*** Final Report ***

DETERMINANTS OF SUCCESS OF IRRIGATED PERIMETERS IN THE BAKEL DELEGATION

PART II: THE REST OF THE STORY

(FAMILY, FARM, PERIMETER AND FINANCIAL ANALYSIS MODULES)

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EXECUTIVE SUMMARY

DETERMINANTS OF SUCCESS OF IRRIGATED PERIMETERS IN THE BAKEL DELEGATION PART II: THE REST OF THE STORY (Family, Farm, Perimeter and Financial Modules)

This consultancy continued and completed the development and application of a computer-based analytical system or "model," for use in analysis of irrigated perimeters in the region of Bakel, Senegal. Tasks undertaken were, in order of priority, the preparation of an engine of analysis; the training of a Senegalese economist in the use of the model, and lastly, the actual analysis of irrigated perimeters. This report says more about the actual analysis than the stated priority would justify, because the analysis that was done demonstrates as well as tests the model; what it will do and what it can find out may be the best explanation of what it is.

The model was originally constructed by Reeser and Brusberg in December 1989. A consultancy in early 1990 produced improvements in the model and Part I of this report, and included extensive discussions of Water and Crops modules. In this continuation of that work, further changes were made in the Lotus 123 spreadsheet program to improve the presentation and make the model easier to use. These changes are explained in this report.

Further changes in CROPS module necessitate further discussion. In FAMILY module, addition of the family's work schedule and labor availability now permit calculation of the area of land that could be handled by the labor of that family.

FARM module is used to study multicropping, the production of more than one crop in a given field in the same year. Three of the multicropping programs developed by Cal Burgett of the Harza team, including double and triple cropping of rice and quadruple cropping of onions, sorghum and niebe, were analyzed to determine their labor requirements and their profitability.

These programs are intended to be implemented on pilot perimeters in an extension of the project. They give cropping intensities of 2.0, 3.0 and 4.0 respectively. High levels of inputs and very close control of the timeliness and quality of operations are required, but high yields are produced. However, budgets reveal that no rice production outside of the rainy season is profitable even with good yields, because of the excessive need for and cost of water in the counterseason, so the multiple cropping of rice cannot be recommended. Rainy-season rice is profitable, but less so than alternative cereals crops. In the quadruple cropping program, individually profitable crops are combined, and the combination produces extremely high net income: about 4.5 million F CFA per hectare, 93% of which comes from the onions.

The Amortization module AMORT is used to calculate and present the cost of development of a perimeter, based on data for development of other perimeters by SAED. This module supplies the total investment required, and the schedule for replacement of items that have useful lives shorter than the life of the project.

In Perimeter module, a standard 40-hectare perimeter is assumed to be rehabilitated and capable of intensive crop production under a multicropping program. Three such perimeters are examined. PERI1 features 25 ha of onions and a total of 130 ha of crops, for an intensity of 3.25. Very high net income is achieved. PERI2 features rice, sorghum and millet in a 60-20-20 ratio in the rainy season, and appropriate other crops in the balance of the year. Net income is not outstanding. PERI3 avoids both onions and rice, selecting high-income crops for all seasons; it shows excellent balance and respectable income.

Financial Analysis combines the operating expenses in PERI modules with the investment expenses from AMORT. Internal Rate of Return (IRR) is used as the measure of desirability of the investment. IRR corresponds to an interest rate, and shows the earning power of funds invested in the project. FIN1, FIN2 and FIN3 provide financial analysis of the corresponding PERI modules. The IRRs produced for these perimeters are 193, 5 and 23 percent respectively. These indicate (1) the whole analysis of PERI1 is severely distorted by the extreme value of the onions; (2) the rice perimeter is only modestly profitable, insufficiently so to attract investment, despite that the best rice options are supported by multiculture with other more profitable crops; and (3) the cereals perimeter shows a reasonable and healthy rate of return from production of well-selected crops.

Sensitivity Analysis determines the IRR when basic assumptions are modified. Twelve tests were made for each of the three perimeters and the details are presented in a table in this report. It was found that the onion perimeter tolerated even the most rigorous conditions; it retained high profitability (IRRs over 46%) even when yields were reduced by 50%, prices reduced by half, or the cost of labor doubled. The rice perimeter, marginally profitable at best, dropped to 1.7% IRR when input costs went up by 10%, and every other change tested (higher labor costs, lower prices, lower water use efficiency, lower yields, and combinations) resulted in negative IRRs. The cereals perimeter, however, survived nearly all these same adversities, retaining a positive IRR except when yields were halved or gross combinations of calamities were imposed.

