.

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Table 3.1.a.

Tillage Operations and Power Requirements

Operation	Tool width	Depth	Force	Total Force	Percent of 700 kg oxen weight
Moldboard plowing shallow, loan soil	18-20 cm	10	.5	90 kg	13%
Moldboard plowing shallow, clay soil	18-20	10	1.0	180 kg	26%
Moldboard plowing deep, loan soil	18-20	20	.5	180 kg	26%
Moldboard plowing deep, clay soil	18-20	20	.1	360 kg	51%
Scarifying (harrow)	5 tires	5	2.0	100 kg	14%
Moldboard plowing shallow, clay soil	15	10	1.0	150 kg	21%
Moldboard plowing deep, clay soil	15	20	1.0	300 kg	42%

Table 3.1.b.

Animal Power Capabilities (*)

Type of Animal	wt	Average continuous efforts/kg	Speed km/hr	Daily Hours
1 Donkey	160 kg	46		6
1 pair Zebu oxen	700 kg	85-105	2.5	4-5
1 pair Zebu oxen	500 kg	60-65	2.5	4-5

(*) Larry Harms "OMVS Design Background Material for Livestock Animal Traction", USAID Technical memo dated 2/25/82.

Table 3.1.7.a

BAKEL

Water Requirements: Basis and Procedures

Medium Cycle Rice Variety:	120 days
Rice Field Water:	120 days - 20 days seed bed - 10 days drain before harvest 90 days
Seed Bed Water:	300 m^2/10,000 m^2 _ 5% rice field in 20 days
Imbibition for Ha:	150 mm
Deep Percolation:	2 mm x 90 = 180 mm
ETP:	Evaporation x 180 x 1.0
Net Water Requirement:	ETP + Imbibition + Percolation
Net Water Application:	Net Water Requirement - effective rainfall
Gross Water Application:	Net water application x conveyance efficiency = Net water app. x 0.70
Pump Discharge ~	300 m^3/hr for Lister HR2
Fuel Consumption ~	4,5 l. diesel fuel/hr Lister HR2
Cost per Cubic Meter Water ~	2,5 CFA
Overall Efficiency:	ETP/net water requirement

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Table 3.1.7.b.

BAKEL

Evaporation Rates: IDP Zone (Class A Trough)

		J	F	M	A	M	J	J	A	S	O	N	D	Year
PODOR	(1)	262	287	362	412	436	401	342	248	279	266	241	235	3771
KAEDI	(2)	290	335	398	496	480	440	370	241	223	264	267	258	3962
BAKEL	(3)	290	335	437	545	528	440	370	241	223	264	267	258	4198
KAYES	(4)	304	352	459	572	554	462	388	253	234	277	280	271	4406

(3) For Bakel, since detailed information is not available, we assume that evapotranspiration is slightly the same as for Kaédi except during the months of March, April and May when temperatures are likely to increase evapotranspiration by 10 percent.

Table 3.1.7.c

BAKEL

Rainfall: IDP Zone

	J	F	M	A	M	J	J	A	S	O	N	D	Year
PODOR - BOGUE					2	8	43	138	79	30	2		310
KAEDI					5	27	89	164	85	16	5	2	392
BAKEL downstream				5	36	78	136	194	133	33	5		620
BAKEL (1)				5	38	83	145	207	141	36	5		660
BAKEL up-stream				5	40	88	154	220	150	38	5		700
KAYES downstream				6	43	93	163	232	158	40	6		740
KAYES (1)				6	44	97	170	241	164	42	6		770
KAYES up-stream				6	46	101	176	251	171	43	6		800

Source: ORSTOM documents
(1): Average rainfall up and downstream

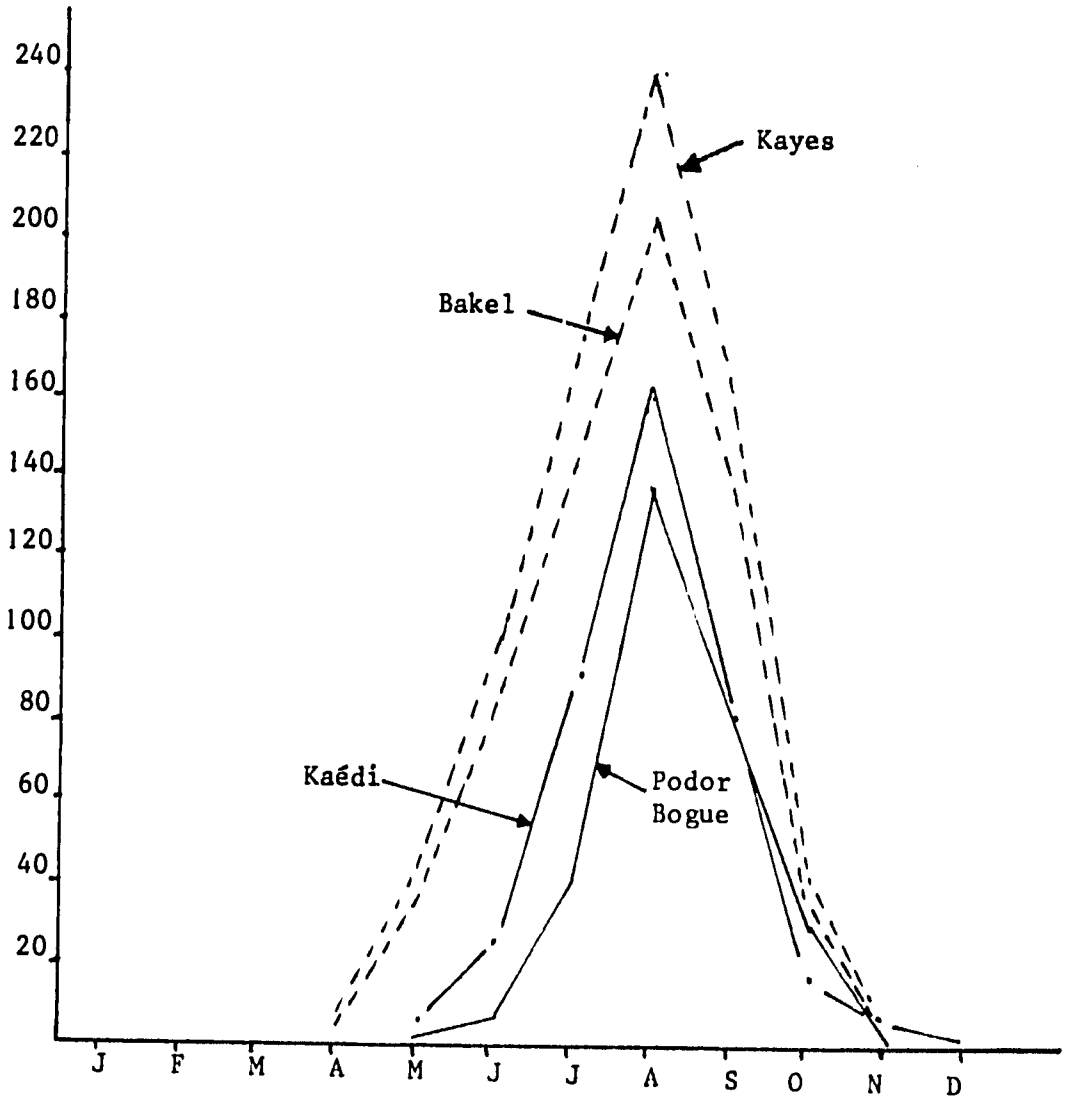
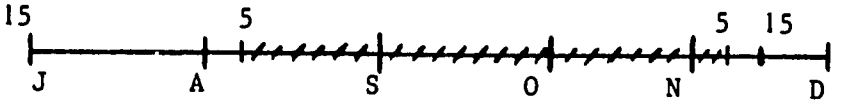


