ISN 76653

*** Draft Report ***

DETERMINANTS OF SUCCESS OF IRRIGATED PERIMETERS IN THE BAKEL DELEGATION

PART I: WATER AND CROPS

Prepared by:

Dr. Robert M. Reeser
Agricultural Economist
Agricultural Cooperatives Development International
Washington, D.C.

for

HARZA ENGINEERING COMPANY
150 South Wacker Drive
Chicago, Illinois
60606-4288 U. S. A.

Bakel, Senegal

March, 1990

EXECUTIVE SUMMARY

DETERMINANTS OF SUCCESS OF IRRIGATED PERIMETERS IN THE BAKEL DELEGATION PART I: WATER AND CROPS

In December 1989, short-term consultants Dr. Robert M. Reeser and Dr. Frederick E. Brusberg developed a computer-based analytical system for use in analyzing various aspects of irrigated perimeters, beginning with water costs and crops produced and continuing through financial and economic analysis of investment feasibility. Dr. Reeser returned in February to apply the analytical system to the problem of profitability and success of a number of perimeters. This document is a report of the analysis, using that analytical system. of water costs and various crops under typical and improved production methods.

The early part of the report reviews the layout of the model and how the various modules comprising it are interrelated. Changes are discussed that have been made in the model since it was originally introduced and described in an earlier report.

The data used in the analyses came from five sources: research reports, reports of other consultants, the TA team and various data sources known best to them, the socio-economic or baseline survey being conducted by the SAED/Harza project, and field work and observations of Reeser and Brusberg during this consultancy. Problems were encountered in reconciling disagreements in information from different sources and in filling voids in data; the consultant's judgement figured rather heavily in the data used.

The Water Cost module provides data about pumping costs, both for the rainy season, when the river level is high and the operating head of the pump is minimized, and for the dry season when low level of the river increases the operating head of the pumping set. Fuel costs are greater in the dry season.

Amortization or fixed costs per hour depend heavily on the life of the equipment; if the GMP can be made to last longer than usual, costs per hour of use are greatly reduced. Service life has little impact on hourly operating costs.

The water cost module also considers water conveyance efficiency, which if low raises the cost of water delivered to the field. Costs are computed for five levels of efficiency and seven different lengths of GMP service life; the results are presented in tables and graphs, and implications for project intervention are discussed.

Crops modules are used to analyze rice production in four villages using socio-economic survey data. Modules for eleven crops and production situations are analyzed and presented. For the rainy season, the crops include rice is it is typically grown in the villages, and also improved production of rice, maize, millet and sorghum. Improved rice is twice as profitable as traditional rice, but the most profitable rainy season crop is sorghum, followed by maize; these crops are 18% and 13% more profitable than rice.

For the dry season, the same crops and also onions are analyzed. Of the cereal crops, maize is most profitable, followed by rice and sorghum. Onions are far more profitable than any cereals crop. With all of the crops observed, farmers are using a lower level of inputs and obtaining much lower yields than the improved methods studied.

To make full use of resources, year-round cropping is desirable. Bananas achieve full resource use, and despite very high labor costs and fertilizer needs show excellent profitability. However, (nearly) full resource use through double cropping is also promising. The combination of sorghum in the rainy season and onions in the dry season showed a profit of over 4 million F CFA per hectare. Bananas produced about half that level of profit. The best combination of cereal crops was sorghum and maize, which was about 30% better than rice and rice.

These analyses show that irrigated agriculture in the Bakel area can be profitable. Using current production packages and the resulting modest level of yields, profit is possible only with cheap or free labor. Higher yield levels and more profitable production is possible. An extension and farmer support program, to raise the farmers' use of inputs and level of production, is thus shown to be an essential, and probably the most important, element in the success of irrigated agriculture in the Bakel area. This applies equally to the individual farmers and to the aggregation of plots and families that make up a perimeter.

Another important element of support for local agriculture is assistance in reducing the cost of water. Programs to extend the service life of pumping sets through better care and maintenance, and to reduce the wastage of water resulting from low water conveyance efficiency, have the potential to reduce water costs by half or more. Extension programs are appropriate in both cases.

Further research in determinants of success of irrigated agriculture in the Bakel Delegation is planned. Such research should determine whether groupements can support the entire cost of irrigation development, and whether such development might be attractive to private investors. Advance indications are that affirmative answers to both questions may be possible.

Training of Senegalese nationals in the use of the analytical system is possible, and should be undertaken on the consultant's next visit.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Preface and Acknowledgements

I consider it a real challenge to be asked to apply to problems at Bakel the analytical system that Dr. Frederick E. Brusberg and I developed there last December. I regret only that time has been too short for me to apply all of the modules in this first attempt. I look forward with anticipation to further opportunity to pursue this challenge.

I acknowledge with thanks the support and assistance of my colleagues of the Harza TA team, under the direction of Chief of Party Dr. Ronald Gaddis. Especially appreciated was my fellow-consultant Dr. Brusberg, who counselled and supported me throughout; whose advice and assistance were particularly helpful in respect of certain data, estimation and computer difficulties; and who made the computer-generated graphs.

Robert M. Reeser
Agricultural Economist

CHAPTER 1

INTRODUCTION

Irrigated agriculture in the region of Bakel is reported to have had its first, tentative start in the middle 1970s, when a local farmer elicited assistance from a foreign source of funds. USAID has been a participant in the development of irrigation in the same area since 1977, when a multi-million dollar project was undertaken. The present contractor, Harza Engineering Company, has been involved in a successor project since 1988.

The primary function of the contractor's technical assistance team in this host-country contract has been the support of SAED and of SAED personnel. In a number of cases, the scope of the resident team has been supplemented by short-term consultants. One such case, in November-December 1989, resulted in the joint elaboration by Drs. Reeser and Brusberg, during the course of other duties, of a computer-based analytical model that could be used to analyze water costs, crop budgets, family farming operations, perimeter and groupement involvement in agriculture, and the feasibility of investment in irrigation facilities[1].

The circumstances of that case did not permit the actual analysis to be carried out, partly because the needed data were not yet available. Therefore the two consultants who had developed the model were brought back simultaneously: Reeser to refine the model, to gather the needed data, and to perform analyses of water management practices, crop production packages, and selected real and hypothetical perimeters; and Brusberg to pursue the Project's analysis of the Socio-Economic Baseline Data and the follow-up monitoring program. Brusberg, with an obvious interest in the model and its use, utilized the crops modules for analyses of perimeter data, and he supplied from survey data certain information including that on labor use in the villages that facilitated and made more relevant the analyses of crop packages done by Reeser.

This analytical system has the capability for work with water costs, crop budgets, subsistence analysis of families' cereals production, and financial and economic analysis of investment in irrigation facilities. Work to date has been focussed on the water cost and crops modules, which are discussed in some detail in this report. The findings are also discussed with reference to their implications for programs of intervention in the Bakel region.

---

[1] This model is presented and described in the report by Reeser and Brusberg entitled An Analytical Model for Irrigated Agriculture, prepared in December 1989.

There is far more potential in this analytical system than could be exploited in the limited time available in this consultancy. However, an important start has been made, and further work can build on the basis herein established. The conclusions are sound and the methodology can withstand close scrutiny. Such close inspection is invited.

This model should be considered as an analytical system, rather than an artifact. It is meant to be dynamic, and further refining and polishing should be done if it serves the purpose of the user. It is hoped that this analytical tool, or some outgrowth or adaptation of it, will be useful not only over time at Bakel but also in a variety of other situations. The utility of the analytical system will be revealed through its application.

CHAPTER 2

THE MODEL

Overview

The computer model referred to and used in the analyses in this report is basically the model developed by short-term consultants to the Harza team and Bakel in November-December 1989[2]. The model has undergone evolution in use since that time, and modifications have been made that increase its flexibility and power, and facilitate certain aspects of its use. Some of these changes are discussed in this chapter.

The model was developed for analyses of engineering, agronomic, economic and sociological information gathered by or available to the SAED-Harza team in residence at Bakel in eastern Senegal, and to show the impact of various factors on the productivity and the financial success of families and perimeters in the Bakel Delegation. Other analytical and geographic applications of the model are possible, but are not addressed in any detail in this report.

The model is an application of the software program LOTUS 123. It is intended for use on the IBM-compatible computers currently available to the project staff.

Despite the obvious requirement of an appropriate computer for the use of the model, it is sincerely hoped that neither the term "model" nor the computer requirement will frighten away prospective users or bias the attitudes of administrators to it. The model does nothing that cannot be done with a hand calculator, a pencil and sufficient paper, although the computer does it much faster. The approach and the principles of analysis are, for the most part, those of farm management and common sense. The purpose is to obtain insights and to show relationships that provide a sound basis for decisions regarding management, policy and investment.

Modules

The analytical system utilizes a number of modules or spreadsheets within the all-encompassing Lotus 123 worksheet. These include water, crops, family, perimeter, amortization, and economic/financial analysis. Which of these is "first" depends on the use one wants to make of the model, as most of them can be

[2] For a more complete description and instructions for use of the model, please see the report prepared at the time the model was elaborated: Reeser, Robert M. and Brusberg, Frederick E. An Analytical Model for Irrigated Agriculture. Bakel, Senegal: Harza Engineering Company, December 1989.

used independently of the others. The order used in the following description is one of convenience and does not imply any ranking as to importance.

Most of the modules are adapted to independent use. The analysis need not be carried through to the end in order to be useful; the water module can stand alone, as can the crops modules insofar as they are used for rainfed cultures. Only the support of the water module (or an independent determination of the cost of water) is needed for the crops modules to be useful for comparison of various irrigated crops, or for study of different production technologies.

The **WATER** module incorporates factors that influence the cost of water. These include the amount of lift or operating head from the river to the discharge basin, the output of the pump, the rate of fuel use of the motor, and the efficiency of conveyance of water from the pump the field. The current revision of the model incorporates differences in river level in rainy and dry seasons to show different levels of cost of water at those times.

CROPS modules have been developed for most of the combinations of crops and seasons that were encountered in irrigated perimeters during the consultants' visits, and for some other combinations that were thought to be potentially useful. Use of these crops modules with input data for local situations permits analysis of the profitability of individual crops on a per hectare basis, while use of research data or figures from other locations shows the potential for other crops and techniques.

The **FAMILY** module incorporates demographic or sociological data into the analysis, and permits calculation of the proportion of the family's subsistence needs for cereals that are produced. This leads to calculation of the extent to which the family can "go commercial" in terms of selling cereal which exceeds the family's needs.

The **FARM** module aggregates crop production activities at the level of the decision-making unit, the family.

The **PERIMETER** module aggregates the families and farms of which it is composed, crop by crop and season by season through the year. Its purpose is to show the total revenue of, or resulting from the operation of, the perimeter, and the total of related expenses incurred by the groupement or by the families operating within it.

The **AMORTIZATION** module provides the acquisition prices and expected useful lives of the investments necessary to the original development of the perimeter, along with any additions or improvements thereto. Annual amortization is calculated.

The **FINANCIAL ANALYSIS** module performs an analysis of the profitability of the perimeter as an investment. Local and market prices are used for both inputs and salable products, showing the cash flow of the groupement over time. The collective burden borne by the groupement in the "overhead" costs of the perimeter, specifically the amortization of the developmental costs, is added at this stage of the analysis.

An **ECONOMIC ANALYSIS** module is also included, to permit the analysis of the desirability of investment in the perimeter, as viewed by the national government or by international donors. This analysis parallels the financial analysis, but uses economic rather than financial prices; the difference is explained elsewhere in the report.

A considerable element of interaction has been achieved in this model. Outputs generated at one level flow automatically to other levels where they are used as inputs. This accumulation of information avoids the need to re-enter information, and results in performance of increasingly complex analyses in the later stages with few items of additional information.

Changes in the Model

As stated earlier, the model is dynamic, and should be changed as needed to meet evolving perceptions of needs. Several changes have been incorporated since the original model was elaborated and reported in December 1989.

Perhaps the most obvious change is that the model is now larger, includes more modules, and takes up more space in the computer's memory. That is not a problem for LOTUS 123, but it does require more time for recalculations to be made after every entry; some computers are slow enough that the wait may be a nuisance. One option and partial solution is to shift to the manual recalculation mode (using the commands /WGRM) so that recalculation is done only when the F9 key is pressed. At other times, the wait is all but eliminated.

In an effort to streamline the model, the overall layout of the modules was changed. Previously, the crops modules were laid out side by side, so that access to the next crop was obtained by moving one screen to the right (Control, Right arrow). Rearrangement has placed most of the crops modules end-to-end at the bottom of the spreadsheet. Access to them is awkward by the scrolling technique, but the "Go To" function solves the difficulty. Simply press the Go To key (F5) and type in the code name of the desired module. The following table lists all the modules in the current version of the worksheet, the shortened or abbreviated names given to them, and the locations of the modules. It is not necessary to type in the location of the module.