These tests, and the findings generally, support the thesis that there is real possibility of successful and profitable irrigated perimeters in Bakel, given excellent technology, intensive culture and high yields of carefully selected crops (but NOT rice), if reasonable improvements are made in water costs. Early application of these findings, through implementation of a Pilot Perimeter scheme, is strongly recommended.

TABLE OF CONTENTS

List of Tables

ACRONYMS USED IN THIS REPORT

CF	Cash Flow
CNCAS	The Senegalese Agricultural Credit Bank
F CFA	Senegalese currency unit
GIE	Groupement d'Interet Economique, an Economic Interest Group
GMP	Groupe Moto-Pompe, French for Pumping Set
GOS	Government of Senegal
IRR	Internal Rate of Return
IWME	Irrigation, Water Management and Engineering
M3	Cubic Meter(s)
NGO	Non-Governmental Organization
PV	Present Value
SAED	Societe pour l'Amenagement et l'Exploitation de la Valle du Fleuve Senegal
WCE	Water Conveyance Efficiency

Preface and Acknowledgements

The study of irrigation and its potential at Bakel grows more and more challenging, as successive layers of complexity become evident, as my understanding of the problems expands, and as my ability to cope with analytical and other difficulties improves. I hope that my efforts to make available to others what I have learned and what analytical capability I have developed in "the model" will be productive of benefits to my fellow workers in development and to the farmers who need help so badly.

Bakel is a difficult place to work, but my colleagues have been good people to work with; I appreciate their assistance and support. During this assignment, the active participation of Cal Burgett and Eric Brusberg, and the support of those individuals and Chief of Party Ron Gaddis, were particularly beneficial. They gave me the strength to persevere.

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Chapter 1

INTRODUCTION

BACKGROUND

The Project

Since the introduction of irrigation to the Upper Valley of the Senegal River in the mid-1970s, the possibilities of intensive development have fired the imagination and the zeal of the Government of Senegal (GOS) and donors alike. Making intensive use of previously little-used resources of land and water, provision of locally-produced supplies of food in a remote area, contribution to a more favorable (or less unfavorable) national food balance, increased employment and greater economic activity in this remote region have been part of the dreams and plans of both GOS and donors. As has been stated by one enthusiast: With all that land, and water, and sunshine, and people, there just HAS to be some way to make it all productive!

USAID has been supporting the effort to make it all productive since 1977. The current USAID project provides technical assistance through a host-country contract with the Societe pour l'Amenagement et l'Exploitation de la Vallee du Fleuve Senegal (SAED), an arrangement whereby a team of expatriate advisers is supported in Bakel.

The Model.

Efforts of the Harza team to find profitable and sustainable patterns and packages for the development of irrigated agriculture in the region have involved the present consultant on repeated occasions. The first time the task was to design a computer-based analytical system or model, jointly with Dr. Frederick Brusberg. In a second visit, parts of the system were applied. This time, the assignment was to continue and if possible to complete refinement and application of the model, and to institutionalize its use through training of personnel.

Earlier Reports.

Earlier work is relevant to the present consultancy, because the \effort is cumulative, with each assignment building on the accomplishments of the previous one. The nature and use of the model is presented in An Analytical Model for Irrigated Agriculture (Reeser and Brusberg, December, 1989). Analysis of water costs, crop budgets, and the impact of each on costs and profitability was reported in Determinants of Success of Irrigated Perimeters in the Bakel Delegation, Part I: Water and Crops (Reeser, March, 1990). The reader is referred to those documents, inasmuch as an effort is made in the present report to avoid repetition of explanations that have already been provided in some detail in the earlier reports.

SCOPE OF WORK.

The consultant's scope of work for this assignment was simply a continuation of the work begun but not completed in earlier assignments. The objectives, as they were clarified and prioritized during the progress of the work, were threefold: to further develop, refine and assure the proper functioning of the model in use, so as to leave behind an operable engine of analysis; to train a Senegalese counterpart in the use of the model, so as to provide an engine driver and to institutionalize analytical capability; and to complete at least a preliminary analysis, so as to demonstrate the model's operation and to establish a measure of the feasibility of certain program options foreseen for pilot perimeters at Bakel. This program would provide for Harza, SAED and USAID as much guidance as possible regarding the factors that determine the viability and sustainability, and thus the replicability, of irrigated perimeters in the Bakel region. It would also improve the capability to perform additional analyses utilizing new information, when it becomes available.