Table 3.1.7.d.

BAKEL

Rice: Rainy Season

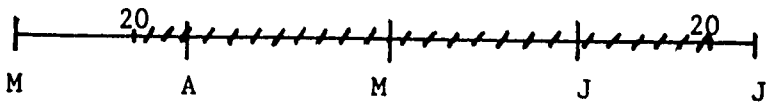


1. Evaporation: Aug. + Sept. + Oct.		
a) Rice field: 241 + 223 + 264	=	728.00 mm
b) Seed bed: 2/3 July x 0.05 (370 x 2/3) x 0.05	=	12.33 mm
	=	740.33 mm
2. ETP Rice: 740.33 x .80 x 1.0	=	592.26 mm
	=	593.00 mm
3. Effective Rainfall: Aug. - Oct. (207 + 141 + 36) x .80	=	307.20 mm
4. Net Water Requirement: 592.26 + 150 + 180	=	922.26 mm
5. Net Water Application = (4 - 3) 922.26 - 307.20	=	615.06 mm
6. Gross Water Application = 615.06/0.70	=	878.65 mm
	=	880.00 mm
	=	8,800 m^3
7. Pumping Time	=	8,800/300
	=	29.33 hrs
	=	30 hrs
8. Fuel Consumption	=	30 x 4.5
	=	135 lit.
9. Pumping Cost	=	8,800 x 2.5CFA
	=	22,000CFA
10. Overall Efficiency: ETP Rice/Net Water Requirement: 593/922.26	=	64%

Table 3.1.7.e.

BAKEL

Rice: Dry Season



1. Evaporation:	1/3 March + April + May + 2/3 June		
	a) Rice field: 146 + 545 + 528 + 293	=	1512.00 mm
	b) Seed bed: 2/3 of March x .05		
	291 x .05	=	14.55 mm
		=	1526.55 mm
2. ETP Rice:	1526.55 x .80 x 1.0	=	1221.24 mm
3. Effective rainfall:	(5 + 36 + 78) x .80	=	95.20 mm
4. Net Water Requirement:	1221.24 + 150 + 180	=	1551.24 mm
5. Net Water Application:	1551.24 - 95.2	=	1456.04 mm
6. Gross Water Application:	1456.04/0.70	=	2080.05 mm
		=	2080 mm
		=	20,800 m^3
7. Pumping time		=	20,800/300
		=	69.33 hrs
		=	70 hrs
8. Fuel Consumption		=	70 x 4.5 l
		=	315 l
9. Pumping Cost		=	2.5CFA x 20,80[illegible]
		=	52,000CFA
10. Overall Efficiency:	ETP Rice/Net Water Requirement	=	1221.24/1551.2[illegible]
		=	78%

Table 3.1.7.f.

BAKEL

Water Requirements: Corn

RAINY SEASON:

1 August — S — O — 1 Nov

1. Evaporation: Aug. + Sept. + Oct. 241 + 223 + 264	= 728.00 mm
2. ETP: 728 mm x 0.80 x 0.70	= 408.00 mm
3. Effective Rainfall: (207 + 141 + 36) x 0.8	= 307.00 mm
4. Net Water Application: 408 mm - 307 mm	= 101.00 mm
5. Gross Water Application: $\frac{101 \times 100}{60}$	= 166.00 mm ≃ 1660 m^3
6. Pumping Time:	= 1660/300 = 5.5 hrs
7. Fuel Consumption: 4.5 l x 5.5	= 25 l
8. Pumping Cost: 2.5 CFA x 1660	= 4150 CFA/ha

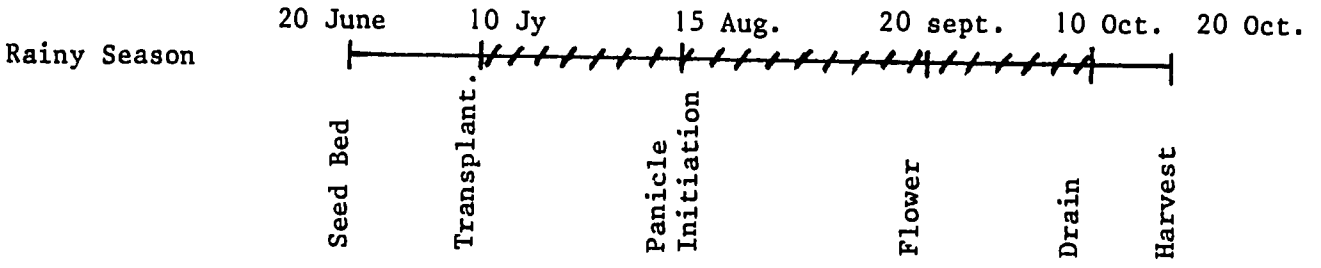
DRY SEASON: 15 Nov — 15 March

1. Evaporation: 1/2 Nov. + Dec. + Jan. + Feb. + 1/2 March 134 + 258 + 290 + 335 + 218	= 1235.00 mm
2. ETP: 1235 x 0.80 x 0.70	= 692.00 mm
3. Net Water Application = ETP	= 692.00 mm
4. Gross Water Application: 692/0.6	= 1153.00 mm ≃ 11530 m^3
5. Pumping Time: 11530/300	= 38 hrs
6. Fuel Consumption: 4.5 l x 38	= 171
7. Pumping Cost : 2.5CFA x 11530	= 28.825 CFAF

Table 3.1.7.g.