Amortization	AMORT	A420..I45
Bananas	BANAN	A181..F24
Fconomic Analysis	ECON	A521..T55
Family Module	FAM	A300..G35
Farm module	FARM	A241..M29
Financial Analysis	FINGR	A461..U50
Maize, DC Season	MAISDC	A981..F10
Maize, Rainy, Potential	MAISRP	A921..F98
Millet, DC season	MILDC	A681..F74
Millet, Rainy, Potential	MILRP	A861..F92
Onions, DC Season	ONIONDC	A741..F80
Perimeter Module	PERI	A361..L40
Rice, DC Season	RICEDC	A121..F18
Rice, Rainy, Potential	RICERP	G61..N119
Rice, Rainy, Typical	RICERT	A61..F119
Sorghum, DC Season	SORGDC	A621..F68
Sorghum, Rainy, Potential	SORGRP	A561..F68
Table of ranges for GoTo use	TABLE	AB1..AC21
Vegetables, DC Season	VEGDC	A801..F85
Water Cost Module	WATER	A1..F54

Many of the modules are identified in the upper corners as to the file or version of the worksheet of which that module is a part, the code name of the module itself, and the date of preparation or printing. Such identification has been useful because many worksheets and a variety of modules have been developed and bypassed. Finding one again, or determining which version was used for a given printout, is vastly simplified by identification of this nature.

Basically, these and other changes should cause no problem to new users, and old users are likely to adapt instantly -- if, in fact they have not already introduced their own innovations.

CHAPTER 3

DATA: SOURCES AND STATUS

The report that accompanied the introduction of this analytical system in December, 1989 did not present an analysis of the situation of irrigated agriculture, despite the fact that the model was developed for that very purpose. The reason for that lacuna was that data were not yet available, and time was too short for the consultants to obtain the needed data. The timing of the current consultancy was intended to remedy both of those shortfalls, and time was allocated in this consultancy for a modest amount of field work.

Sources of Data

Five sources of data were available:

a) Research information, from work already done in Senegal or elsewhere, and available through scholarly publications, reference texts, etc.;

b) The findings of earlier consultancies and other projects, especially in but not restricted to Senegal, available through published or photocopied reports of the concerned consultants;

c) Contributions from the technical assistance team of the Harza project, both from their personal knowledge and experience and from their access to sources a) and b) above;

d) The socio-economic survey of agriculture in Bakel delegation; and

e) Field data to be gathered during visits to perimeters in the Bakel Delegation.

All of these sources have been used; their importance varies from topic to topic.

The consultants visited and gathered data on several perimeters, selected to represent the range to be encountered in respect to organization, management level, size, and degree of success. Reports of those visits were prepared; they are being submitted as a separate information file, that is likely to be of use as a source of data for further analyses.

The various modules draw on information from many sources. Inasmuch as this is a working system, made to be modified as needed and to be used with all kinds of data, rather than an artifact to be preserved, an effort has been made to record and show the source of the information by the use of codes inserted in the modules. This should help in evaluating the validity of the figures used. H, S, K, SE and C are codes that refer to, respectively, the Harza TA team, SAED, the 1983 report of Moribadjan Keïta, the socio-economic survey, and the consultant. The items labelled "C" are in most cases judgement calls, where other sources are lacking or in disagreement. Where two sources are shown (as H,C) the consultant's estimate was based on guidelines or related information from the other source.

An Illustration of Data Problems

To illustrate the problem of disagreements in alternative souces of information, the available figures on labor requirements for rice production may be examined. In this case, all of the earlier-mentioned sources contributed, yet the variation in the figures, as well as their lack of comparability, meant that in the end the consultant's judgement was used to determine figures for use in budgets.

Table 1 presents a summary of labor data for production of rice. Sources are explained in the table. The Keita report shows labor use in three zones that, in the year the research was done, had quite different weather situations. Keita's records do not separate out irrigation labor. The Socio-Economic Survey of the SAED/Harza project combines observations from several locations, and includes a task that no other source mentioned: canal and field maintenance. Recent records of labor use at the project's demonstration farm provide data of a high order of accuracy, but the methods used on this farm do not correspond exactly to traditional methods. The BSIP project that preceded the Harza/SAED project operated the same farm, and the End-of-Project report shows their labor use -- which is grossly different. Data from a farmer who keeps unusually complete records, obtained by the consultants in their visits, complete the listings. As can be seen in Table 1, these figures span a wide range.

Averages of the four data series that relate to traditional farming (AVG TRAD in the table) seem reasonable, but still reflect the weather encountered and the peculiarities of the farms and fields sampled. Therefore, another column (REP VLG) shows the consultant's estimate of the representative situation in the typical village.

Similarly, the four cases that relate to improved or advanced agricultural methods are averaged (AVG ADV). These cases are based on traditional technology, but they also use some innovations. An estimate is provided of the labor use pattern that can be achieved in the village perimeters, using technology that is known in the area and that at least some farmers have shown willingness to adopt.

Table 1

LABOR REQUIRED FOR PRODUCTION OF CROPS: RICE
In Man-Hours per Hectare *

TASK	KEITA U G	'83 L G	STUDY Fal	S-EC SURV	AVG TRAD	REP VLG	PROJECT A	B	FARM C	TAN-DIA	AVG IMPR	IMP METH
Seedbed Prep & appl of fert	205	89	398	359	263	220	208	208	5	32	113	200
Dir Planting and Transplanting	931	465	607	557	640	450	120	Not	Done	136	85	150
Full Trnsplt (incl nursery)	N	o	t	D	o	n	e	728	112	ND	280	ND
Irrigation:				322			330	330	?	475	284	400
:	1262	904	1054		1004	900						
Weeding : and Tillage				740			200	200	37	20	114	200
Harvest :							60	60	32	65	54	
:	820	681	679	1615	949	800						200
Thresh :							200	200	24	130	139	
Field & Canal Maint				165		100						
TOTAL	3218	2139	2738	3662	2855	2470	1118	1726	210	858	1069	1150

* Notes:

A: Labor in the Bakel region may be either 6.5 or 8-hour days. Standard wages paid: 1000 F CFA for 6.5 hrs, or 1500 for 8 hrs. This table uses hours as a common denominator.

B: Task categories are imprecise; comparability of data from different sources is only approximate.

Sources:

KEITA = Moribadjan Keita: "The Bakel Small Scale Perimeters: An economic analysis of Agricultural Production." USAID, June 1983 Reported are zones of Upper Goye, Lower Goye and Faleme.

PROJECT FARM is located at Colangel. A and B are current records for direct-seeded and transplanted rice. C is for 1986-87, from the BSIP End of Project report.

S-EC SURV = Socio-Economic Survey. Total labor is the average of all rice producers. Distribution is based on analysis of ten fields.

TANDIA is a 6 ha family-run perimeter with better-than-average records.

AVG TRAD is the average of the 4 cases of traditional operations shown.

REP VLG is the consultant's judgement selection of a figure that fairly represents the typical village situation.

AVE IMPR is the average of the 4 cases of improved operations shown, based on but not restricted to traditional methods.

IMP METH is the consultant's judgment of labor use that can be achieved with improved methods: better water control, some mechanization and use of weedicides.

CHAPTER 4

WATER COSTS

Upon retrieval of the worksheet for the analysis of irrigation perimeters in the program LOTUS 123, the first module encountered is entitled Water Costs. This module facilitates calculation and analysis of the costs of supplying water for irrigation. A sample printout of this module is shown as Figure 1.

Pump Output

Entry of motor and pump specifications may be done to facilitate record-keeping, but it is not essential to the analysis. Pump output of the relevant GMP for rainy season (high water) conditions and dry season (low water) conditions should be entered if available. If direct measurements are not available, pump curves for the exact make and model can be used to determine what the output should be. With less assurance of accuracy, a figure may be chosen or extrapolated from Table 2, Performance of Pumping Sets.

Investment Costs

The cost of the pumping set, including both motor and pump, should be entered, as well as costs of pipe and fittings to convey the water to the stilling basin, and completed costs of the canal system. Investment costs are not critical to the analysis at this stage, as only the variable (operating) costs of water figure in the analysis of current operations of an already-established perimeter. However, they will be needed eventually, for calculation if amortization costs. (The reader is referred to further discussion of variable and fixed costs in a later section of this chapter.)

The investment costs shown in the Water module in Figure 1 are estimated for a typical situation based on costs of a very few specific cases in SAED and project records. Table 3 presents two sources: a SAED teaching manual and a summary of a SAED/USAID billing that is shown in full as Figure 2. As better or more recent figures become available, from price lists, purchase records, suppliers' quotations, etc., they should replace the estimates shown.

The amortization of the motor and pump under Bakel conditions cannot reliably be based on years of life, because the life in years depends so heavily on the amount and conditions of use and/or also of disuse. Under local conditions, which typically include less-than-ideal servicing and maintenance, the life of pumping sets is short. Rather than the 15000 to 20000 hours of

Figure 1

WATER COST MODULE FOR PERIMETER: NORMAL CONDITIONS 28-Mar-90
FILE: NORMAL / (Water)

ITEM			Rainy Season	Dry Season
Motor: make, model, size	1 Lister HR-2			
Pump: make, model, size	G-R			
Rated pump output, M3 / hr B	319			
Operating head in Rainy/Dry season M B			7	16
Pump output in Rainy/Dry season, M3/hr B			319	230
Pump efficiency (default .75) H	0.75		0.75	0.75
Brake HP Hrs per liter of fuel	4.45	default	4.45	4.45
GMP Investment cost, F CFA H	8,459,840			
Pipe Investment cost S	2,000,000			
Civil Engr works for water S	2,355,000			
TOTAL investment cost, F CFA	10,459,840			
Years of useful life	?			
Hrs of service (pipes 2X this)S,C	6,000			
Amortization of GMP per hr	1,410			
Amortizarion of repair costs / hr	649			
Amort. of pipes and canals / hr	363			
Total Amortization / hr of pumping	2,421			
FIXED COSTS or Amortization / M3 of water pumped, Rainy/dry season			7.59	10.53
Fuel used per hour, liters H			2.47	4.08
Fuel cost per liter, 1990 price	210			
GMP fuel cost per hour			519.32	855.85
GMP oil + lube, % of fuel cost S,H		17	88.29	145.49
GMP routine maintenance, % of fuel cost H		6	31.16	51.35
Pompiste salary expressed as % of fuel cost		6	31.16	51.35
VARIABLE (Operating) COSTS PER HR OF PUMPING		29	669.93	1104.05
VARIABLE COSTS / M3 WATER PUMPED, Rainy/Dry season			2.10	4.80
TOTAL (Fixed + Var.) COST OF WATER PER M3 PUMPED Rainy/dry season			9.69	15.33
Assumed water conveyance efficiency, percent H			75	75
Water delivered to field, M3/hour, Rainy/dry season			239	173
VAR. COSTS PER M3 DEL'D TO FIELD, Rainy/Dry season			2.80	6.40
FIXED COSTS PER M3 DEL'D TO FIELD, Rainy/Dry season			10.12	14.04
TOTAL (Fixed + Var.) COST OF WATER PER M3 DELIVERED: Rainy/dry season			12.92	20.44
Water pumped, M3 / l of fuel			129	56
Water del. to field, M3 per l of fuel			97	42

PERFPUMP.WK1 02-Apr-90

Table 2

PERFORMANCE OF PUMPING SETS

Pumping Set	Discharge, M3/hr Low water	High water
Ave. of 4 pumps with HR-2 engines	230	319
Ave. of 3 pumps with HR-3 engines	287	388

Source: Calculated from BSIP End of Project Report, Vol. II, page 441

Note: Pumps are incompletely identified.
Speeds varied from 1450 to 1700 RPM.
"High water" and "Low water" were not quantified.
Efficiencies were incompletely reported and variable, but were generally higher at low water.

IRRICOST.WK1
02-Apr-90

Table 3

COST OF DEVELOPMENT OF IRRIGATED PERIMETERS
(000 F CFA)

ITEM	PIV TYPE 1 Total	per ha	%	PIV TYPE 2 Total	per ha	%	SAED/USAID BILLING Total	per ha	%
SAED INPUTS:	1715	89	17	4515	234	34			
Preliminary work	--Included--			--Included--			2785	31	5
Reconnaissance,	"			"					
Topo studies,	"			"					
and Design	"			"					
Land preparation	"			"			2184	24	4
Clearing,	"			"					
Prelim leveling	"			"					
Earthworks	"			"			42171	463	83
Canals, drains,	"			"					
and dikes	"			"					
Civil engr. works	"			"			2355	26	5
Stilling basin,	"			"					
turnouts, etc.	"			"					
Supervision	"			"			1485	16	3
OTHER INPUTS:									
Tech. Assistance	600	31	6	600	36	5	--Not Included--		
Farmer investments	3428	178	33	3508	213	31	--Not Included--		
Pumping set	4500	233	44	4500	273	40	--Not Included--		
TOTAL	10243	531	100	13123	680	100	50980	560	100

Note 1: Types 1 and 2 are easy and difficult interventions of, respectively, 19.3 and 16.5 hectares, presented in "Les Amenagements Hudro-Agricoles et la Gestion de l'Eau a la SAED" (undated), prepared for teaching use at SAED's Centre National d'lApplication et de Perfectionnement aux Techniques d'Irrigation

Note 2: These were SAED's estimated costs, identical with their subsequent billing to and payment by USAID, for development of three irrigated perimeters totalling 91 hectares in 1989-90. Source: USAID, PIL 0282-14 for IWM-I (685-0280)

Figure 2

DEVIS ESTIMATIF ET QUANTITATIF DES AMENAGEMENTS DE LA REGIE POUR 87/88 (BAKEL)

DESIGNATION	UNITE	PREVISIONS	REALISATIONS		
		(QUANTITES)	QUANTI.	PRIX UNIT. CFA	PRIX TOTAL CFA
TRAVAUX PRELIMINAIRES					
-Travaux de reconnaissance	jour	1	1	30.000	30.000
-Etude Topographique et Plan d'aménagement.	HA	95	95	29.000	2.755.000
Préparation du Terrain					
-Implantation	HA	95	91	4.000	364.000
-Déboisement/Dessouchage	HA	95	91	20.000	1.820.000
-Terrassement					
-Préplanage	HA	20	20	100.000	2.000.000
-Canal d'amenée (5 GMP) (Moudéri)	ML	1140	1140	4.200	4.788.000
-Canal Principal (2 GMP) (Moudéri)	ML	870	870	2.900	2.523.000
-Canal Principal (1 GMP)	ML	2630	2530	2.400	6.072.000
-Canal secondaire (1/2GMP=	ML	8635	8515	1.400	11.921.000
-Drain	ML	3055	3055	1.400	4.277.000
-Piste	ML	2020	2020	.800	1.616.000
-Diguette	HA	95	91	70.000	6.370.000
-Digue	ML	1205	1085	2.400	2.604.000
GENIE CIVIL					
-Bassin dissipation	U	1	1	350.000	350.000
-Partiteur principal	U	2	2	165.000	330.000
-Partiteur secondaire	U	22	22	55.000	1.210.000
-Chute principale	U	1	0	120.000	0
-Chute secondaire	U	5	0	40.000	0
-Passage busé	U	5	3	155.000	465.000
CONTROLE					
-Supervision SAED (3%)					1.484.850
TOTAL					50.979.850

service expected and obtained in United States, only 6000 hours (5 years at 1200 hours per year) is projected by SAED[3].