The analyses undertaken, both in this and in earlier assignments, used real or empirical data and hypothetical data and assumptions in a way that derived benefit from both. The observation and study of actual perimeters and use of data drawn from their current situations as to crops grown, production technology, yields, water use, preservation or deterioration of facilities and resources, marketing strategy, etc., helped to establish whether and to what extent perimeters were already profitable, viable and sustainable. In thus quantifying the profitability or lack thereof for the perimeters, a benchmark was set against which any progress that might be made could be measured.

To study possible changes or modifications in the perimeters, certain features of the perimeters such as area developed, soils, human resources, etc. that are hardly amenable to change, were retained. Different crops, alternative production technology, improvements in water management and other changes were introduced; these changes could only be estimated because they have not yet been made, so hypothetical data were used. Such a combination of real and hypothetical data was utilized in the earlier report (Reeser, March 1990) for water and crops. Findings were presented in that report that showed high water costs, low crop yields, and indifferent or negative profitability in the current situation, but considerable potential for reduction of water costs, improvement of crop yields, and substitution of alternative crops. The combination of possible changes could make irrigated farming at Bakel financially quite attractive.

The earlier analysis was able fully to utilize only the Water and Crop modules of the analytical system. The permutations and possibilities imposed by and revealed through the Family, Farm, Amortization, and Perimeter modules and the overall desirability of the program(s) as revealed by Financial/Economic Analysis modules remained to be considered and treated; that is the task of the present assignment.

Training.

In planning for the assignment, it was hoped to provide training in the use of the model for one or more Senegalese SAED personnel,

so that some measure of institutionalization of analytical capability would be achieved. That kind of training in use of computers, understanding and use of Lotus 123, project analysis, and use of the model to facilitate project analysis was in fact given to the SAED/Bakel Senegalese Chief of the Bureau of Evaluation. Showing excellent learning ability and more than ordinary initiative, he made rapid progress in the use of Lotus and Quattro software programs. Before the departure of the consultant, the trainee had acquired a good general understanding of the model and ability to use parts of it. Instilling full capability to use all aspects of the model will require more time and continued effort.

CHANGES IN THE MODEL

Development of the analytical system has been an iterative process. While the original (December 1989) model appeared to be quite operational, subsequent use has revealed difficulties and, more important, a number of opportunities for improvement to give greater flexibility, broader utility, etc. Further changes have been introduced this time, as described below:

Source Table. A table of standard prices for inputs and products has been established (at A1..E30); it is shown in Table 1.1. Other modules draw data from this table. Examples are prices of fertilizer, farm-gate prices for rice and other products, labor cost per Man-Day, interest rate, water conveyance efficiency, etc.

The result is not only that individual tables are less cluttered, but more importantly that one can change prices and other factors across the board by making only one entry in this "control panel," although the change may affect a dozen or more different crops and several of the modules.

Sensitivity Testing. Tests of sensitivity and playing "what if" are facilitated by the Prices table. Varying the prices of inputs or products and certain other factors up or down can be done by altering a percentage in the Prices table. Likewise, yields of all crops can be varied by entering the percentage of the base yield that one wishes to test.

Table 1.1 Range: PRICES
19-Jul-90

STANDARD PRICES AND MEASURES
For Use in All Modules
Prices in F CFA per Unit

INPUTS	Base Price	Adjustmt Factor,%	Price as used
Diesel fuel, per liter	210	100	210
Fertilizer, Urea. kg	95	100	95
Fertilizer, 18-46-0, kg	93	100	93
Fertilizer, KCl, kg	90	100	90
Pesticides, liter	3000	100	3000
Hired Labor, per Man-Day	750	100	750
Interest on borrowed funds:			
% of amount borrowed	15	100	15
OUTPUTS: Farm-gate prices			
Rice (as Paddy)	85	100	85
Maize, grain	80	100	80
Sorghum, grain	80	100	80
Millet, grain	80	100	80
Wheat, grain	100	100	100
Niebe, grain	160	100	160
Onions, kg	125	100	125
Bananas, kg	175	100	175
Crop yields (shown in CROPS module)		100	see modules
Water Cost Factors:			
GMP Life, hours	12,000		
WCE, percent	75		
Fin. Internal Rate of Return	PERI1	PERI2	PERI3
Fin IRR =	192.6	5.1	23.2

Investment Costs. Amortization of pipes and canals has been removed from the water cost calculations, to join these costs with other costs of perimeter development in the Amortization module, thus making water cost more nearly independent of other aspects of infrastructure. Costs of water is still considered to include the amortization of the GMP.