BAKEL

Rice After Diama and Manantali



1. Potential Evaporation: 1/3 Jul. + Aug. + Sept. + 2/3 Oct.
   a) Rice Field: 123 + 241 + 223 + 176 = 763.00 mm
   b) Seed Bed: 2/3 June x 0.5 = 15.00 mm
   = 778.00 mm

2. ETP Rice: 778 mm x .80 x 1.0 = 622.40 mm

3. Effective Rainfall: (48 + 207 + 141 + 24) x .80 = 336.00 mm

4. Net Water Requirement: 622.40 + 150 + 180 = 952.40 mm

5. Net Water Application: 952.40 - 336 mm = 616.40 mm

6. Gross Water Application: 616.40/.70 = 880.57 mm
   = 8,800 m^3/ha

7. Pumping Time: = 8,800/300
   = 29.33 hrs

8. Fuel Consumption: = 4,5 1 x 29.33
   = 132 1

9. Pumping Cost: = 2,5CFA x 8,800
   = 22,000CFA/ha

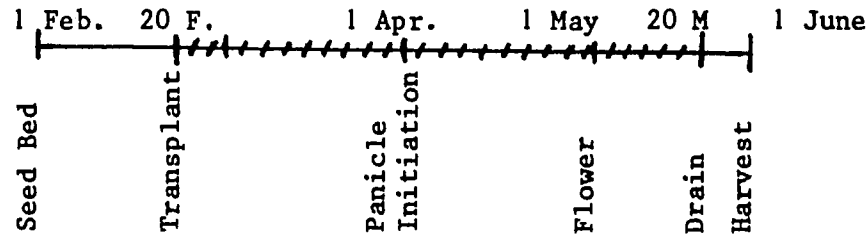
10. Overall Efficiency: = 622,40/952.4
    = 65%

Table 3.1.7.h.

BAKEL

Rice after Diama and Manantali

Hot and Dry Season



1. Potential Evaporation: 1/3 Fev + March + April + 2/3 May	=	90 days
a) Rice field: 112 + 437 + 545 + 352	=	1446.00 mm
b) Seed Bed: 2/3 Feb x 0.5	=	11.15 mm
	=	1457.15 mm
2. ETP Rice: 1457.15 x .80 x 1.0	=	1165.72 mm
3. Effective Rainfall: 40 x 2/3 x .80	=	21.33 mm
4. Net Water Requirement: 1165.72 + 150 + 180	=	1495.72 mm
5. Net Water Application: 1495.72 - 21.33	=	1474.39 mm
6. Gross Water Application: 1474.39/.70	=	2106.27 mm
	≈	21,050 m^3/ha
7. Pumping Time:	=	21.050/300
	=	70,16 hrs
8. Fuel Consumption:	=	4,51 x 70,16
	=	316 l
9. Pumping Cost	=	2,5CFAx21,05
	=	52,625CFA/ha
10. Overall Efficiency	=	1165.72/ 1495.72

Table 3.1.7.i.

BAKEL

Area, Crop Yield and Production on an Average Traditional Farm

Crop	Area (ha)	Yield (t/ha)	Production
Dieri:			
Sorghum	1.60	0.40	0.64
+ cowpeas		0.15	0.24
straw		0.30	0.48
Millet	0.40	0.25	0.10
+ cowpeas		0.15	0.06
straw		0.30	0.12
Peanuts	0.16		
nuts		0.45	0.07
straw		0.80	0.13
Walo:			
Flood recession sorghum	1.36	0.45	0.61
Crops on irrigated and falo land	0.1		

Source: FAO-BIRD Report (Gouraye Zone), 1981.

Table 3.1.8.a.