For pipes and civil engineering works, useful life depends more on proper maintenance and avoidance of damage than on hours of use. For this reason, the life of these items is estimated at twice the life in hours of the GMP. The module computes the amortization per hour automatically, based on the "Hours of Service" entry. Alternative figures can and should be entered, if a better expression of expected life is available. The amortization figure is also expressed on a "per cubic meter pumped" basis, based on the pump output supplied.

Major repairs

Matforce, an important supplier of pumping equipment in Senegal, uses a formula to estimate repair and maintenance cost: 10% of initial cost each year for three years, then 32% for each of the fourth and fifth years, or 92% of new cost over the five-year life. This percentage of new cost would make repairs over the life of the machine nearly as great an expense as depreciation. However, adjustments need to be made.

Because the pump is simpler than the motor and is subject to fewer problems necessitating major repairs, it is assumed that the formula applies only to the cost of the motor. In the absence of hard data, the motor is assumed to make up 50% of the cost of the entire GMP. Allowance for major repairs, therefore, is calculated as follows:

Major repairs = (GMP investment cost * .5 * 0.92)

Major repairs constitute an item that one hopes to avoid or at least postpone, like eventual replacement of the GMP. Thus it is an item to be depreciated or amortized, just as the original purchase price is amortized. For this reason, "major repairs" is listed as one of the fixed or overhead costs, to be spread over the service life of the machine. This change from the method of allowing for major repair cost that was used in an earlier version of the water cost module adds to fixed costs and reduces variable costs. The change therefore has implications for profitability of crops, be to considered later.

---

[3] A service life of 6000 hours was suggested by Steve Copeland in a memo dated 5 March 1990; this was confirmed in a memo of 13 March 1990. In both cases, Copeland referred to "a SAED document." The 6000-hour life was used regularly in discussions within the project, and the consultant assumed that it was a well-accepted figure.

Operating Costs

The hourly fuel use of the pumping set in question should be entered, if known, but it is unlikely that pump operators will have more than a vague notion of rate of fuel use. Alternative methods of estimating fuel consulption are supplied below.

Annual fuel use or fuel cost for the perimeter is sometimes available. If total pumping time per year is known, hourly fuel use can be calculated:

Total cost of fuel / Cost per liter /hours of pumping = l / hr.

Estimation can by done from the following information supplied by an engineer of the SAED/Harza project:

Typical rates of fuel consumption

Equipment	Fuel used, l. per hr
Lister HR-2 or equivalent. . .	3.4 to 4.4
" HR-3 " "	5.2 to 6.5
" HR-4 " "	8 to 9
" HR-6 " "	12 to 13

Source: In-house memo from Steve Copeland, Operations Engineer, dated 5 March 1990.

A figure of 4 liters per hour was used by the consultant as a starting point for calculations. An alternative method for estimation was subsequently developed with the aid of the Harza engineers, and it is incorporated in the water module. The formula is as follows:

$$\text{Fuel used l/hr} = \frac{\text{Operating head * Pump Output}}{\text{270.55 * Brake HP per l fuel * Pump Efficiency}}$$

Operating head approximates the height of life from the river to the pipe outlet, adjusted for friction losses. Pump output has already been discussed. The number 270.55 is a constant. Default figures are provided for BHP per l of fuel (4.45) and Pump efficiency (.75), but if more appropriate figures are available, they should be used.

Hourly fuel cost is computed automatically using the standard local price of diesel fuel.

Oil consumption of Lister engines (at 0.75% of fuel consumption), plus the oil needed for oil changes and oil for the air filter, is the basis for calculation of oil and lubrication costs equal to 17 % of fuel cost[4]. Routine maintenance includes filters for fuel and oil, and is estimated at 6% of fuel cost, based on records of SAED[5].

The pump operator is a part of the variable costs of obtaining water, "variable" meaning that cost varies with the amount of water used, and would cease if no water were pumped. Keita, in his 1983 study of agricultural production in the BSIP project (see bibliography), reported fuel cost and oil, maintenance and operator costs that worked out as 5.2, 5.6 and 6.0 percent, respectively, of fuel costs. The former items are at least roughly comparable to the rates used here, so the operator cost factor (6 % of fuel cost) has been adopted for use in this model. Another figure can be substituted, if desired.

Variable and Fixed Costs

The variable costs of water are automatically presented on a per hour and per M3 of water pumped, and fixed (amortization) costs and variable costs are summed and presented in the same way. It will be noticed that in the example used, costs are much less than variable costs. To say it another way, variable costs represent only 22% (in the rainy season) to 31% (in the dry season) of the total costs of pumping water. It is also noteworthy that water costs are significantly higher in the dry season, especially as to variable costs. This difference has implications for counterseason culture, as will be seen later.

As suggested earlier in this chapter, there are situations when fixed costs can and should be ignored. Farmers or perimeters who already have irrigation facilities are not currently concerned with the cost of establishing such facilities; the costs either were borne by others (as in the cases where SAED paid for the installation), or they have already been incurred so that the commitment is inescapable. In these cases, knowledge or use of fixed costs contributes nothing, and crop production decisions should not consider them. Most of the decisions of farmers, other than decisions about new investment in irrigation facilities, fit this picture.

Therefore, only variable costs of water pumping and conveyance are considered at present, although fixed costs are also calculated. At a later stage, when the overall profitability of the perimeter is to be considered (especially with a view to the

---

[4] Based on literature for Lister engines. Figure supplied by Steve Copeland of the Harza team. Current prices for diesel fuel and motor oil are 210 and 1000 F CFA per liter, respectively; it is assumed that the formula supplied fits the relationship between those prices.

[5] Source: Memo from Copeland to Reeser dated 5 March 1990.

desirablity of replication of the facility), total costs including the necessary investments must be taken into account.

Water Conveyance

The foregoing calculations establish the cost of water pumping. To be useful to the crop, the water must be delivered to the field. Under Bakel conditions, this conveyance of water always results in losses, and the losses may be large. Typically, water is conveyed from the pump (floating in the river) to the stilling basin by plastic or metal pipe of 8 to 12 inch (200 to 300 mm) diameter. Typically, there are leaks in the pipe joints. From the stilling basin, water flows by gravity through a main canal, most of which is of earth construction. The soil at this location is relatively coarse, and infiltration may be rapid. Further down the canal, in lower-lying areas, soils are heavier and contain more clay; here the infiltration loss is likely to be much less. Unfortunately, by that time there is also less water available to be lost.

The BSIP EOP report (Volume II, p 364) estimates percolation losses at 41%, but it is not clear to what or where that rate applies, as the same source shows conveyance efficiency at 80% for rice and 65% for maize (p 401).

Joe Tabor, soils scientist with the Dames and Moore team preparing the Master Plan for the Senegal Valley, measured infiltration at a site at Colangel, near Bakel. He found the initial rate to be 7 cm per hour, stabilizing after about 30 minutes at 4.6 cm per hour[6]. That particular canal had a width (wetted perimeter) of over 3 m, and the infiltration rate was felt to be representative of 2 km of canal. Water conveyance losses from that stretch of canal would therefore be nearly 300 M3 per hour -- equal to the entire output of most pumps!

A Dutch engineer of the West African Rice Development Association (WARDA) measured water flow in canals in various perimeters near Bakel. These measurements, in canals of less than 1000 m length, indicate conveyance efficiencies ranging from 95% to as low as 44% [7].

---

[6] Mr. Tabor's measurements were made on 17 March 1990 and reported to the consultants the same day. This information is expected to be found in the Dames and Moore report on the Master Plan for the Senegal Valley, to be issued later this year.

[7] This work was done by Els Feenstra in late 1989. To date the only report of her findings is an unofficial, privately circulated monograph dated November 4, 1989.

Estimates of Harza engineers suggest 75% efficiency for an average system[8].

An estimate -- or, if available, a measurement -- of the water conveyance efficiency should be entered in the Water Cost module. The consequential rate of water delivery is calculated automatically, adjusting for the loss of water in the canal. The variable and total cost per M3 of water delivered to the field is also calculated.

Analytical factors are calculated by the module: water pumped and water delivered to the field per liter of fuel used. These factors are useful in the crops modules, where calculations are made of fuel consumed per hectare of crop produced

The calculations in this module reveal the importance of extending the life of the pumping set, the variation in pumping costs resulting from seasonality and the height of the river, and the significance of water losses in conveyance. These factors have gross implications for the costs and profitability of irrigation.

To better demonstrate the importance of and the interrelatedness of these measure, the water cost module was used for calculation of cost of water under a wide variety of conditions: all possible combinations of water conveyance efficiencies of 25, 50, 75, 85 and 100%, and service lives of the pumping set of 3000, 6000, 9000, 12000, 18000, 24000 and 30000 hours, in both rainy and dry seasons[9]. The resulting costs are presented in Table 4 (A and B).

Great differences in costs are evident. At very short GMP service life (3000 hours, equivalent to two or three years) and very poor conveyance efficiency (25%, so that three-fourths of the water pumped is wasted), cost of water in the rainy season is 74.3 F CFA per M3. At the other extreme of perfect efficiency and maximum pump life, water cost is only 4.9 F CFA per M3: one fifteenth as much! It is interesting to note that each of these factors has about equal total impact. Maximum life at lowest efficiency produces about the same water cost as maximum efficiency and shortest life: 19.7 vs 18.6 F CFA per M3.

Graphic presentation of these data in the form of line graphs is made in Figures 3 and 4, which show the rapidly-decreasing cost of water delivered to the field, as pump life is extended to the maximum, at all levels of conveyance efficiency. The greatest

---

[8] Source: Memo from Steve Copeland, dated 5 March 1990.

[9] These are total costs of water delivered to the field. Variable costs are not used in this demonstration because they remain essentially constant during the life of the pump, and are minimally affected by variations in service life.

H2CCOSTS.WKI
J4/02/90

Table 4

TOTAL COSTS OF WATER DELIVERED TO FIELD
IN RAINY AND DRY SEASONS
F CFA per M3

A. RAINY SEASON

Water Conveyance Efficiency	Life of GMP in Hours 3000	6000	9000	12000	18000	24000	30000
100%	18.58	10.99	8.46	7.19	5.90	5.29	4.92
85%	21.86	12.93	9.95	8.46	6.97	6.23	5.78
75%	24.77	14.65	11.28	9.59	7.90	7.06	6.55
50%	37.16	21.98	16.91	14.38	11.85	10.59	9.83
25%	74.31	43.95	33.83	28.77	23.71	21.18	19.66

B. DRY SEASON

Water Conveyance Efficiency	Life of GMP in Hours 3000	6000	9000	12000	18000	24000	30000
100%	25.77	15.24	11.73	9.98	8.22	7.34	6.82
85%	30.31	17.93	13.80	11.74	9.67	8.64	8.02
75%	34.36	20.32	15.64	13.30	10.96	9.79	9.09
50%	51.54	30.48	23.46	19.95	16.44	14.69	13.63
25%	103.07	69.96	46.92	39.90	32.88	29.37	27.27

Note: Costs include both variable costs (fuel, oil and routine maintenance) and fixed costs of amortization of GMP, pipes and canals, and major repairs.
Other costs of perimeter development are not included.
See text for additional details.