Streamlining of Crops Modules. The replication of crops modules to over 20 occupied more spreadsheet space and was more complicated to manage than was desired. In the Crops module, the standard form for entering the data was extensively rearranged to set up three groups of data: inputs and outputs information; costs and returns calculated from the inputs and outputs data; and analytical factors. These data in three groups form a column, and adjacent columns for 20-odd crops and options facilitate comparison as to amount of water required, net income per hectare, product per unit of inputs, or any other item of information presented. To further facilitate analysis, comparison and selection of crops, data for alternative crops are also presented side-by-side, with crops for the rainy season in Table 1.2 and crops for the counterseason season in Table 1.3.

Codes for crops were also introduced. These are intended to convey information at a glance, rather than to mystify. The codes used in Tables 1.2 and 1.3 include a letter to indicate the species: R for rice, S for sorghum, C for corn (maize) to avoid confusion with M for millet, O for onions, etc. The digits that follow reveal the number of the option for that crop and months of planting and harvesting, in that order. Thus, for example, R2-0812 is the second option presented for rice; it is planted in August and harvested in December. In the case of niebe, which can be planted almost anytime and harvested within a three-month period, the crop is represented as follows: N3-??+3.

Other modifications that are likely to be of more restricted interest and impact are these:

* The availability of family labor for work in irrigation farming, as opposed to the culture of rainfed (dieri) crops by months, is calculated in the Family module. Discussion of this is found in Chapter 2.

* Interest charges. A word of explanation is in order regarding charges for interest, particularly in the crops budgets and Financial Analysis module. Currently relatively small amounts of inputs are bank-financed, largely because of the difficulty of obtaining credit. One of the assumptions made for the planned pilot perimeter program is that credit will be more easily available. The rate of interest charged by CNCAS does not express well all of the costs of credit, which is much higher than the nominal rate if one includes costs such as establishing GIE status, setting up a bank account with a minimum deposit, fees for loan application, interest foregone on the down payment, transport and time costs of trips to the bank, etc. Because of the high

Comparison of Alternative Crops
FILE: JUNEREV3 Range: COMPR INPUTS, OUTPUTS, COST!
19-Jul-90 AVAILABLE TO BAKI

Crop and Option	Rice R2-0812	Rice R3-0611	Rice RV-0812
INPUTS and PRODUCTS			
(All prices supplied from PRI			
Seed, kg/ha	150	150	150
Fert: Urea, kg/ha	200	200	0
Fert: NPK (18-46-0) kg/ha	150	150	0
Fert: KCL, kg/ha	100	100	0
Pesticides	2	2	0
Total Labor, Man-Days	200	220	343
Water req'mnt, low cost, M3/ha	7,800	7,000	7,800
Water req'mnt, high cost,M3/ha	0	3,700	0
Tools, annual cost per ha	5,000	5,000	5,000
Hired Traction, cost/ha	0	0	0
Primary Product, kg/ha	5,000	5,000	2,700
Primary Product, Price/kg	85	85	85
By-Product, Value/ha	0	0	0
COSTS and RETURNS			
Seed	15,300	15,300	15,300
Fert: Urea	19,000	19,000	0
Fert: NPK (18-46-0)	13,950	13,950	0
Fert: KCL	9,000	9,000	0
Pesticides	6,000	6,000	0
Subtotal, Purchased Inputs	63,250	63,250	15,300
Labor cost if all hired labor	150,000	165,000	257,250
Water cost per hectare	55,397	86,162	55,397
Tools, annual cost per ha	5,000	5,000	5,000
Hired Traction, cost/ha	0	0	0
Subtotal, Production Costs	273,647	319,412	332,947
Credit cost at standard rate	41,047	47,912	49,942
TOTAL, ALL COSTS, F CFA	314,695	367,324	382,890
Value of Primary Product	425,000	425,000	229,500
TOTAL VALUE, ALL PRODUCTS F CFA	425,000	425,000	229,500
ANALYSIS			
Net Income per Hectare	110,305	57,676	(153,390)
Net Income/MD total labor, cfa	552	262	(447)
Net Income/1000 CFA prod'n exp.	351	157	(401)
Net Income/M3 of water, cfa	14	5	(20)
Product/manday of total labor,	25	23	8
Product per m3 of water, kg	0.6	0.5	0.3
Cost of Production/kg of Primary Product			
- if all labor family/unpaid	28	36	32
- if all labor is hired/paid	63	73	142