Soil Typology of The PODOR Zone

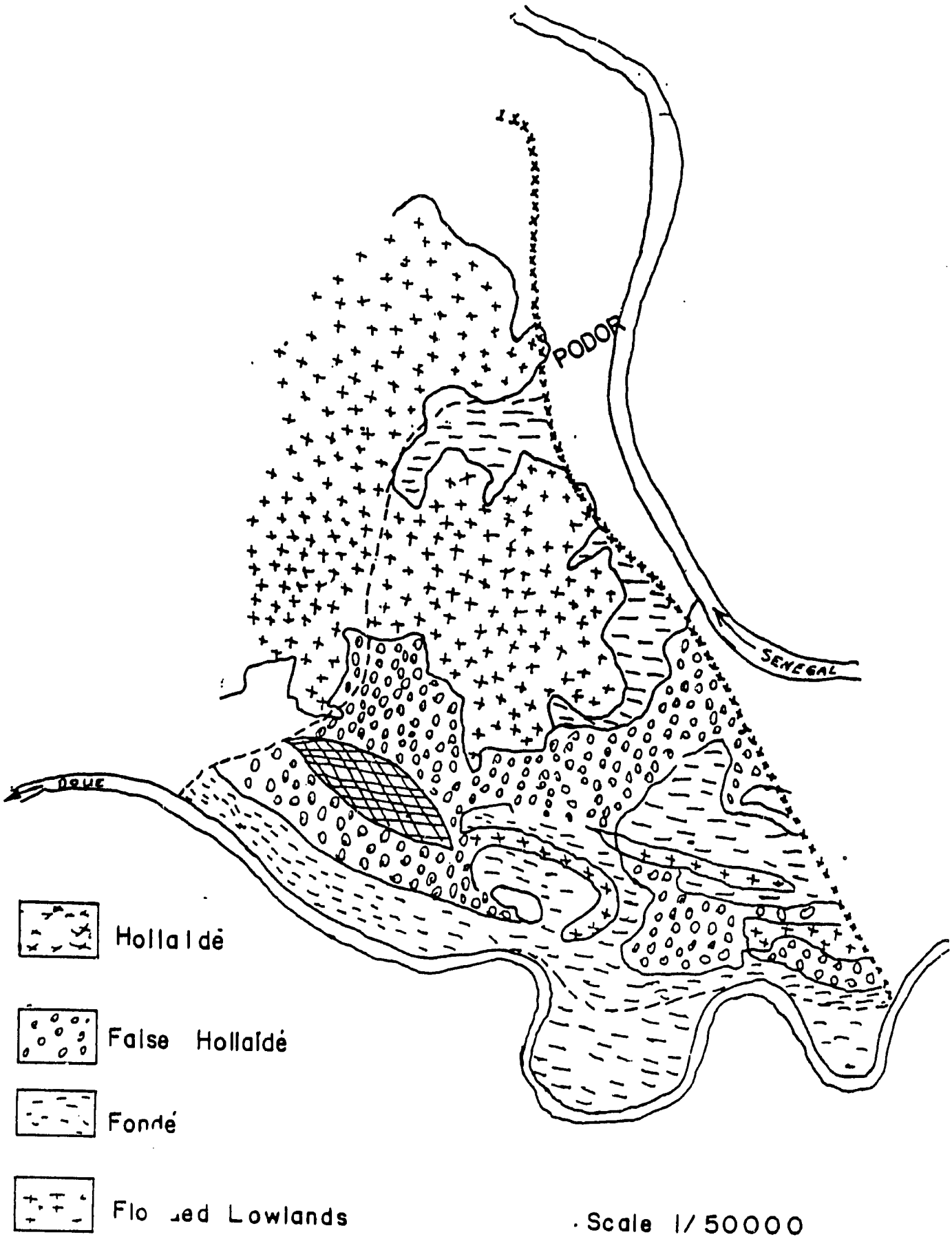


Table 3.1.8.b.

PODOR

Soil use in Agriculture

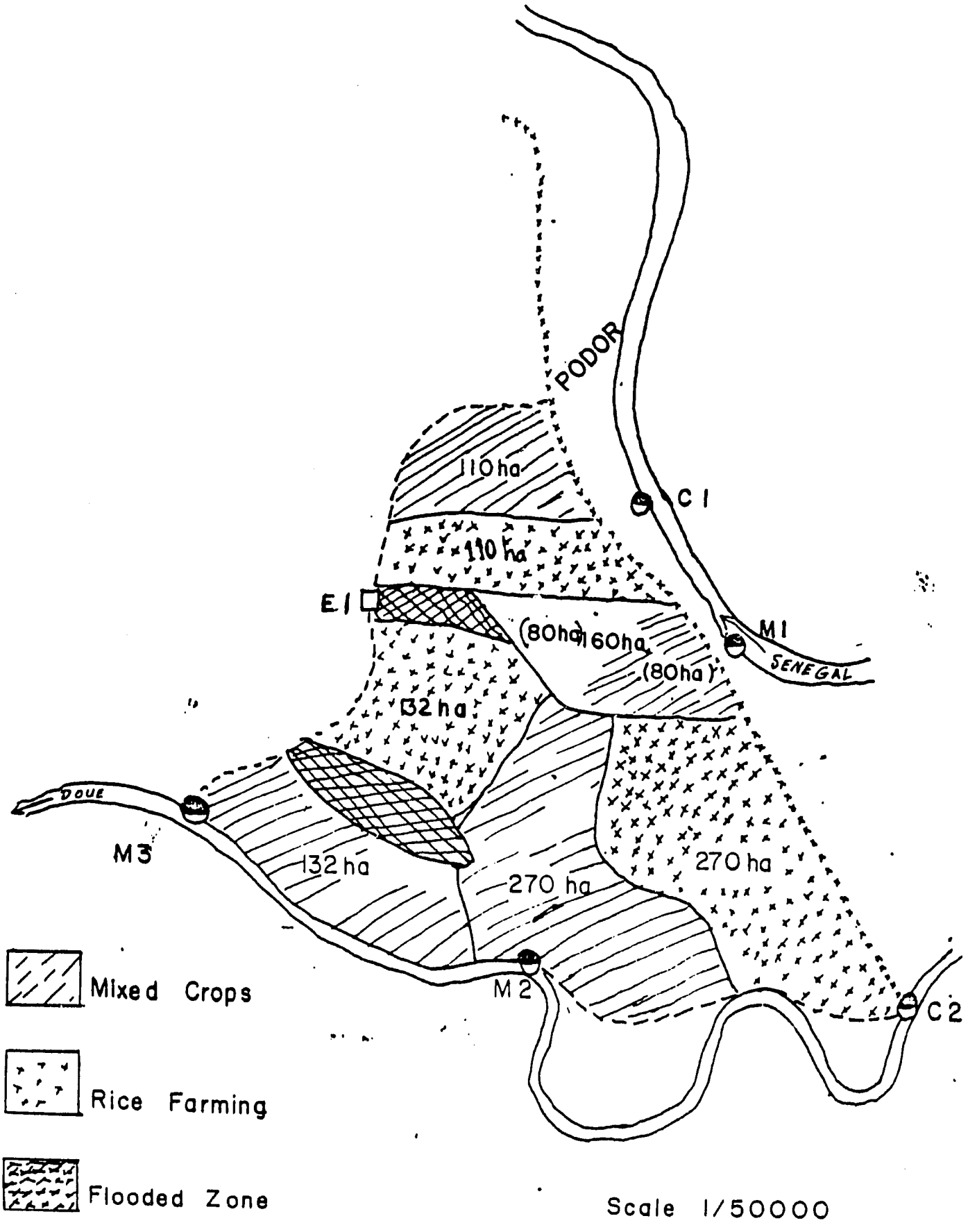
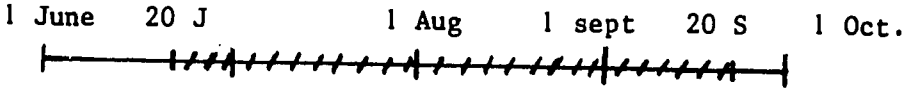


Table 3.1.8.c.

PODOR

Rice

RAINY SEASON



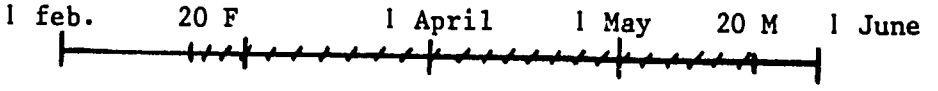
1. Evaporation: 1/3 June + July + August + 2/3 Sept.	
a) Rice Field: 134 + 342 + 246 + 185	= 907.00 mm
b) Seed Bed: 2/3 June x .05	= 14.00 mm
	= 921.00 mm
2. ETP Rice: 921 x .80 x 1.0	= 737.00 mm
3. Effective Rainfall: (43 + 138 + 53) x .80	= 187.00 mm
4. Net Water Requirement: 737 + 150 + 180	= 1067.00 mm
5. Net Water Application: 1067 - 187	= 880.00 mm
6. Gross Water Application: 880/170	= 1257.00 mm
	≃ 12,600 m^3
7. Pumping Time:	= 12,600/300
	= 42 hrs
8. Fuel Consumption	= 4.51 x 42
	= 189 l ≃ 20 cl
9. Pumping Cost	= 2,5CFA x 12,600
	= 31,500/ha
10. Overall Efficiency	= 737/1067
	= 69%

Table 3.1.8.d.