WATER DELIVERY COSTS: RAINY SEASON

Conveyance Effeiciencies: 100%–25%

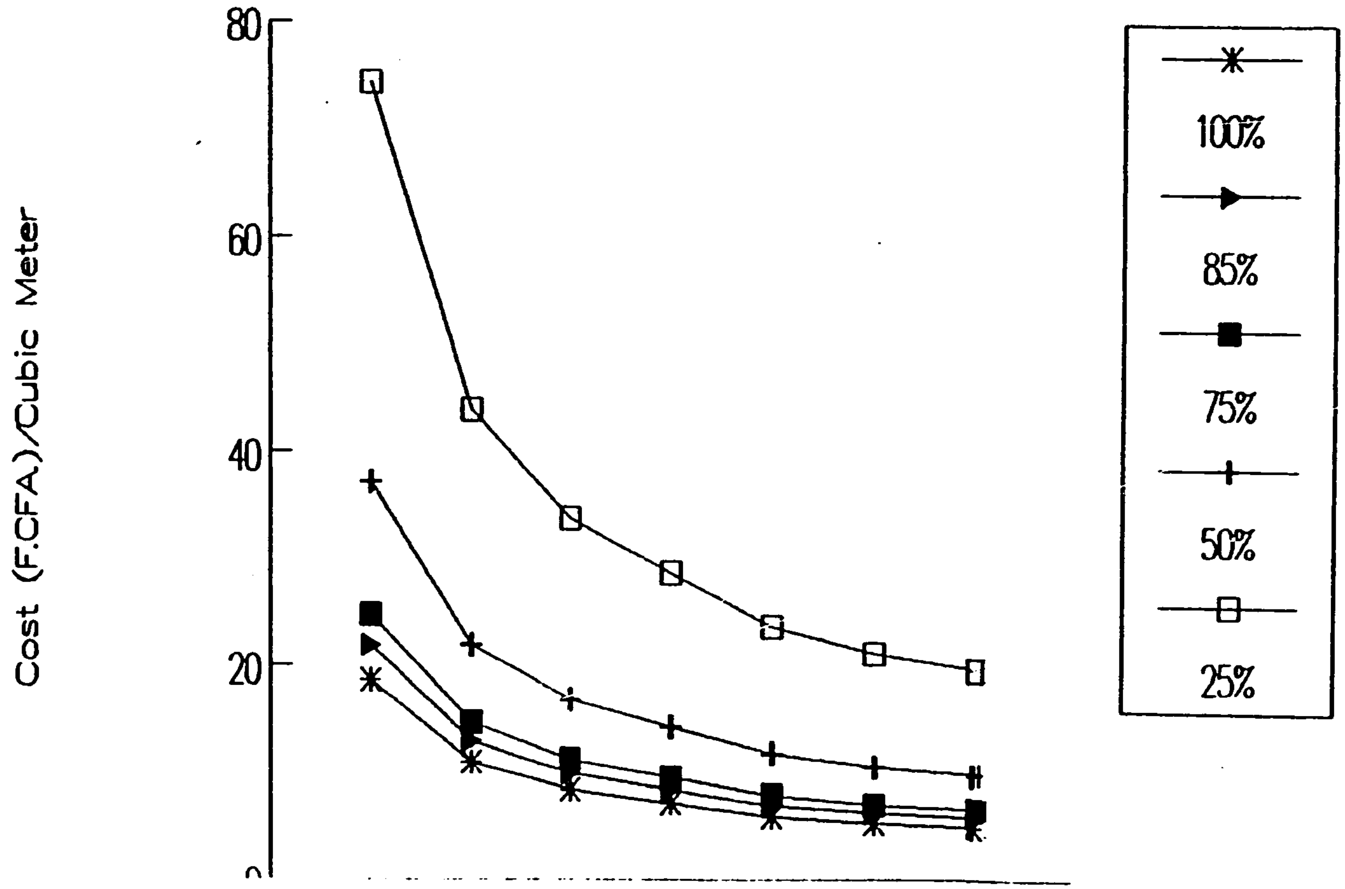

Figure 3

WATER DELIVERY COSTS: DRY SEASON

Conveyance Efficiencies: 100%-25%

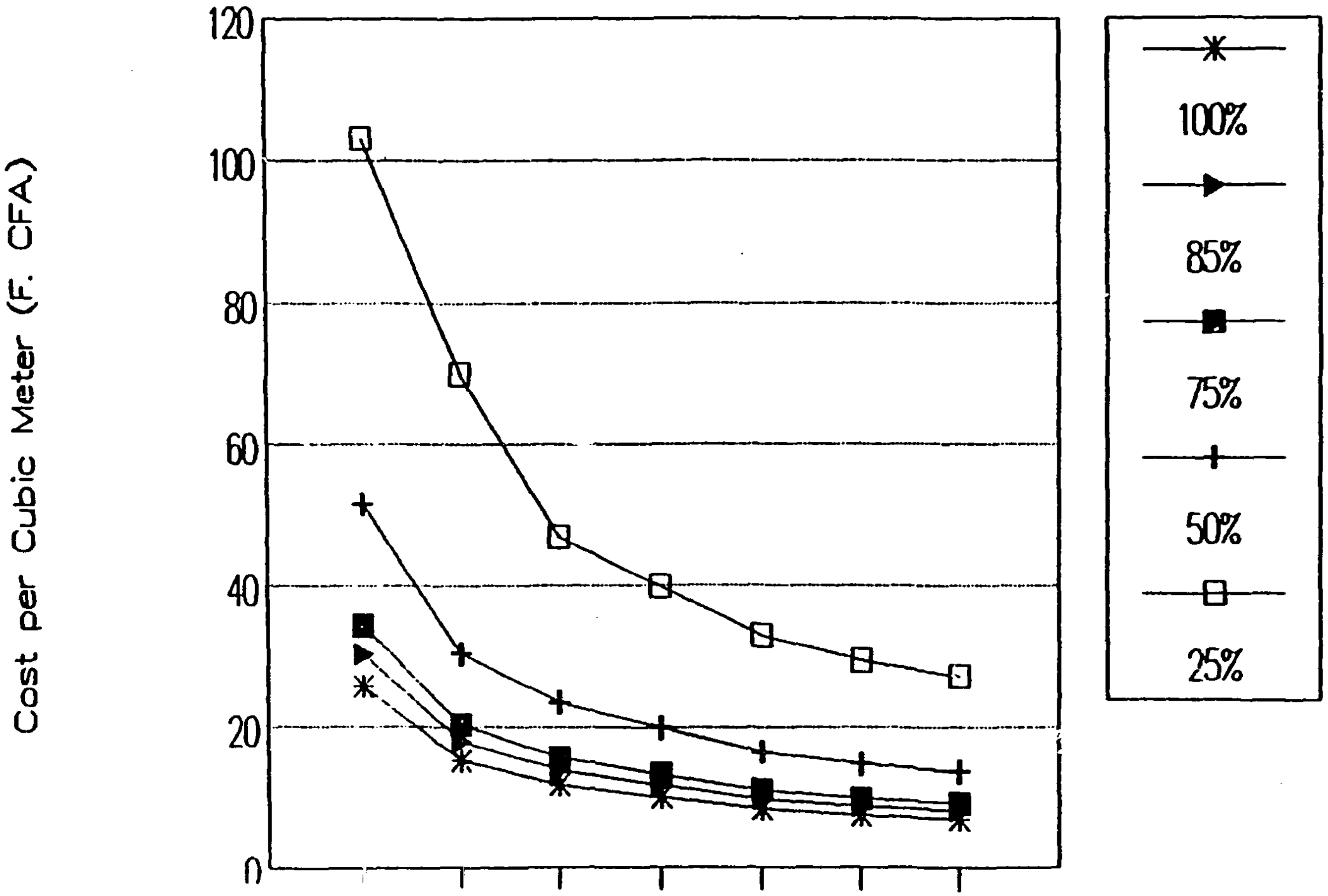

Figure 4

reductions are with the poorer efficiencies. At 75% or greater efficiency, after 18000 hours of life has been achieved, further reduction of cost does not appear to be great.

It is apparent that various combinations of service life and conveyance efficiency can produce equivalent costs. To explore this idea, the data of Table 4 have been redistributed so that the intervals along the X and Y axes on the page are proportional to the intervals in the data. All that then remains is addition of iso-cost lines, comparable to the contour lines on a topographic map. These have been drawn in freehand, without any great precision, and are presented as Figure 5 for Rainy Season Water Costs and Figure 6 for Dry Season Costs.

It is hoped that study of these curves will be not only interesting but productive of a greater awareness of the overwhelming importance of water conveyance efficieny and service life of pumping equipment. Fortunately, these vitally important factors are subject to modification through programs of intervention.

Water transmission can be made more efficient, and the means of improving efficiency include a number of options ranging from simple and inexpensive repair of faulty turnout structures and plugging of obvious holes in canal walls, through various chemical and mechanical treatments, lining with different materials, and continuing all the way to redesign, relocation and/or rebuilding of canals.

The task starts with inventory of the real situation: determining the current level of efficiency, and where the major losses are taking place. This would be followed by determining how the losses can be reduced, estimating the cost of such action, evaluating the benefits in terms of water savings, and prioritizing the tasks so as to make maximum impact with available resources. Some of the possible actions can be carried out by farmers themselves, but instruction and guidance will be needed.

As for the problem of short life of puming sets, this problem also can be addressed. It has been and is being addressed through training of pompistes, but rethinking the training program and repair services may be worthwhile. Are there operators that have not yet been trained? Is refresher training or advanced training needed? Would forms for recording service and maintenance operations, and inspection of those records as a part of all service calls, be worthwhile? Could dirty fuel be avoided by providing better fuel storage facilities? Could a prepaid service be offered, perhaps by a private-sector entrepreneur, to guarantee trouble-free performance if certain procedures are followed and certain conditions and services accepted (and paid for, of course)?

Figure 5

H2OCOSTS.WKI
03/27/90

TOTAL COSTS OF WATER DELIVERED TO FIELD IN RAINY AND DRY SEASONS
F CFA per M3

A. RAINY SEASON

Water Conveyance Efficiency	Life of GMP in Hours: 3000	6000	9000	12000	18000	24000	30000
100%	18.58	10.99	8.46	7.19	5.90	5.29	4.92
85%	21.86	12.93	9.95	8.46	6.97	6.23	5.78
75%	24.77	14.65	11.28	9.59	7.90	7.06	6.55
50%	37.16	21.98	16.91	14.38	11.85	10.59	9.83
25%	74.31	43.95	33.83	28.77	23.71	21.18	19.66

Note: Costs include both variable costs (fuel, oil and routine maintenance) and fixed costs of amortization of GMP, pipes and canal, and major repairs.
Other costs pf perimeter development are not included.
See text for additional details.

Figure 6

H2OCOSTS.WKI
03/27/90

TOTAL COSTS OF WATER DELIVERED TO FIELD IN RAINY AND DRY SEASONS F CFA per M3

B. DRY SEASON

Water Conveyance Efficiency	Life of GMP in Hours: 3000	6000	9000	12000	18000	24000	30000
100%	25.77	15.24	11.73	9.98	8.22	7.34	6.82
85%	30.31	17.93	13.80	11.74	9.67	8.64	8.02
75%	34.36	20.32	15.64	13.30	10.96	9.79	9.09
50%	51.54	30.48	23.46	19.95	16.44	14.69	13.63
25%	103.07	69.96	46.92	39.90	32.88	29.37	27.27

Note: Costs include both variable costs (fuel, oil and routine maintenance) and fixe(costs of amortization of GMP, pipes and canal, and major repairs.
Other costs pf perimeter development are not included.
See text for additional details.

The importance of improving water conveyance efficiency and maximizing service life of pumping equipment is so great that careful, thoughtful attention should be devoted to the deveopment and implementation of appropriate programs of intervention.

CHAPTER 5

CROPS AND CROPPING COMBINATIONS

The analysis of each crop, in each situation in which that crop is produced, is undertaken with the aid of a crop module. For this report, eleven such modules have been prepared and included. In the worksheet, they are to be found in two general locations, immediately after the water module and following all of the other modules. The reader may refer to the table on page 6 that shows the range names for the various modules; use of these "code names" with the GoTo function will facilitate finding them.

A sample crop module, for rice production under typical village conditions, is shown as Figure 7. In principle, each crops module shows all of the inputs for production of that crop and all of the cost elements of the production package. This omits, of course, such items as planting dates, seed spacing, interval between irrigations, depth and thoroughness of seedbed preparation, etc. which are also very important but which can hardly be assigned a cost. In reality, the full capabilities of the module may seldom be utilized, because data are difficult to obtain or to disaggregate for analysis. Examples are aggregation of seed, fertilizer and pesticides into one bundle of out-of-pocket costs, grouping of all labor amounts and expenses into one total, and reporting of water as cost of fuel for the pump rather than as volume of water. Most such difficulties can be overcome by bypassing the detailed listing and entering the monetary costs. However, this expedient precludes the production of certain of the analytical factors of which the module is capable.

The analytical factors that are shown at the bottom of the module do not always compute. For example, if there is no entry for family labor, or if family labor is zero, the factors using family labor (such as Net Income per MD of Family Labor) will be shown as ERR.

The analytical utility of the crops module can best be demonstrated by using it for a number of crops or situations, and then comparing the results. That has been done. First, rice production is analyzed under conditions believed to be typical of village perimeters (PIVs) in the area. This is ashown in the module RiceRT, already referred to as Figure 7. Next, characteristics of rice production in four villages in the Bakel Delegation are presented for comparison (Table 5). The analytical factors shown in this table result from the use of the module, but only a summary of the findings (rather all of the modules) is included. Sources of the figures presented in Figure 5 can be determined by comparing Table 5 to the module RiceRT shown in Figure 7.