Comparison of Alternative Crops
FILE: JUNEREV3 Range: COMPD INP
19-Jul-90

Crop and Option	Rice R1-0106	Onions 03-1203	Onions 04-0105
INPUTS and PRODUCTS		Seed Adj	Seed Adj
(All prices supplied from PRICES tabl			
Seed, kg/ha	150	50	50
Fert: Urea, kg/ha	200	300	300
Fert: NPK (18-46-0) kg/ha	150	345	345
Fert: KCL, kg/ha	100	100	100
Pesticides	2	0	0
Total Labor, Man-Days	250	610	610
Water req'mnt, low cost, M3/ha	0	0	0
Water req'mnt, high cost,M3/ha	16,050	15,400	18,500
Tools, annual cost per ha	5,000	5,000	5,000
Hired Traction, cost/ha	0	0	0
Primary Product, kg/ha	5,000	40,000	40,000
Primary Product, Price/kg	85	125	125
By-Product, Value/ha	0	0	0
COSTS and RETURNS			
Seed	15,300	7,500	7,500
Fert: Urea	19,000	28,500	28,500
Fert: NPK (18-46-0)	13,950	32,085	32,085
Fert: KCL	9,000	9,000	9,000
Pesticides	6,000	0	0
Subtotal, Purchased Inputs	63,250	77,085	77,085
Labor cost if all hired labor	187,500	457,500	457,500
Water cost per hectare	158,100	151,698	182,234
Tools, annual cost per ha	5,000	5,000	5,000
Hired Traction, cost/ha	0	0	0
Subtotal, Production Costs	413,850	691,283	721,819
Credit cost at standard rate	62,078	103,692	108,273
TOTAL, ALL COSTS, F CFA	475,928	794,975	830,092
Value of Primary Product	425,000	5,000,000	5,000,000
TOTAL VALUE, ALL PRODUCTS F CFA	425,000	5,000,000	5,000,000
ANALYSIS			
Net Income per Hectare	(50,928)	4,205,025	4,169,908
Net Income/MD total labor, cfa	(204)	6,893	6,836
Net Income/1000 CFA prod'n exp.	(107)	5,290	5,023
Net Income/M3 of water, cfa	(3)	273	225
Product/manday of total labor,	20	66	66
Product per m3 of water, kg	0.3	2.6	2.2
Cost of Production/kg of Primary Product			
- if all labor family/unpaid	52	7	8
- if all labor is hired/paid	95	20	21

total cost, some producers will choose to finance production costs from other sources or from private funds with a lower opportunity price.

The nominal CNCAS interest rate is used in this study as a proxy for and estimation of an average of the higher real cost of bank financing and the lower opportunity costs of self-financing, weighted by the amount of use of each.

* Automation. Several opportunities have been found for automating the transfer of information within the model, to make the "bottom line" easier to reach. Facilitating of sensitivity testing, as mentioned earlier, is one of these opportunities; others include instant transfer of crops information to perimeter modules and from perimeter modules to Financial Analysis. However, no amount of automation can completely replace a skilled operator; understanding of the analytical system and how its works is still important.

Chapter 2

THE FAMILY: SOCIOLOGICAL AND SUBSISTENCE CONSIDERATIONS

Analysis of the irrigated agriculture of Bakel, using the computer-based analytical system already mentioned and discussed, has up to this point ignored the human resource angle except for calculation of labor requirements for crop production. At this point, it is appropriate to consider the availability of labor within the family -- the basic unit of organization of agricultural production -- and the requirements of the family for cereals. It is commonly (and reasonably) assumed that the primary motivation of farm families is subsistence: to produce food to feed the family. A measure of how well families in Bakel are able to do that constitutes one measure of the success or adequacy of their agriculture, and indicates how well positioned these families are to move into commercial production

The socio-economic survey carried on by the SAED-Harza project has collected data on a sample of families in the four Zones of the Bakel Delegation. Preliminary analysis of the data collected in that effort was made and reported by Dr. Frederick E. Brusberg in his Interim Report (Second Mission) in March 1990. Some additional analysis has been made of the data gathered in that survey to permit the use of real data rather than professional estimates.