PODOR

Rice

DRY SEASON



1. Potential Evaporation: 1/3 Feb + March + April + 2/3 May		
a) Rice Field: 96 + 362 + 412 + 291	=	1161.00 mm
b) Seed Bed: 2/3 Feb. x .05	=	10.00 mm
	=	1171.00 mm
2. ETP Rice: 1171 x .80 x 1.0	=	937.00 mm
3. Effective Rainfall:	=	0
4. Net Water Requirement: 937 + 150 + 180	=	1267.00 mm
5. Net Water Application:		
6. Gross Water Application: 1267/.70	=	1810.00 mm
	≃	18,100 m^3
7. Pumping Time	=	18,100/300
	=	60 hrs
8. Fuel Consumption	=	4,5 l x 60
	=	270 l
9. Pumping Cost	=	2,5CFA x 18,100
	=	45,250 CFA
10. Overall Efficiency	=	937/1267
	=	73%

Table 3.1.8.e.

PODOR

Water Requirements: Corn

RAINY SEASON — July — A — S — Oct.

1. Evaporation: July + Aug. + Sept.
   342 + 248 + 279 = 869.00 mm

2. ETP: 869 x 0.80 x 0.70 = 4870.00 mm

3. Effective Rainfall: (434 + 138 + 79) x 0.8 = 208.00 mm

4. Net Water Application: 487 - 208 = 279.00 mm

5. Gross Water Application: $\frac{279 \times 100}{60}$ = 495.00 mm ≃ 4950 m^3

6. Pumping Time: 4950/300 = 16,5 hrs

7. Fuel Consumption: 4.5 1 x 16.5 = 74 1

8. Pumping Cost: 2.5FCFA x 4950 = 12.375FCFA

DRY SEASON — 15 oct. — 15 Feb.

1. Evaporation: 1/2 Oct + Nov + Dec + Ja + 1/2 Feb.
   133 + 241 + 235 + 262 + 143 = 1014.00 mm

2. ETP : 1014 x 0.80 x 0.70 = 568.00 mm

3. Effective Rainfall: 15 x 0.8 = 12.00 mm

4. Net Water Application: 568 mm - 12 = 556.00 mm

5. Gross Water Application: $\frac{556 \times 100}{60}$ = 927.00 mm ≃ 9270 m^3

6. Pumping Time: 9270/300 = 30 hrs

7. Fuel Consumption: 4.5 1 x 30 = 135 1

8. Pumping Cost: 2.5FCFA x 9270 = 23,175FCFA

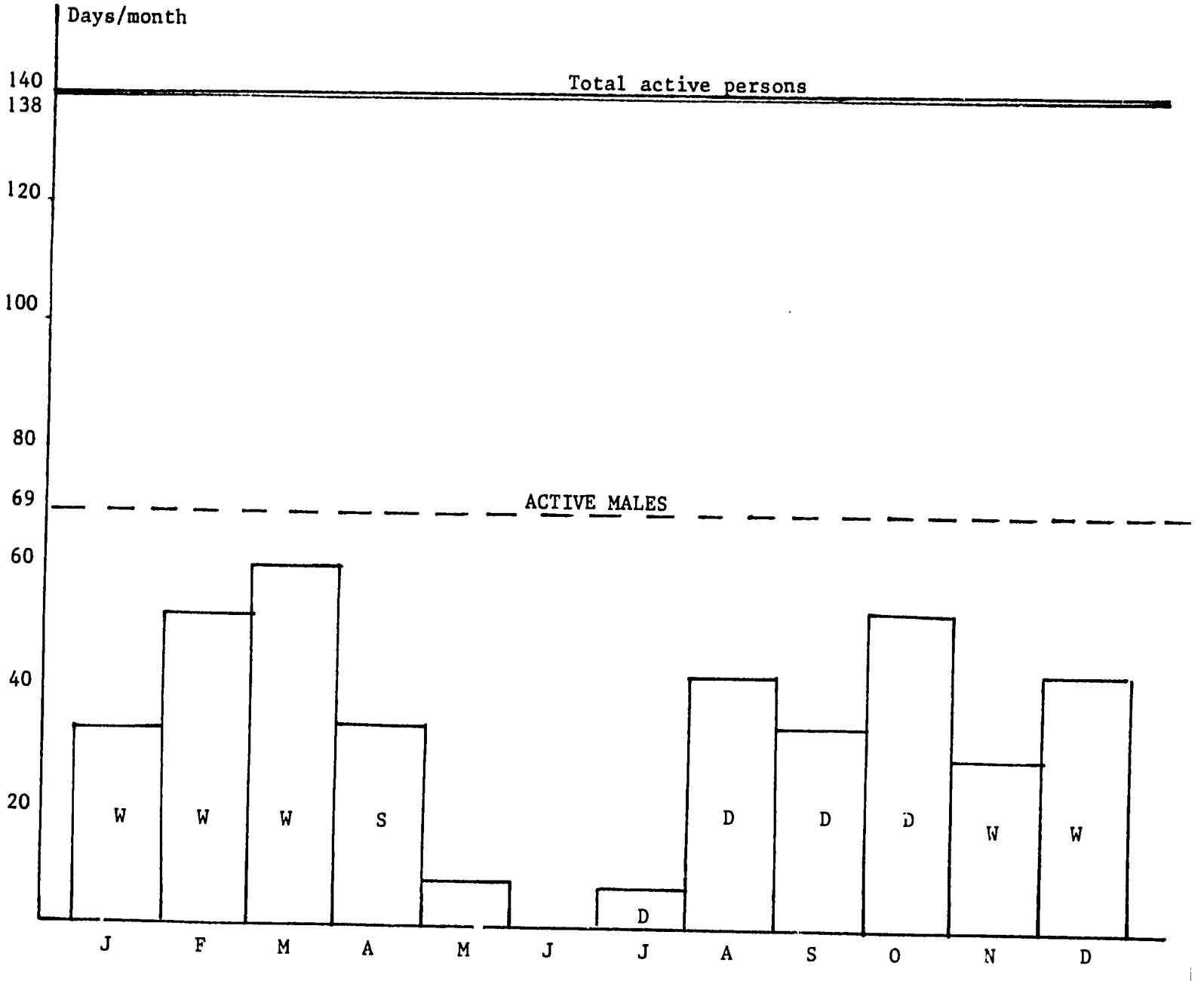
Table 3.1.8.f.