It is apparent that from village to village considerable variation exists in the use of labor, the level of yield, the net

CROPS MODULE FOR PERIMETER: Typical 28-Mar-90
RAINY SEASON FILE: Typical RiceRT
RICE as it is produced in the villages
Sources of data:
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha		Details			
Fert: Urea, kg/ha			not		
Fert: NPK (18-46-0) kg/ha				available	
Fert: KCL, kg/ha					
Pesticides		Total shown below			
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					
Labor: Plant (direct seeding)		Details			
Labor: Transplant			not		
Labor: Weed				available	
Labor: Irrigate					
Labor: Harvest and Thresh		Total shown below			
Labor: Storage and Transport					
Labor: TOTAL per hectare	SE		343.0		
Family Labor (Unpaid) %	SE 96		329.3		
Hired labor @ 607 F CFA/MD	4		13.7	8,328	
		AMT.	PRICE		
Water requirement, m3/ha	H	7,800	2.80	21,841	
Tools, annual cost per ha	K			4,755	
Mech/Animal Traction, hrs/ha	SE			0	

SUMMARY OF COSTS:	Labor, Hired	8,328	10.6
	Water	21,841	27.7
	Seed, fert., pesticides	44,000	55.7
	Mech/Animal Traction	0	0.0
	Tools	4,755	6.0
	Subtotal	78,924	100.0
	Credit = 0 % of costs	0	0.0
GRAND TOTAL OF COSTS (Purchased Inputs)		78,924	100.0

PRODUCTS	Yield	Price	Value
Paddy/Raw Grain. hg/ha	2700	82	221,400
Straw. kg/ha	?	?	0
TOTAL PRODUCTS, Value F CFA			221,400

Net Income per ha (Value of crop less costs), F CFA	142,476
Net income per MD of total labor, cfa	415
Net Income per MD of family labor, cfa	433
Net Income per m3 of water, cfa	18
Paddy per manday of total labor, kg	8
Paddy per manday of family labor, kg	8
Paddy per m3 of water, kg	0.35
Fuel used per hectare of crop, liters	81
Cost of Production per kg of paddy, cfa:-	
-- if all labor is provided by family at no cost	26
-- if all labor is hired, @ 1000 per 6.5-hr man-day	153

LABORSUM.WK1 02-Apr-90

Table 5

RICE PRODUCTION IN BAKEL DELEGATION
Based on data from the Socio-Economic Survey

Item	Ballou	Aroundou	Bakel	Diawara	Average
Total labor used per ha	531	674	337	138	343
Percent of labor hired	4	2	1	11	4
Ave. cost of labor per MD	239	629	1500	494	607
Total cost of purch. inputs **	40382	48597	41435	45669	44000
Yield, kg per ha	2970	2180	3750	2360	2700
Value of product at 82 F CFA/kg	243540	178760	307500	193520	221400
Net Income	111093	34695	174021	53363	82083
Net Income per MD of family labor	218	53	522	434	259
Net Income per M3 of water	10	3	16	5	7
Paddy per MD of labor	6	3	11	19	8
Paddy per M3 of water	0.27	0.20	0.34	0.21	0.25
Cost of production per kg of paddy:					
if all labor is unpaid	43	62	34	56	49
if all labor is hired	86	257	169	85	126
Ave size of plot	0.61	0.72	0.69	1.36	0.87
Net income from the family's plot	67767	24981	120075	72574	71412

** Total costs includes these items, standardized for all cases:
Water, 11000 M3 at 7.48 F CFA/M3
Tools, 4755 F CFA per ha

Note: Six cases in each village.
Averages are weighted by area of plots.

income and other characteristics of rice production. The averages from Table 5 were used to establish yield, labor amount and wages, and purchased input costs for module RiceRT. (However, those analyses used an earlier version and a preliminary cost of water, and the error was detected too late for correction.)

Additional use of the crops modules produced analyses and printouts for five rainy season crops, five crops for the cold dry season, and one year-round or perennial crop, all (except typical village rice) under improved conditions to show the potential production. Those crops are listed below with the code names of their respective modules.

Rainy season:	Rice (typical)	RiceRT
	Rice (potential)	RiceRP
	Maize	MaisRP
	Millet	MilRP
	Sorghum	SorgRP
Dry season	Rice	RiceDC
	Maize	MaisDC
	Millet	MilDC
	Sorghum	SorgDC
	Onions	OnionDC
Year-round	Bananas	Banan

Printouts of the modules are annexed to the report. The findings are compared in Table 6 for rainy season crops and in Table 7 for cold dry season and perennial crops.

<u>Analysis of one crop: Traditional Rice</u>

Traditional rice, in the first column of Table 6, is rice as it is produced in irrigated perimeters of the Bakel Delegation. Inputs and yields are drawn from the socio-economic survey. Even without intracrop comparison, this analysis is revealing. Production costs are about a third of the value of the crop (35.6%), so there is little question about recovery of one's expenditures. Purchased inputs (fertilizer, seed, chemicals) cost twice as much as water, and five times as much as hired labor. The small expenditure for hired labor indicates that most of the labor was provided by the family (96% of it, as shown in the appropriate printout, RiceRT).

Net income is significant, being nearly two-thirds of the gross value of the crop. However, this net income is the residual return to the labor and management input of the family; it is the only pay the family receives for the work they did in producing the crop. Prorating the net income to the labor that produced it indicates an income or wage of 415 F CFA per manday. Of course the hired labor has been paid; the family labor has not. The residual "income" per MD of family labor is 433 F CFA. Bear in

CROPCOMP.WK1 02-Apr-90

Table 6

ALTERNATIVE IRRIGATED CROPS
FOR THE RAINY SEASON
IN BAKEL DELEGATION
(Per Hectare)
(Quantities in Kg, Values in F CFA)

	Traditional	Improved Technology			
	Rice	Rice	Maize	Millet	Sorghum
Yield, kg/ha	2700	5500	5500	4000	5500
Value of crop / kg	82	82	80	80	80
Total value of crop	221400	451000	440000	320000	440000
Fert. kg/ha:					
Urea	?	200	160	160	160
18-46-0	?	150	150	100	100
KCl	?	100	100	50	50
F, S,& P inputs cost	44000	59950	41350	29160	29320
Labor, Mandays	343	177	108	108	108
Hired labor cost	8328	8591	4954	4589	4953
Hired Traction	0	30000	20000	20000	20000
Water used, M3	7800	7800	3600	2500	3000
Water cost	21841	21841	10080	7000	8400
Total Prod'n costs	78924	143908	91943	73964	76177
Prod costs/crop value %	35.6	31.9	20.9	23.1	17.3
Net Income per:					
Hectare	142476	307092	348057	246036	363823
Manday of labor	415	1736	3223	2278	3369
MD Family Labor	433	1887	3709	2450	3877
M3 of water	18	39	97	98	121
Product, kg per:					
Manday of labor	8	31	51	37	51
MD of family labor	8	34	59	40	59
M3 of water	0.35	0.71	1.53	1.60	1.83
Fuel, l. used per ha	81	81	37	26	31
Cost / kg product:					
If all fam. labor	26	25	16	17	13
If all hired labor	153	26	35	44	33

CROPCOMP.WK1 02-Apr-90
DC Season

Table 7

ALTERNATIVE IRRIGATED CROPS
FOR THE COLD DRY SEASON
IN BAKEL DELEGATION
(Per Hectare)
(Quantities in Kg, Values in F CFA)

	Commercial Production					
	Rice	Maize	Millet	Sorghum	Onions	Bananas
Yield, kg/ha	5500	5000	2500	3500	41000	40000
Value of crop / kg	82	80	80	80	125	175
Total value of crop	451000	400000	200000	280000	5125000	7000000
Fert. kg/ha:						
Urea	200	160	160	160	300	0
18-46-0	150	150	150	100	345	1800
KCl	100	100	100	50	100	600
F, S,& P inputs cost	59950	41350	38350	29320	75585	221400
Labor, Mandays	177	108	108	108	660	3650
Hired labor cost	177000	108000	108000	108000	660000	3650000
Hired Traction	30000	20000	20000	20000	0	0
Water used, M3	10320	10700	3500	7400	10700	16500
Water cost	66051	68483	22401	47362	68483	91204
Total Prod'n costs	388419	277610	221166	239486	928780	4568495
Prod costs/crop value	86.1	69.4	110.6	85.5	18.1	65.3
Net Income per:						
Hectare	62581	122390	(21166)	40514	4196220	2431505
Manday of labor	354	1133	(196)	375	6358	666
MD Family Labor	**	**	**	**	**	**
M3 of water	6	11	(6)	5	392	147
Product, kg per:						
Manday of labor	31	46	23	32	62	11
MD of family labor	**	**	**	**	**	**
M3 of water	0.53	0.47	0.71	0.47	3.83	2.42
Fuel, l. used per ha	244	253	83	175	253	337
Cost / kg product						
If all fam. labor	38	34	45	38	7	23
If all hired labor	71	56	88	68	23	114

** No family labor involved.
Note that Bananas are a year-round crop.

mind that the average cost of hired labor (shown in the RiceRT printout) is 607 F CFA per MD. Thus, the family worked in the rice fields for a lower daily wage, typically, than the same family paid its hired help -- and for considerably less than the "going rate" for hired labor, generally considered to be 1000 F CFA per (short) day.

The return to water is greater than the cost of water, or at least more than the variable cost used in this analysis (2.80 F CFA per M3 of water delivered to the field). Therefore the use of water appears to be profitable. The total costs of water, including both the variable costs of operating the pump and the fixed or overhead costs connected with owning, repairing and eventually replacing it, are 12.92 F CFA per M3 (see the Water module printout). Thus irrigation of rice seems to be "pulling its own weight," paying its way, at the cost of water used here.

Reference to Table 4 shows, however, that with lower efficiency of water conveyance or with poor pump maintenance and resulting short life of the GMP, the cost of water could easily be more than the price used so far, and more than the return to water. In such a case, continuation of production would be justified as long as the pumping set lasts, but investment in a new pump would not be justified.

Fuel used is only 81 liters per hectare. This is less than was reported in some of the perimeters visited by the consultants. This lends weight to the thought that the formula used in the water module to calculate fuel use of the motor produces an overly-optimistic figure. This possibility should be researched further.

How much does it cost to produce rice? Paddy can be sold for 83 F CFA per kg. If production costs are less than that, there is a profit; if costs are more, the reasonable decision-maker would cease his efforts to produce. Whether traditional rice is profitable or not depends on whether family labor is considered to be a cost. If rice were produced with ALL family labor, and the costs of hiring help avoided altogether, paddy worth 82 F CFA per kg would be produced for only 26 F CFA. Thus, if one uses family labor more or less exclusively and considers it as a free good, rice production is profitable. On the other hand, if one undertakes production of paddy using these input cost levels, receives the yield and price herein shown, and pays full price (1000 F CFA per day) for all labor, one will surely lose money, as the cost of production is 153 F CFA per kg for a product salable for 82!

No doubt intuitive understanding of these relationships on the part of local producers explains, at least in part, why rice production utilizes such a small proportion of hired labor, and why rice production is restricted to small plots -- .87 hectare average in the sample studied by the project's Socio-Economic Survey. Also, in view of the shortage of labor in the area, it helps one to understand why enthusiasm for expanding or even continuing rice production is low in the region of Bakel.

Comparison of Old and New Methods for Rice.

Four alternative crops for the rainy season, all of them irrigated crops, have been analyzed using crops modules. The appropriate printouts are appended at the end of the report, and the results are summarized in Table 6, already presented. A number of interesting observations can be made, but a useful first start is the comparison (and contrast) between traditional rice and rice under improved technology.

"Improved technology" rice is shown in the module RiceRP (Rice in Rainy season showing Potential achievements). In that module, inputs and yield are at the level tested and proven at the Harza/SAED demonstration farm at Colangel. The major differences between traditional and improved technology are in total labor, purchased inputs and yield. Labor use is reduced to half the traditional amount by use of hired plowing, chemical weed control, and some improvements in threshing methods -- all of which techniques are well past the trial stage and are in use on some local farms. Labor hired in the improved package was held at about the same level as in traditional production (although it would have been equally reasonable to assume that available family labor, unassisted, could handle the reduced work load). Allocation of labor to individual tasks was estimated by the consultant; such allocation should be measured under real conditions when possible, because of the implications for reducing intracrop competition for labor, and for permitting greater areas of crops to be handled by the labor available to a family.

Doubling of the yield while using the same amount of water and less labor results in far more favorable net income, and the analytical factors are also favorable. Despite the heavier expenditure for chemical products and for mechanical inputs, net income is doubled, net income per unit of water is doubled, and net income per unit of labor is quadrupled. Cost of production, even when all labor is paid full wages, is less than a third of the sale price of the crop.

One need go no further to see possibilities for extension activity. Teaching the importance of the right amount and balance of inputs, helping farmers obtain the inputs that are needed, and helping them to obtain the credit necessary to finance the purchase of those inputs, will pay off handsomely through increasing the area of rice that is produced under proper conditions. Increased yield not only will result in greater production from the same area, but the higher profit will provide incentive to farmers to increase the land area dedicated to rice production.

Intracrop Comparisons

The other crops for which improved technology packages have been develcped are Maize, Millet and Sorghum. All three of these crops are suited to coarser-textured soils than is rice, although they too can be produced on heavy clay soils. They are similar crops in several respects other than soils adaptability; as members of the grass family they are adapted to cultivation in lines or rows, and thus are suited to use of animal traction for intra-row cultivation. They all respond well to nitrogenous fertilizers. They all play an important role in the diet of the family and its animals. All are adapted to production as irrigated, high-intensity crops, in both rainy and cold dry seasons.

There are also many similarities among these three crops in the summaries (in Table 1) of their crop modules (MaisRP, MilRP, and SorgRP, printouts of which are attached). Millet yields somewhat less than the other two. Maize needs more fertilizer and water to maximize its potential. Labor requirements are similar, and production costs are not grossly different. The analytical factors also are also closely grouped, even including net income per hectare. Between maize and sorghum, the contest is too close to call, and millet is close enough to be worth a trial, too.

All three of these crops are grossly superior to traditional rice. They are also very competitive with improved rice, having comparable net incomes, greater profitability per manday of labor, far lower outlay for purchased inputs, and half or less rice's water need.