PODOR

Distribution of Labor Time on a Family Farm
Horizon Zero - Traditional Farming System

Hypothetical Labor Potential:

23 days x 3 adult males = 69 work-days per month
23 days x 6 active persons (total) = 138 work-day per month



D = Dieri
W = Walo (oualo)

Table 3.1.9.a.

GOURAYE

Proposed Distribution of Crops

		Total gross area in hectares		
		Total	Rice	Mixed Crops
Khabou Guidimakha	1	100	20	80
	2	40	8	32
Salou		75	--	75
Dioungountourou	1	30	15	15
	2	70	35	35
Moulessimou		140	70	70
Diradj		20	--	20
Woumpou		50	--	50
Sagne	1	20	20	--
	2	25	--	25
Toulel		60	--	60
Wali		80	40	40
Bedenki		20	20	--
Synthiane		20	20	--
Fimbo-Toulel	1	20	20	--
	2	--	--	--
TOTAL		790	268	322
		100%	34%	66%

Table 3.1.9.b.

Water Requirements per Hectare of Crops Planted

Actual requirements on individual plots	J	F	M	A	M	J	J	A	S	O	N	D	Total
in m3; water loss 10% Off-season rice: water loss 10%	4400	2948	4807	5940	2486								20851
- Rainy season rice: water loss 10%							2805	-	902	3377	1408		8492
- Off-season maize and sorghum: water loss 10%	495									1104	2093	3668	6360
- Rainy season maize and water loss 15%						58	2262	115	173				2608
- Rainy season cowpeas: water loss 15%							35	-	426				461
- Off-season cowpeas: water loss 15%	1334									805	2093	208	6313
- Off-season vegetables (onions, cabbage, tomatoes): water loss 15%	2668	3852	5025	3128							1173	1484	17330
1 hectare planted with mixed crops: Gouraye	1499	1284	1675	1043		58	2262	115	173	636	1786	2078	12609

AREAS UNDER CULTIVATION, YIELDS, AND PRODUCTION LEVELS ON AN AVERAGE TRADITIONAL FARM: GOURAYE ZONE

	Crop	Area (ha)	Yield (t/ha)	Production (t)
Dieri:	Sorghum	1.60	0.40	0.64
	+ cowpeas :		0.15	0.24
	hay		0.30	0.48
	Millet: grain:	0.40	0.25	0.1
	hay		0.15	0.06
	Peanuts:	0.16	0.45	0.07
	hay		0.80	0.13
Walo:	Flood recession sorghum	1.36	0.45	0.61
Crops on irrigated and falo land:		0.1		

Source: FAO-BIRD 1981 (Gouraye Zone).

Table 3.1.11.a.

KAEDI

Total Gross Area in Hectares

for Perimeter Rehabilitation

and Construction

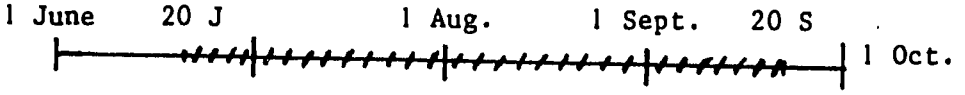
		Total	Rice	Mixed Crops
Youmane Yire	1	30	25	--
	2	25	--	25
Cive	1	40	40	--
	2	20	20	--
Tokomadji		40	30	10
Koundel Reo	1	40	20	20
	2	40	40	--
Aere Dindi		30	30	--
Tetienne		20	20	--
Diovol	1	60	30	30
	2	40	--	40
Palel Guiraye		20	20	--
Sinthiou		40	40	--
Nere Walo	1	160	100	--
	2	60	60	--
Dawalel		40	40	--
Dabbe		40	20	20
Vinding		20	10	10
Sori Male		80	80	--
	TOTAL	780	625	155
		100%	80%	20%

Table 3.1.11.b

KAEDI

Rice

RAINY SEASON



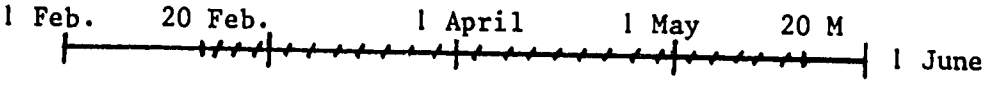
1. Potential Evaporation: 1/3 June + July + August + 2/3 Sept.		
a) Rice Field: 147 + 370 + 241 + 149	=	907 mm
b) Seed Bed: 2/3 June x .05	=	15 mm
	=	922 mm
2. ETP Rice: 922 x .80 x 1.0	=	738 mm
3. Effective Rainfall: 9 + 89 + 162 + 55	=	315 mm
4. Net Water Requirement: 738 + 150 + 180	=	1068 mm
5. Net Water Application: 1068-315	=	753 mm
6. Gross Water Application: 753/.70	=	1075.7 mm
	=	10,750 m^3
7. Pumping Time	=	10,750/300
	=	36 hrs
8. Fuel Consumption	=	4,5 1 x 36
	=	162 1
9. Pumping Cost	=	2,5 x 10,750
	=	26,875 CFA
10. Overall Efficiency	=	738/1068
	=	69%

Table 3.1.11.c.

KAEDI

Rice

DRY SEASON



1. Potential Evaporation: 1/2 Feb + March + April + 2/3 May	
a) Rice Field: 112 + 398 + 496 + 320	= 1326 mm
b) Seed Bed: 2/3 Feb. x .05	= 12 mm
	= 1338 mm
2. ETP Rice: 1338 x .80 x 1.0	= 1071 mm
3. Effective Rainfall	= 0 mm
4. Net Water Requirement: 1071 + 150 + 180	= 1401 mm
5. Net Water Application	
6. Gross Water Application: 1401/.70	= 2001.42 mm
	≃ 20,000 m^3
7. Pumping Time	= 20,000/300
	= 66,66
8. Fuel Consumption	= 4,5 1 x 66,66
	= 300 1
9. Pumping Cost	= 2,5 1 x 20,000
	= 50,000 CFA
10. Overall Efficiency	= 1071/1401
	= 76%

Table 3.1.11.d.

KAEDI

Water Requirements: Corn

RAINY SEASON — July — Oct.