The choice between rice and and any one of the alternative cereals crops of maize, soghum or millet probably comes down to a question of soils adaptability and water conveyance efficiency. If water conveyance efficiency is good, grow rice where rice is adapted, but be sure that appropriate production techology is used to assure high and profitable yields. Where water losses in conveyance are high, and where the soil is not well suited to rice, cut the water requirements and increase both prodction and profit by producing maize, sorghum or millet.

Counterseason Crops.

The foregoing discussion has considered only crops grown during the rainy season. That season is the natural one for crop production; without irrigation it is the only season. However, with irrigation in place, there is no reason why counterseason culture of various crops should not be considered. There is currently some production of irrigated counterseason crops in Bakel perimeters, but these are limited to small areas of only a few crops: maize (mostly for the green ears), onions, some vegetables. In addition, a few perimeters have small banana plantations, which of course require watering on a year-round basis.

There are many and strong reasons why double-cropping or lengthening of the growing season should be considered and might be successful. The resources are already there: land that otherwise will go unused, labor that is likely to be under-employed, capital in the form of pumping equipment and irrigation facilities, management capability needing only to learn a few new tricks. Deterioration of the pumping set, especially the motor, may actually be less with careful use than if unused and rusting during the same period. The markets are there for at least some crops and products; people have to eat all twelve months of the year.

There may well be reasons, particularly economic reasons, why counterseason crops cannot be produced. The purpose of this inquiry is to determine by a budgeting study whether such reasons exist. The data that make up the budgets should be based on actual field experience. In some cases, such data are not available. Missing figures have been supplied based on anecdotal and research data and observations from other countries with comparable soils and climate. The results, while not definitive, offer excellent guides for action programs.

Rice as a Counterseason Crop.

Rice is produced year-round in many countries. Can it be produced economically here, in the cold dry season? This is investigated in the appropriate module, RiceDC, attached at the end of the report. Inputs of seed, fertilizer, labor, etc. are assumed to be generally the same as for properly-done rice in the rainy season. It is assumed that the person undertaking production of paddy in the counterseason would do so as a strictly commercial venture, without the support of free labor from within the family. Therefore, in these budgets all labor is hired at the full price of 1000 F CFA per day. It is also assumed that the funds to pay expenses would be borrowed, adding credit charges to the costs.

The water requirement is greater in the cold dry season, because of higher evapotranspiration in the low-humidity months without rainfall. At the same time, the cost of water is significantly higher, because the river level is lower and the pump operates against a greater head, resulting in both lower pump output and greater fuel consumption.

The combined result is significantly higher production costs. The changes mentioned add 168,000 F CFA to labor costs and 44,000 F CFA to water costs (variable costs only); there are also credit charges. The extra two million of expenses leaves dry-season rice "in the black," but the margin is not great: net income is some 60,000 F CFA per hectare, compared to expenses of close to

400,000 F CFA. If all or a substantial share of the labor were provided free, the margin would be increased.

Whether this is the way to go, and whether available resources should be allocated to paddy production, should depend on the opportunity costs: what other uses, with what level of returns, could be made of the same resources?

Other Grains and Intracrop Comparisons

The alternatives to paddy production in the cold dry season include maize, millet, sorghum, and onions. Budgets have been developed for these crops, and printouts of the modules (MaisDC, MilDC, SorgDC, and OnionDC) are attached. Discussion of these crops follow, with Onions in a separate section. Vegetables are another possible dry-season crop, but insufficient data were available to permit developing satisfactory budgets for vagetables.

Maize is raised in the cold dry season in Bakel, usually in small plots. It is used as a vegetable, the ears being harvested for roasting. However, usually some of the grain is allowed to mature. If large-scale production were undertaken, it would seem that a large proportion of the crop, or all of it, would be for (dry) grain, and the marketing of large quantities of such grain would be a new challenge for the Bakel area. Mitigating the difficulties are these facts:

a. Maize stores well if thoroughly dry.

b. Drying should be easy in the heat and low humidity at harvest time.

c. Length of storage should be short because the season of strongest demand for cereals is just before the rainy season, which follows soon after the harvest period.

The production of maize should be very attractive, judging from the budget study of the crop module MaisDC.

The same differences exist for maize as for rice in this season: all hired labor, significantly more water, and higher-cost water. Total production costs are tripled, compared to the rainy season. A yield variable is added: in recognition of the bird problem encountered in the dry season for other cereal crops, yields of maize are reduced from rainy-season level by 500 kg, to 5000 kg per ha. The resulting net income is only about one-third that in the rainy season. However, the result is still strongly positive: net income for maize is the highest of any grain crop in the dry season, and it is double that of rice.

Millet is hurt by the assumptions made for the budgeting study of [roduction in the in the dry season. Of course, costs are higher for the usual reasons of higher-priced labor and more and higher-cost water, but in addition, yields are reduced by a third due to bird damage. The combination is too much for the profit margin, which shrinks to below the survivability level: a loss of 21000 F CFA per ha.

There is no question but that bird damage sounds the death knell for millet profitability. Rerunning the same module with only one change, that of raising the yield from 2,500 to 3,000 kg/ha, puts millet "in the black," with a net income of 18,000 F CFA. With yield at the rainy-season level of 4,000 kg, net income reaches nearly 100,000 F CFA, and millet becomes competitive with maize.

Sorghum, which had a substantial lead over millet in the rainy season, also does better than millet in the cold dry season. Water needs are higher than for millet, and water costs are more than double those of millet. The bird problem reduces the yield by about a third, roughly the same proportion as for millet, but the crop remains profitable, with a net income of 40,000 F CFA per ha. Sorghum can therefor be seen as very competitive with rice in the dry season, for while net income is somewhat lower, labor needs, expenses and water requirements are also lower. In terms of either net income or quantity of product per unit of either labor or water, and also in cost of production per kg of crop, paddy and sorghum are nearly identical, although both are inferior to maize.

The sensitivity testing reported earlier for millet was also done for sorghum, to see what would happen if bird damage could be reduced or eliminated. Raising the yield of sorghum by 500 kg (from 3,500 to 4,000) doubles the net income. Another ton of increase (to 5,000 kg) doubles the net income again, to 160,000 F CFA -- better than maize at the same yield level and comparable to maize even at its rainy-season yield level of 5,500 kg.

If bird damage to sorghum and millet could be eliminated, and the dry season yields brought up to the rainy-season level, serious changes would be brought about in the profitability ranking of the cereal crops, and the options for profitable production of grain in the cold dry season would be expanded. There are strong implications here for research to be conducted at the project demonstration farm. "Birdproof" (really only bird-resistant) varieties of maize and sorghum are known to exist, and comparable strains of millet may also exist. Varieties of these grains that are suited to the needs should be sought and tested. Mechanical and/or electronic devices for frightening or repelling birds should be tried; they are seldom completely successful but may be worth more than they cost. Solution of the bird/yield-loss problem would have a tremendously invigorating effect on the viability of counterseason production of grains, and would be of general benefit to irrigation in the Bakel region.

In summary of the dry season grain crops, maize is clearly the leader, showing twice the net income of rice and three times that of sorghum. Using current estimations of yield, millet is not economically viable.

Onions

Onions were analyzed in the module OnionDC, using input and yield data based on several well-replicated trials at the SAED demonstration farm. A printout of the module is attached. Heavy applications of fertilizer are required for high-yield onion production, and much labor is needed. Water requirements were set at the same level as dry-season maize. Analysis assumed commercial production, with labor being paid 1000 F CFA per day of work, and credit charges were included. Production costs for onions total nearly one million F CFA.

At yields and prices shown in the OnionDC module, net income is over four million F CFA, far more than any other crop studied. Such a level of profit is suspect; certainly local farmers would undertake onion production in quantity if profits of that order are to be realized. The module was re-run using yield at half the former (and proven achievable) level, and with the price reduced to 100 F CFA per kg (despite that even at 125 F CFA, the margin for wholesalers is on the order of 100%). With these changes (see the second OnionDC module) net income is still over one million F CFA. Even at the reduced yield level, cost of production is only 45 F CFA per kg, so scope exists for absorbing large price reductions if need be. Truly, onions appear to have a golden potential.

Several implications for the local SAED/Harza program and the local community can be observed. First, promotion of onions as a counterseason crop, on a large scale and for many producers, appears to be eminently justified. Second, local producers apparently are not obtaining yields at this level; something must be missing in the local production package. Extension teaching efforts including on-farm demonstartions to disseminate better technology are suggested. Third, the highest-cost item in the budget is labor. Some reduction of the hand labor required should be both possible and profitable, perhaps by mechanized preparation of the seedbed, by planting in rows (perhaps double rows) to permit intrarow cultivation with animal traction, and by partially-mechanized harvest, with an animal-drawn plow to lift the onions from the soil. Fourth, the seed of onions (at about 15000 F CFA per kg) is a high-priced commodity, although,because of the small amount needed, not a major item in the expense budget. If local production of the seed is feasible, it should be profitable given the high price.

Finally, onions at Bakel constitute an opportunity that should be exploited by the private sector. Someone should set himself up as a wholesale buyer, offering to buy any amount of onions (of specified quality, size, cleanliness, etc.) at a pre-announced price, thereby providing incentive for producers to undertake onion culture and to adopt the extension service's recommended practices. Failing the appearance of such a private-sector buyer, associations or producers' clubs should be organized to promote the crop, to procure the inputs, and to handle the details of marketing the crop. Such a program could make Bakel the onion capital of Senegal.

Year-round use of the land: Bananas

As already mentioned under Counterseason Crops, there are many reasons for making fuller use of resources that are already in place. It should prove interesting to observe the profit possibilities from using the fixed resources of land and irrigation facilities to the maximum, first by year-round or perennial crops, and then by combining two crops to approximate year-round use.

Bananas are raised in several perimeters as collective enterprises, supported by contributed labor, and with the revenues used to defray costs of operating the pumping station. The plantations that were visited by the consultant were considerably under a hectare in size, so neither the labor requirements nor the income possibilities were as evident as they are when presented on a per hectare basis. At the same time, it is unlikely that locally bananas are produced in accordance with the production package used in the budget. The fertilizer use in that budget includes heavy applications every month, and it is improbable that such a practice is being followed. However, when the demonstration farm's banana plantation comes into full production, those who see it may be persuaded to follow the recipe that is in use there.

A factor that is important for bananas (and even more important for other perennial crops such as deciduous fruit trees) is that a period of establishment is required, during which costs continue and the labor input goes on, but there is nothing to sell and no revenue at all. For bananas this period is about a year, but full production is not achieved even in the second year. To make the budget as nearly comparable as possible, an established plantation is shown, ignoring the losses incurred during the period of establishment.

The analysis of bananas through use of the crops module is shown in the attached printout for the module Banan. Bananas have the highest water requirement of any crops shown, because they must be watered in all months of the year. As already mentioned, very large quantities of fertilizer are required, and much labor. However, once established and in full production, bananas reward the persistant and faithful with net income of over two million F CFA per hectare. At this rate, a one-tenth hectare banana plot would produce income greater than a hectare of most other crops.

Of course, that small plot would require labor and other inputs like most full hectares, too. Bananas are in a category all to themselves as year-round crops in this analysis, and only onions are comparable in terms of intensity of input use.

Further analysis of actual input use and actual yield on local plots (if the data were available) would reveal the extent to which extension training of banana producers is needed or justified. However, without such detailed documentation, general appearances indicate that the banana demonstration plot already coming into production on the SAED/Harza project farm is likely to be one of the more beneficial efforts of the project.

Crop combinations for year-round use of the land

A number of possibilities for combinations exist, and the most promising are examined here: rice and rice, sorghum and maize, sorghum and onions. The combinations and bananas are shown in Table 8.

The first comparison should be between combinations of grain crops. Rice and Rice produce the highest crop value, but with far more labor, higher costs for purchased inputs, and more water. Total production costs are half again as much as those of the sorghum-maize combination. However, net income for double-cropped rice is only three-fourths that of the combination of sorghum and maize. This analysis clearly indicates that, if net income is the criterion, rice is not the first choice for double-cropping. It is not the crop that extension programs, if they are aimed at helping families and perimeters to maximize their profits, should support. That honor goes to sorghum, the most profitable crop in the rainy season, and maize, the winner in the cold dry season.

If one is really focussed on maximizing net income, the combination of sorghum and onions sets standards that no other combination, and no perennial crop for which information is available, can match. While the value of the crop of bananas is higher than the combined value of sorghum and onions, there is a greater difference in favor of the combination in respect to expenses. This is due primarily to the extraordinarily high labor requirement and cost for bananas. Net income for bananas, at well over two million F CFA per hectare, is not a figure to be taken lightly, but it is little more than half of the net income from sorghum combined with onions.

The findings from study of combined budgets reinforces the conclusions drawn from the separate budgets: counterseason culture can be profitable, but one must be selective of the crops to be produced. The most profitable crops in each season when combined make the most profitable use of the resources on a year-round basis. Rice as typically produced in the local villages is profitable at the costs used in the analysis, but its yield and

FULLUSE.WK1 02-Apr-90

Table 8

CROP COMBINATIONS FOR FULL USE OF LAND
Comparison of Four Possibilities
(Values in F CFA)

	Rice + Rice	Sorghum + Maize	Sorghum + Onions	Bananas All year
Total crop value	902,000	840,000	5,565,000	7,000,000
F S & P cost	119,900	70,670	104,905	2,221,400
Labor, ManDays	354	216	768	3,650
Hired Labor cost	185,591	112,953	664,953	365,000
Hired traction	60,000	40,000	20,000	0
Water used, M3	18,120	13,700	13,700	16,500
Water cost	87,892	76,883	76,883	91,204
Total prod costs	532,327	353,787	1,004,957	4,568,495
Net Income/ha	369,673	486,213	4,560,043	2,431,505
" "/MD labor	1,044	2,251	5,938	666
" "/M3 water	20	35	333	147

profitability can be greatly improved by the use of a package of inputs and production techniques. Water costs higher than those budgeted would severely reduce the profitability of rice, because of its large water requirement. Even with the best known technology, rice is not the profit leader in either season, giving way to sorghum and maize in the rainy season and to onions and maize in the cold dry season.