1. Evaporation: July + Aug + Sept 370 + 241 + 223	=	834 mm
2. ETP: 834 x 0.8 x 0.7	=	467 mm
3. Effective Rainfall: (89 + 162 + 85) x 0.8	=	269 mm
4. Net Water Application: 467 - 269	=	198 mm
5. Gross Water Application: $\frac{198 \times 100}{60}$	=	330 mm 3300 m^3
6. Pumping Time: 3300/300	=	11 hrs
7. Fuel Consumption: 4.5 l x 11	=	50 l
8. Pumping Cost: 2.5 CFA x 3300	=	8250 CFA

DRY SEASON — 15 oct. — 15 Feb.

1. Evaporation: 1/2 Oct + Nov + Dec + Jan + 1/2 Feb. 132 + 267 + 258 + 290 + 167	=	1114 mm
2. ETP: 1114 x 0.80 x 0.70	=	624 mm
3. Effective Rainfall: 8 x 0.80	=	6 mm
4. Net Water Application: 624 - 6	=	618 mm
5. Gross Water Application: 618/0.60	=	1030 mm 10300 m^3
6. Pumping Time: 10300/300	=	34 hrs
7. Fuel Consumption: 4.5 l x 34	=	153 l
8. Pumping Cost: 2.5 CFA x 10,300	=	25,750 CFA

TABLE 3.1.12 a

ANALYSIS OF PERIMETERS PROPOSED FOR REHABILITATION:

KAYES ZONE: MALI

Perimeter	Improved hectarage			Hectares farmed C.O-S	Proposed extension ha	Quality of technical management	Agronomic improvements due (apart from hydraulic improvements)	Remarks
	Rice	Mixed crops	Total					
Maloum	–	26	26	7	–	average	Fence and windbreak	
Ijoumekan	–	12	12	?	–		Fence and windbreak	Not visited
Sapou	8	7	15	7	–	good	Fence	
Moussa Gouya	5	4	9	2	–	average	Fence and windbreak	funding problems
Targuine	9	6	15	3	–	average	Fence and windbreak	
Samankole	–	40	40	30	–	good	–	
Samankidi	5	15	20	7	–	–		Not visited
Moussala	8	12	20	3	–	poor	Fence and windbreak	
Makoura	25	–	25	?	–	–		Not visited
Dramone	10	40	50	5	–	good	Fence and windbreak	
Sobokou								
TOTAL	70	162	232	64/195				
STATISTICS	30%	70%	33%					

TABLE 3.1.12.b.

ANALYSIS OF IMPROVEMENT PROJECTS ON NEW SITES:

MALI

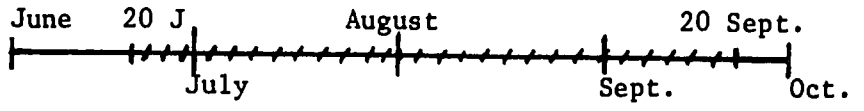
Sites	Phase	Hectarage to be improved			Distance from river Km	Present use	Agronimic potential	Double crop	Stage of studies	Conclusions
		Rice	Other	Total						
Coumbaye	1st	130	25	155	1.5	Rainy season rice 30 ha & pasture	Average to good	Yes	Pilot study	Pumping suitable for 1st part
	2nd	220	35	255						
Djoumakan	1st	–	40	40	0.2			no	"	Not visited
	2nd		43	43	0.3			no	"	" "
Kounta	1st	8.4	–	8.4	0.1	None	Good	Yes	"	Suitable for execution of 1st phase. Farakotodou basin to wait
	2nd	15.3	–	15.3	0.1	None	Good	Yes		
Kiakandape	1st	7	–	7	1.0	None	Good	no	No plan	To be studied
	2nd	4	–	4	1.5	Rice	Very good	no	No plan	To be studied
Malinkane		40	–	40	0.5	Pasture	Average to poor	no	No plan	To be studied
Dramane Sobokou		150	–	150		Rice, millet pasture	Variable to poor	no	No plan	To be defined and studied
Dakoura	2nd	115	–	115	0.3	Rice	Quite good	no	No plan	To be defined
Sobokou	2nd	100	–	100	1.5	None	Variable	no	No plan	To be defined and studied
TOTAL		789.7	143	932.7						
Statistics		85%	15%	100%						

Table 3.1.12.c.

KAYES

Rice

RAINY SEASON



1. Potential Evaporation: 1/3 June + July + August + 2/3 Sept.
   a) Rice Field: 154 + 338 + 253 + 156 = 901.00 mm
   b) Seed Bed: 2/3 June x 0.5 = 15.40 mm
   = 916.40 mm

2. ETP Rice: 916.4 x .80 x 1.0 = 733.12 mm

3. Effective Rainfall: 32 + 170 + 241 + 109 = 382.00 mm

4. Net Water Requirement: 733.12 + 150 + 180 = 1095.24 mm

5. Net Water Application: 1095.24 - 351.12 = 713.24 mm

6. Gross Water Application: $\frac{713.24}{.70}$ = 1018.91 mm
   = 10,200 m^3

7. Pumping Time = 10,200/300
   = 34 hrs

8. Fuel Consumption = 150 l

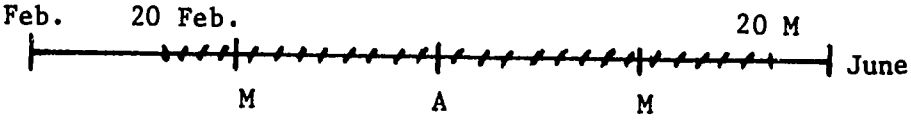
9. Pumping Cost = 2,5 x 10,200
   = 25,500 CFA

Table 3.1.12.d.

KAYES

Rice

DRY SEASON



1. Potential Evaporation: 1/3 Feb + March + April + 2/3 May
   a) Rice Field: 117 + 459 + 572 + 369 = 1517.00 mm
   b) Seed Bed: 2/3 Feb x .05 = 21.12 mm
   = 1538.12 mm

2. ETP rice: 1538.12 x .80 x 1.0 = 1230,50 mm

3. Effective Rainfall = 0

4. Net Water Requirement: 1230 + 150 + 180 = 1560.00 mm

5. Net Water Application

6. Gross Water Application: $\frac{1560}{.70}$ = 2228.57 mm
   = 22,280m^3

7. Pumping time = 22,280/300
   = 74,29 hrs

8. Fuel Consumption = 4,5 l x 74.29
   = 334 l

9. Pumping Cost = 2,5 x 22,280
   = 55,700 CFA

Table 3.1.12.e.

KAYES

Water Requirement: Corn

RAINY SEASON — August — Nov.

1. Evaporation: August + Sept + Oct. 253 + 234 + 277	=	764 mm
2. ETP: 764 x 0.8 x 0.7	=	428 mm
3. Effective Rainfall: (241 + 164 + 42) x 0.8	=	358 mm
4. Net Water Application: 428 - 358	=	70 mm
5. Gross Water Application: $\frac{70 \times 100}{60}$	=	117 mm 1170 m^3
6. Pumping Time: 1170/300	=	4 hrs
7. Fuel Consumption: 4,5 l x 4	=	18 l
8. Pumping Cost: 2.5 CFA x 1170	=	2925 CFA

DRY SEASON — 15 Nov — 15 March

1. Evaporation: 1/2 Nov. + Dec + Jan + Feb + 1/2 March 140 + 271 + 304 + 352 + 230	=	1297 mm
2. ETP: 1297 x 0.80 x 0.70	=	726 mm
3. Net Water Application = ETP	=	726 mm
4. Gross Water Application: $\frac{726 \times 100}{.60}$	=	1210 mm 12100 m^3
5. Pumping Time: 12100/300	=	40 hrs
6. Fuel Consumption: 4.5 l x 40	=	180 l
7. Pumping Cost: 2.5 CFA x 12100	=	30,250 CFA

TABLE 3.1.13.

CEREALS YIELD - TONS/Ha

BAKEL IRRIGATED PERIMETERS PROJECT (685-0208)

CROPS	75 - 76	76 - 77	77 - 78	79 - 80	80 - 81
Rice	2	2.2	4.0	4.2	6.178
Corn					2.385
Millet					
Sorghum					2.38

TABLE 3.1.14

TABLE A: COMPARISON OF HIVERNAGE CULTIVATED AREA FOR THE ENTIRE PROJECT ZONE BY CROPPING PATTERN

(1979 - 82)

BAKEL IRRIGATED PERIMETERS PROJECT (685-0208)

	1979 - 80			1980 - 81			1981 - 82			% increase or decrease in hectarage	
Cropping Patterns	Cleared Land (Ha)	Cultivated Land (Ha)	Number of Villages	Cleared Land	Cultivated Land (Ha)	Number of Villages	Cleared Land	Cultivated Land (Ha)	Number of Villages	1979 - 80 to 1980 - 81	1980 - 81 to 1981 - 82
No crops	450	17	2	578	88 Ha not cultivated	7	611	97 Ha not cultivated	7	417% increase in non-cultivated	10% increase in non cultivated
Rice	450	224.35	20	578	245	11	611	285.15	13	9% increase	16% increase
Corn	450	39.6	8	578	106.25	13	611	107.15	12	186% increase	0.8% increase
Sorghum	450	0	0	578	8	2	611	21.5	4	-	169% increase
Rice & Corn	450	74.85 (40.85 Rice) (34 corn)	6	578	133.7 (93 Rice) (40.7 Com)	5	611	176.8 107.15 Rice (69.65 Corn)	6	Rice: 127% In. Corn: 20% In. Overall:79% In.	Rice: 15% In. Corn: 71% In. Ov.: 32% In.
Rice, corn, sorghum	450	0	0	578	33	1	611	30	1	-	9% Decrease
Total	450	264	25 (Niayé not included	578	359.25	26	611	443.8	26	28% In. in cleared land	8% In. in cleared land
	28% mixed cropped			46% mixed cropped			47% mixed cropped			48% In. in cultivated land	24% Increase in cultivated land

Appendix B

Bakel Farming Systems

Farmers in Bakel Area utilize irrigated rainfed and flood recession agricultural systems. As regards to any of these types of enterprises, the farm operator is more and more viewed as a rational economic agent whose decisions are based not only on subjective variables such as food self-sufficiency and security, preferences and tastes, but also on exogenous economic variables such as market prices, returns to production factors including labor.

Rice production was thus a new technique that was introduced to the villagers by extension agents of the GOS Regional Development Agency, SAED, financed in part by USAID. The success of this technology transfer can be gleaned from Table 3.1.13 which shows yield data from project initiation through the harvest in 1981. The attainment of yields in 1981 well above the world average demonstrates the determination and adaptability of the Bakel area farmers in accepting new farming techniques.* In addition to learning the variables associated with the crop itself the farmers also had to master the skills for operating diesel pumps. Farmers in the area are now approaching the point when further inputs from SAED for pump maintenance will not be necessary. Workshops in Diesel pump maintenance and operation have been and will continue to be held at regular intervals thus creating an increasingly able collection of farmers capable of managing their own production schedules.

Increased production in Bakel is now faced with the major constraint of labor availability. To date the field work has been done entirely by hand with both sexes participating. An animal traction program has been initiated under the Bakel project as a first step towards eventual appropriate mechanization.

Because of the migration of the youth to other towns in the country and to overseas coupled with drought conditions in the area, the farming systems have shown dramatic changes. First, the project area farmers incur substantial expenses in seeds, fertilizers, farm tools, and irrigation fuel. GOS subsidies for these inputs have dramatically decreased in past years, implying same amount of increase in production costs. Secondly, since all farm level operations are done manually, this implies some opportunity cost of employing limited labor inputs to one type of farming rather than the other. Third, on rainfed farms, farmers have little or no investment since few modern inputs such as improved seeds and fertilizers, the main determinant of agricultural production from rainfed farms being annual rainfall levels, and more importantly the distribution of rain over time. Irrigation patterns are included in Table 3.1.14. This table does not include irrigation lands made available to farmers on the new perimeter of Collenga.

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* See Table 3.1.13 for yield data in Bakel.

Table 3.1.14 best gives an insight into the rainy season cropping patterns in the project area, at the project overall level. It should be noted that both sole crop and mixed crop lands have increased and that, whenever feasible, farmers use mixed crop enterprises as a risk avoiding and/or cash earning activity. In that case, a rice field and a corn or sorghum field are cultivated where corn crop is partly sold in green form or sorghum crop is used to supplement farm family consumption requirements. Average data included in the table are from various crop reports of the extension services office in Bakel (i.e., SAED/Bakel).

Another risk avoiding practice in Bakel is the modular system employed in perimeter expansion. Each motor pump can effectively irrigate 20-30 hectares. When optimum hectarage has been irrigated with one pump a second pump is purchased by the villagers and installed. The risks of mechanical failure (which can be considerable in the remote area of Bakel) are thus spread over two or more pumps as the perimeter increases. This approach was decided upon rather than the purchase of a larger capacity single pumping system after examination of the larger perimeters down river. In some instances entire perimeters (up to 1500 hectares) were lost because of mechanical failure. Additionally increases can be made in hectarage by the farmers through lining of principal canals and improvements in water management. These options are being explored as part of the continuing operations envisioned under the IDP project.