The future of irrigated agriculture in the Bakel region appears to depend on the adoption by farmers of improved practices for rice and other crops. Maximization of net income of farmers will be achieved by their production of crops other than rice. The success of an extension program in the Bakel region will depend on the extent to which that program supports and teaches innovations capable of improving farmers' yields and profits on a continuing basis. Such continuation requires an ongoing research and testing program. A mandate for the emphasis to be given by the project in the future thus seems to be rather clearly demarcated.

CHAPTER 6

FUTURE WORK

The analyses completed and presented in the foregoing chapters have involved only the Water and Crops modules of the analytical system. Modules in the system that have not yet been utilized with real data from the Bakel area are the Family, Farm, Perimeter, Amortization, Financial Analysis and Economic Analysis modules. These modules are also worthy of exploitation but, like the others, their use will require finding or generating appropriate data, analyzing the data with the appropriate module or modules, and interpretation of the results. Research done in this manner can produce findings that are meaningful and useful for the project, for the host organization, and for donor organizations. In view of the strong prospects for a continuing flow of broader and higher-quality data emanating from the socio-economic monitoring program, and the probability that other types of information will also be gathered in increasing quantity, it is only reasonable that maximum use should be made of such data.

Properly done research can discover technical relationships and economic applications that may have significant implications for project management, program emphasis, personnel requirements, national policies regarding pricing and subsidizing agricultural inputs and products, and for donor support. An illustration of the kind of questions to which answers can and will be sought is the question of feasibility: Can one justify investment in irrigated agriculture, from the point of view of the groupement or the individual, as private-sector investors, and from the viewpoint of society, the national government and the international donor? It is anticipated that the consultant will have the opportunity the continue research of this nature in the near future.

Another very important element in the use of the analytical system is the training of counterparts. Up to the present time, no Senegalese nationals have used this analytical system, nor, to the consultant's knowledge, are any qualified to use it. Yet, because of the utility of the system for meeting Senegalese needs, it is highly desirable that one or more of the counterpart staff of the project be trained in the use of the model. Ifproperly trained, such a person or persons could continue making analyses of newly-available data, and of new systems and techniques as the innovations and information about them become available. Only with such institutionalization can the full import and the full impact of the system be realized.

It is strongly to be desired, therefore, that in the consultant's next visit to the Bakel project one or more counterparts, hopefully persons who are aleady computer-literate, will be assigned to work jointly with him in an on-the-job training mode. In this way the Senegalese can learn the system and how to apply it to the needs of SAED and Senegal.

ANNEX:

Crop Modules

for crops discussed in this report.

CROPS MODULE FOR PERIMETER: Typical 26-Mar-90
RAINY SEASON FILE: Typical RiceRT
RICE as it is produced in the villages
Sources of data:
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha		Details			
Fert: Urea, kg/ha			not		
Fert: NPK (18-46-0) kg/ha				available	
Fert: KCL, kg/ha					
Pesticides		Total	shown below		
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					
Labor: Plant (direct seeding)		Details			
Labor: Transplant			not		
Labor: Weed				available	
Labor: Irrigate					
Labor: Harvest and Thresh		Total	shown below		
Labor: Storage and Transport					
Labor: TOTAL per hectare	SE		343.0		
Family Labor (Unpaid) %	SE 96		329.3		
Hired labor à 607 F CFA/MD	4		13.7	8,328	
		AMT.	PRICE		
Water requirement, m3/ha	H	7,800	2.80	21,841	
Tools, annual cost per ha	K			4,755	
Mech/Animal Traction, hrs/ha	SE			0	

SUMMARY OF COSTS:		Cost,cfa	% Distr
	Labor, Hired	8,328	10.6
	Water	21,841	27.7
	Seed, fert., pesticides	44,000	55.7
	Mech/Animal Traction	0	0.0
	Tools	4,755	6.0
	Subtotal	78,924	100.0
	Credit = 0 % of costs	0	0.0
GRAND TOTAL OF COSTS (Purchased Inputs)		78,924	100.0

PRODUCTS	Yield	Price	Value
Paddy/Raw Grain. hg/ha	2700	82	221,400
Straw. kg/ha	?	?	0
TOTAL PRODUCTS, Value F CFA			221,400

Net Income per ha (Value of crop less costs), F CFA	142,476
Net income per MD of total labor, cfa	415
Net Income per MD of family labor, cfa	433
Net Income per m3 of water, cfa	18
Paddy per manday of total labor, kg	8
Paddy per manday of family labor, kg	8
Paddy per m3 of water, kg	0.35
Fuel used per hectare of crop, liters	81
Cost of Production per kg of paddy, cfa:-	
-- if all labor is provided by family at no cost	26
-- if all labor is hired, à 1000 per 6.5-hr man-day	153

CROPS MODULE FOR PERIMETER: Potential 28-Mar-90
RAINY SEASON FILE: Normal RiceRP
RICE, fully commercialized production
Sources of data:
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	150	80	12,000	
Fert: Urea, kg/ha	H	200	95	19,000	
Fert: NPK (18-46-0) kg/ha	H	150	93	13,950	
Fert: KCL, kg/ha	H	100	90	9,000	
Pesticides	C	2	3000	6,000	
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha	C	200	30.8		17.4
Labor: Plant (direct seeding)	C	150	23.1		13.0
Labor: Transplant		0	0.0		0.0
Labor: Weed	C	200	30.8		17.4
Labor: Irrigate	C	400	61.5		34.8
Labor: Harvest and Thresh	C	200	30.8		17.4
Labor: Storage and Transport		0	0.0		0.0
Labor: TOTAL per hectare		1150	176.9		100.0
Family Labor (Unpaid) % SE 92		1058	162.8		
Hired labor @ 607/MD % SE 8		92	14.2	8,591	
		AMT.	PRICE		
Water requirement, m3/ha	H	7,800	2.80	21,841	
Tools, annual cost per ha	K			4,755	
Mech/Animal Traction, hrs/ha	C	1	30000	30,000	

		Cost,cfa	% Distr
SUMMARY OF COSTS:	Labor, Hired	8,591	6.0
	Water	21,841	15.2
	Seed, fert., pesticides	59,950	41.7
	Mech/Animal Traction	30,000	20.8
	Tools	4,755	3.3
	Subtotal	125,137	87.0
	Credit = 15% of costs	18,771	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		143,908	100.0

PRODUCTS	Yield	Price	Value
Paddy/Raw Grain. hg/ha	5500	82	451,000
Straw. kg/ha	?	?	0
TOTAL PRODUCTS, Value F CFA			451,000

Net Income per ha (Value of crop less costs), F CFA	307,092
Net income per MD of total labor, cfa	1,736
Net Income per MD of family labor, cfa	1,887
Net Income per m3 of water, cfa	39
Paddy per manday of total labor, kg	31
Paddy per manday of family labor, kg	34
Paddy per m3 of water, kg	0.71
Fuel used per hectare of crop, liters	81
Cost of Production per kg of paddy, cfa:-	
-- if all labor is provided by family at no cost	25
-- if all labor is hired, @ 1000 per 6.5-hr man-day	26

22

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
RAINY SEASON FILE: Normal MaisRP
MAIZE with supplementary irrigation
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	20	160	3,200	
Fert: Urea, kg/ha	H	160	95	15,200	
Fert: NPK (18-46-0) kg/ha	H	150	93	13,950	
Fert: KCL, kg/ha	H	100	90	9,000	
Pesticides				0	
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		ERR
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	SE	816	108.0		31.5
Family Labor Unpaid %	92	751	93.8		
Hired labor @ 607 CFA %	8	65	8.2	4,953	
		AMT.	PRICE		
Water requirement, m3/ha	H,C	3,600	2.80	10,080	
Tools, annual cost per ha	K			3,567	
Mech/Animal Traction, hrs/ha	SE	1	20,000	20,000	

SUMMARY OF COSTS:		Cost,cfa	% Distr
	Labor, Hired	4,953	5.4
	Water	10,080	11.0
	Seed, fert., pesticides	41,350	45.0
	Mech/Animal Traction	20,000	21.8
	Tools	3,567	3.9
	Subtotal	79,951	87.0
	Credit =15% of costs	11,993	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		91,943	100.0

PRODUCTS		Yield	Price	Value
Grain. hg/ha	SEC	5500	80	440,000
Stalks. kg/ha		?	?	0
TOTAL PRODUCTS, Value F CFA				440,000

Net Income per ha (Value of crop less costs), F CFA	348,057
Net income per MD of total labor, cfa	3,223
Net Income per MD of family labor, cfa	3,709
Net Income per m3 of water, cfa	97
Maize grain per manday of total labor, kg	51
Maize grain per manday of family labor, kg	59
Maize grain per m3 of water, kg	1.53
Fuel used per hectare of crop, liters	37
Cost of Production per kg of grain, cfa:-	
-- if all labor is provided by family at no cost	16
-- if all labor is hired, @ 1000 per 8-hr man-day	35

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
RAINY SEASON FILE: Normal MilRP
MILLET with Supplementary Irrigation
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	2	80	160	
Fert: Urea, kg/ha	H	160	95	15,200	
Fert: NPK (18-46-0) kg/ha	H	100	93	9,300	
Fert: KCL, kg/ha	H	50	90	4,500	
Pesticides					
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		ERR
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	SE	864	108.0		31.5
Family Labor Unpaid %	93	804	100.4		
Hired labor @ 607 CFA %	7	60	7.6	4,589	
		AMT.	PRICE		
Water requirement, m3/ha	C	2,500	2.80	7,000	
Tools, annual cost per ha	K			3,567	
Mech/Animal Traction	SE		20,000	20,000	

		Cost,cfa	% Distr
SUMMARY OF COSTS:	Labor, Hired	4,589	6.2
	Water	7,000	9.5
	Seed, fert., pesticides	29,160	39.4
	Mech/Animal Traction	20,000	27.0
	Tools	3,567	4.8
	Subtotal	64,316	87.0
	Credit =15 % of costs	9,647	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		73,964	100.0

PRODUCTS		Yield	Price	Value
Millet Grain. hg/ha	C	4000	80	320,000
Straw/stalks, kg/ha		?	?	0
TOTAL PRODUCTS, Value F CFA				320,000

Net Income per ha (Value of crop less costs), F CFA	246,036
Net income per MD of total labor, cfa	2,278
Net Income per MD of family labor, cfa	2,450
Net Income per m3 of water, cfa	98
Millet per manday of total labor, kg	37
Millet per manday of family labor, kg	40
Millet per m3 of water, kg	1.60
Fuel used per hectare of crop, liters	26
Cost of Production per kg of grain, cfa:-	
-- if all labor is provided by family at no cost	17
-- if all labor is hired, @ 1000 per 8-hr man-day	44

'CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
RAINY SEASON FILE: Normal SorgRP
SORGHUM with supplementary irrigation
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	4	80	320	
Fert: Urea, kg/ha	H	160	95	15,200	
Fert: NPK (18-46-0) kg/ha	H	100	93	9,300	
Fert: KCL, kg/ha	H	50	90	4,500	
Pesticides					
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		ERR
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	SE	816	108.0		31.5
Family Labor Unpaid %	92	751	93.8		
Hired labor @ 607 CFA %	8	65	8.2	4,953	
		AMT.	PRICE		
Water requirement, m3/ha	H,C	3,000	2.80	8,400	
Tools, annual cost per ha	K			3,567	
Mech/Animal Traction, hrs/ha	SE	1	20,000	20,000	

		Cost,cfa	% Distr
SUMMARY OF COSTS:	Labor, Hired	4,953	6.5
	Water	8,400	11.0
	Seed, fert., pesticides	29,320	38.5
	Mech/Animal Traction	20,000	26.3
	Tools	3,567	4.7
	Subtotal	66,240	87.0
	Credit =15% of costs	9,936	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		76,177	100.0

PRODUCTS		Yield	Price	Value
Sorghum Grain. hg/ha	C	5500	80	440,000
Stalks/straw		?	?	0
TOTAL PRODUCTS, Value F CFA				440,000

Net Income per ha (Value of crop less costs), F CFA	363,823
Net income per MD of total labor, cfa	3,369
Net Income per MD of family labor, cfa	3,877
Net Income per m3 of water, cfa	121
Sorghum grain per manday of total labor, kg	51
Sorghum grain per manday of family labor, kg	59
Sorghum grain per m3 of water, kg	1.83
Fuel used per hectare of crop, liters	31
Cost of Production per kg of grain, cfa:-	
-- if all labor is provided by family at no cost	13
-- if all labor is hired, @ 1000 per 8-hr man-day	33

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
DRY COLD SEASON FILE: Normal (RiceDC)
RICE w/ proper inputs and some mechanization (Commercial production)
Sources of data:
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	150	80	12,00	
Fert: Urea, kg/ha	H	200	95	19,000	
Fert: NPK (18-46-0) kg/ha	H	150	93	13,950	
Fert: KCL, kg/ha	H	100	90	9,000	
Pesticides	C	2	3000	6,000	
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha	C				0.0
Labor: Plant (direct seeding)	C	Details			0.0
Labor: Transplant			not		0.0
Labor: Weed	C			available	0.0
Labor: Irrigate	C				0.0
Labor: Harvest and Thresh	C	Total	shown below		0.0
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	C	1151	177.0		51.6
Family Labor Unpaid * %	0	0	0.0		
Hired labor @ 1000 F CFA %100		1151	177.0	177,000	
		AMT.	PRICE		
Water requirement, m3/ha		10,320	6.40	66,051	
Tools, annual cost per ha	K			4,755	
Mech/Animal Traction, hrs/ha	C	1	30000	30,000	

SUMMARY OF COSTS:	Labor, Hired	177,000	45.6
	Water	66,051	17.0
	Seed, fert., pesticides	59,950	15.4
	Mech/Animal Traction	30,000	7.7
	Tools	4,755	1.2
	Subtotal	337,756	87.0
	Credit = 15% of costs	50,663	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		388,419	100.0

PRODUCTS	Yield	Price	Value
Paddy/Raw Grain. hg/ha	5500	82	451,000
Straw. kg/ha	?	?	0
TOTAL PRODUCTS, Value F CFA			451,000

Net Income per ha (Value of crop less costs), F CFA	62,581
Net income per MD of total labor, F CFA	354
Net Income per MD of family labor, F CFA	ERR
Net Income per m3 of water, F CFA	6
Paddy per manday of total labor, kg	31
Paddy per manday of family labor, kg	ERR
Paddy per m3 of water, kg	0.53
Fuel used per hectare of crop, liters	244
Cost of Production per kg of paddy, F CFA:-	
-- if all labor is provided by family at no cost	38
-- if all labor is hired, @ 1000 per 6.5-hr man-day	71

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
DRY COLD SEASON FILE: Normal MaisDC
MAIZE, Irrigated
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	20	160	3,200	
Fert: Urea, kg/ha	H	160	95	15,200	
Fert: NPK (18-46-0) kg/ha	H	150	93	13,950	
Fert: KCL, kg/ha	H	100	90	9,000	
Pesticides					
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		ERR
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	SE	864	108.0		
Family Labor Unpaid %	0	0	0.0		
Hired labor @ 1000 CFA %	100	864	108.0	108,000	
		AMT.	PRICE		
Water requirement, m3/ha	H,C	10,700	6.40	68,483	
Tools, annual cost per ha	K			3,567	
Mech/Animal Traction, hrs/ha	SE	1	20000	20,000	

SUMMARY OF COSTS:	Labor, Hired	108,000	38.9
	Water	68,483	24.7
	Seed, fert., pesticides	41,350	14.9
	Mech/Animal Traction	20,000	7.2
	Tools	3,567	1.3
	Subtotal	241,400	87.0
	Credit = 15% of costs	36,210	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		277,610	100.0

PRODUCTS	Yield	Price	Value
Grain. hg/ha	5000	80	400,000
Straw. kg/ha **	?	?	0
TOTAL PRODUCTS, Value F CFA			400,000

Net Income per ha (Value of crop less costs), F CFA	122,390
Net income per MD of total labor, cfa	1,133
Net Income per MD of family labor, cfa	ERR
Net Income per m3 of water, cfa	11
Maize per manday of total labor, kg	46
Maize per manday of family labor, kg	ERR
Maize per m3 of water, kg	0.47
Fuel used per hectare of crop, liters	253
Cost of Production per kg of grain, cfa:-	
-- if all labor is provided by family at no cost	34
-- if all labor is hired, @ 1000 per 8-hr man-day	56

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
COLD DRY SEASON FILE: Normal MilDC
MILLET, Irrigated
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	2	100	200	
Fert: Urea, kg/ha	H	160	95	15,200	
Fert: NPK (18-46-0) kg/ha	H	150	93	13,950	
Fert: KCL, kg/ha	H	100	90	9,000	
Pesticides					
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		ERR
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	SE	864	108.0		31.5
Family Labor Unpaid %	0	0	0.0		
Hired labor @ 1000 CFA %	100	864	108.0	108,000	
		AMT.	PRICE		
Water requirement, m3/ha	H,C	3,500	6.40	22,401	
Tools, annual cost per ha	K			3,567	
Mech/Animal Traction, hrs/ha	SE	1	20,000	20,000	

SUMMARY OF COSTS:			
Labor, Hired		108,000	48.8
Water		22,401	10.1
Seed, fert., pesticides		38,350	17.3
Mech/Animal Traction		20,000	9.0
Tools	K	3,567	1.6
Subtotal		192,318	87.0
Credit =15 % of costs		28,848	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		221,166	100.0

PRODUCTS		Yield	Price	Value
Millet Grain. hg/ha	C	2500	80	200,000
Straw. kg/ha		?	?	0
TOTAL PRODUCTS, Value F CFA				200,000

Net Income per ha (Value of crop less costs), F CFA	(21,166)
Net income per MD of total labor, cfa	(196)
Net Income per MD of family labor, cfa	ERR
Net Income per m3 of water, cfa	(6)
Millet per manday of total labor, kg	23
Millet per manday of family labor, kg	ERR
Millet per m3 of water, kg	0.71
Fuel used per hectare of crop, liters	83
Cost of Production per kg of grain, cfa:-	
-- if all labor is provided by family at no cost	45
-- if all labor is hired, @ 1000 per 8-hr man-day	88

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
DRY COLD SEASON FILE: Normal SorgDC
SORGHUM, Irrigated
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	H	4	80	320	
Fert: Urea, kg/ha	H	160	95	15,200	
Fert: NPK (18-46-0) kg/ha	H	100	93	9,300	
Fert: KCL, kg/ha	H	50	90	4,500	
Pesticides					
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		ERR
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	SE	864	108.0		
Family Labor Unpaid %	0	0	0.0		
Hired labor @ 1000 CFA %	100	864	108.0	108,000	
		AMT.	PRICE		
Water requirement, m3/ha	H,C	7,400	6.40	47,362	
Tools, annual cost per ha	K			3,567	
Mech/Animal Traction, hrs/ha	SE	1	20000	20,000	

SUMMARY OF COSTS:	Labor, Hired	108,000	45.1
	Water	47,362	19.8
	Seed, fert., pesticides	29,320	12.2
	Mech/Animal Traction	20,000	8.4
	Tools	3,567	1.5
	Subtotal	208,249	87.0
	Credit = 15% of costs	31,237	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		239,486	100.0

PRODUCTS	Yield	Price	Value
Grain. hg/ha (heavy bird damage)	3500	80	280,000
Straw, kg/ha	?	?	0
TOTAL PRODUCTS, Value F CFA			280,000

Net Income per ha (Value of crop less costs), F CFA	40,514
Net income per MD of total labor, cfa	375
Net Income per MD of family labor, cfa	ERR
Net Income per m3 of water, cfa	5
Sorghum per manday of total labor, kg	32
Sorghum per manday of family labor, kg	ERR
Sorghum per m3 of water, kg	0.47
Fuel used per hectare of crop, liters	175
Cost of Production per kg of grain, cfa:-	
-- if all labor is provided by family at no cost	38
-- if all labor is hired, @ 1000 per 8-hr man-day	68

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
DRY COLD SEASON FILE: Normal OnionDC
ONIONS, Irrigated
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	C	0.4	15000	6,000	
Fert: Urea, kg/ha	H	300	95	28,500	
Fert: NPK (18-46-0) kg/ha	H	345	93	32,085	
Fert: KCL, kg/ha	H	100	90	9,000	
Pesticides					
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		0.0
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	C		660.0		192.4
	0	0	0.0		
Hired labor @ 1000 CFA %	100	0	660.0	660,000	
		AMT.	PRICE		
Water requirement, m3/ha	H,C	10,700	6.40	68,483	
Tools, annual cost per ha	C			3,567	
Mech/Animal Traction, hrs/ha				0	

SUMMARY OF COSTS:	Labor, Hired	660,000	71.1
	Water	68,483	7.4
	Seed, fert., pesticides	75,585	8.1
	Mech/Animal Traction	0	0.0
	Tools	3,567	0.4
	Subtotal	807,635	87.0
	Credit = 15% of costs	121,145	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		928,780	100.0

PRODUCTS		Yield	Price	Value
Onions. hg/ha	H,C	41000	125	5125000
Byproduct. kg/ha				
TOTAL PRODUCTS, Value F CFA				5125000

Net Income per ha (Value of crop less costs), F CFA	4196220
Net income per MD of total labor, cfa	6,358
Net Income per MD of family labor, cfa	ERR
Net Income per m3 of water, cfa	392
Onions per manday of total labor, kg	62
Onions per manday of family labor, kg	ERR
Onions per m3 of water, kg	3.83
Fuel used per hectare of crop, liters	253
Cost of Production per kg of output, cfa:-	
-- if all labor is provided by family at no cost	7
-- if all labor is hired, @ 1000 per 8-hr man-day	23

( )PS MODULE FOR PERIMETER: Potential 27-Mar-90
DRY COLD SEASON FILE: Normal OnionDC
ONIONS, Irrigated Adjusted Yield & Price
Sources of data: Socio-economic survey = SE
Harza TA team = H; Keita = K; SAED = S; Consultant = C

INPUTS		Amount	Price	Cost,cfa	% Distr
Seed, kg/ha	C	0.4	15000	6,000	
Fert: Urea, kg/ha	H	300	95	28,500	
Fert: NPK (18-46-0) kg/ha	H	345	93	32,085	
Fert: KCL, kg/ha	H	100	90	9,000	
Pesticides					
		HOURS	MANDAYS		
Labor: Land prep, man hrs/ha					0.0
Labor: Plant (direct seeding)		Distribution			0.0
Labor: Transplant					0.0
Labor: Weed		of labor			0.0
Labor: Irrigate					0.0
Labor: Harvest and Thresh			not known		0.0
Labor: Storage and Transport					0.0
Labor: TOTAL per hectare	C		660.0		192.4
	0	0	0.0		
Hired labor à 1000 CFA %	100	0	660.0	660,000	
		AMT.	PRICE		
Water requirement, m3/ha	H,C	10,700	6.40	68,483	
Tools, annual cost per ha	C			3,567	
Mech/Animal Traction, hrs/ha				0	

SUMMARY OF COSTS:	Labor, Hired	660,000	71.1
	Water	68,483	7.4
	Seed, fert., pesticides	75,585	8.1
	Mech/Animal Traction	0	0.0
	Tools	3,567	0.4
	Subtotal	807,635	87.0
	Credit = 15% of costs	121,145	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		928,780	100.0

PRODUCTS		Yield	Price	Value
Onions. hg/ha	H,C	20500	100	2050000
Byproduct. kg/ha				
TOTAL PRODUCTS, Value F CFA				2050000

Net Income per ha (Value of crop less costs), F CFA	1121220
Net income per MD of total labor, cfa	1,699
Net Income per MD of family labor, cfa	ERR
Net Income per m3 of water, cfa	105
Onions per manday of total labor, kg	31
Onions per manday of family labor, kg	ERR
Onions per m3 of water, kg	1.92
Fuel used per hectare of crop, liters	253
Cost of Production per kg of output, cfa:-	
-- if all labor is provided by family at no cost	13
-- if all labor is hired, à 1000 per 8-hr man-day	45

41

CROPS MODULE FOR PERIMETER: Potential 02-Apr-90
YEAR-ROUND OR PERENNIAL CROPS FILE Potential(Banan)
BANANAS Data shown are for an established plantation.
First year has comparable costs but little income.
(Source of data) Cal Burgett, Harza agronomist

INPUTS		Amount	Price	Cost,cfa	% Distr
Plants					
Fert: Urea, kg/ha			95	0	
Fert: NPK (18-46-0) kg/ha		1800	93	167,400	
Fert: KCL, Kg/ha		600	90	54,000	
(Fertilizer applied every month)					
			MANDAYS		

Operating labor is not divided by tasks.
360 mandays required for each 100 plants.
Plants are spaced 3 x 3 m apart = about 1000 plants per ha
Total labor for maintenance and operations = 3650.0 MD per ha per year

Hired labor @ 1000 F CFA %100				3650000	
			PRICE		
Water at 45 l/day/plant, M3/ha		16500			
4 Months rainy season:	C	4000	2.80	11,200	
8 Months dry season:	C	12500	6.40	80,003	
Tools, annual cost per ha	C			10,000	

SUMMARY OF COSTS:	Labor, Hired	3650000	79.9
	Water	91204	2.0
	Seed, fert., pesticides	221400	4.8
	Mech/Animal Traction		0.0
	Tools	10000	0.2
	Subtotal	3972604	87.0
	Credit = 15% of costs	595891	13.0
GRAND TOTAL OF COSTS (Purchased Inputs)		4568495	100.0

PRODUCTS	Yield	Price	Value
Salable product, units per ha	40000	175	7000000
Byproducts, per ha			0
TOTAL PRODUCTS, Value F CFA			7000000

Net Income per ha (Value of crop less costs), F CFA	2431505
Net income per MD of total labor, cfa	666
Net Income per MD of family labor, cfa	ERR
Net Income per m3 of water, cfa	147
Product per manday of total labor, kg	11
Product per manday of family labor, kg	ERR
Product per m3 of water, kg	2.42
Fuel used per hectare of crop, liters	337
Cost of Production per kg of bananas, cfa:-	
-- assuming all family labor (unpaid)	23
-- if labor is charged @ 1000/man-day	114