A TYPICAL CONCESSION

The text table on the following page presents data from Brusberg's report. "Concession" is the local (French) term for an extended family, a group that is related by ancestry and marriage and that lives, eats, and works together. This family unit is sometimes used as the basis for allocation of land in the perimeter, although what appears to be a family farm is normally only a part of the operations of a concession.

Analysis of the labor availability and adequacy of subsistence for any concession or perimeter should, of course, use data for that concession or perimeter, if such data are available. In the present situation, an appropriate starting point for analysis appears to be the average of the data available for the region, which is 17 members per concession. Table 2.1 presents the Family Module showing the makeup of the family and the labor availability that it represents.

FAMILY MODULE 19-Jul-90

File: JUNEREV3

Table 2.1

FAMILY MAKEUP AND LABOR SUPPLY
In an Average or Typical Concession

Source of data:
Socio-Econon Survey

	Adults Male	Adults Female	Children	TOTAL
Members	5	5	7	17
Residents = Consumers	3	5	7	15
Economically active	3	5	0	8
Avail. for Farm Labor	3	4	0	7
Dieri Crops Area, ha	--	--	--	1.35
Cereals Requirement @ 200 kg/consumer/yr	600	1000	1400	3000

FARM LABOR SUPPLY **

MONTH	DAYS	WORK DAYS	FAMILY WORK DAYS Total	Djeri	Irrig
January	31	23	163	0	163
February	28	23	163	0	163
March	31	23	163	0	163
April	30	23	163	0	163
May	31	23	163	3	160
June	30	23	163	40	123
July	31	23	163	67	96
August	31	23	163	86	77
September	30	23	163	38	125
October	31	23	163	25	138
November	30	23	163	11	152
December	31	23	163	2	161
TOTAL	365	280	1960	272	1688

FOOD SUBSISTENCE AND MARKETING INDICATORS for the family/farm unit

Consumer/Producer Ratio	0.53
Cereals Consumption Requirement, Annual kgs	3000

CONCESSION SIZE AND LABOR ALLOCATION IN BAKEL REGION

Village	Concession Size Range	Ave.	% of Family Labor in Rice	% Labor to Irrig.
Soninke Concessions				
Diawara	13-39	24	84	69
Yelingara	13-28	20	-- (Sorghum)	35
Bakel	7-35	15	80	55
Aroundou	7-31	19	92	55
Ballou	11-25	18	94	33
Subgroup	7-39	20 (Ave. of 4)	88 (Ave. of 5)	49
Toucouleur Concessions				
Naye	6-25	14	--	--
Guitta	4-20	9	--	--
Subgroup	4-25	11	--	--
Entire Sample	4-39	17	--	--

The gender-age breakdown shown for the family membership is estimated for this typical concession (in Table 2.1) on the basis of a subsample of a dozen concessions whose family make-up averaged 30% men, 31% women and 39% children. It may surprise the reader to note that the proportion of working adults in the family is so large, in a society known for rapid rates of reproduction and a large proportion of young persons. This may be explained by the definition of childhood and adulthood that is used.

Western societies commonly define persons as children until the age of puberty, and such persons do not enter into the working force until their late 'teens. In the local society, much use is made of, and much labor performed by, boys and girls of pre-adolescent age; the status of economic adulthood and "actif" in terms of contribution to the local labor supply is achieved at about 10 years of age.

Membership in the concession is a matter of relationship rather than of location. When members of the concession live elsewhere or work abroad, as many young Soninke men do, they are still considered members of the concession. Brusberg's report states that remitters (from abroad in most cases) average 2 per concession, so that at least that many are absent from the family abode. Consumers, thus, number two fewer (males) than members.

Of the remaining 8 adult members of the concession, all are in the working force ("actifs"). This fails to allow for aged persons and for other commitments; some of the young adults attend school and some of the men and women have outside employment (although few outside of Bakel Commune). Adjustment is not made for such cases, because their incidence is not known, and also because in many if not most cases ways are found to free the time of otherwise committed individuals to permit farm work when needed.

Another adjustment seems to be required, however: the women have domestic responsibilities that are inescapable, even in peak work times. While the women do in fact appear to cope with vast amounts of work and innumerable duties, logically there has to be an upper limit, and the cooking must be done. To adjust for that, the availability of "active" women for farm work is reduced by the equivalent of one woman in each concession. If there is only one adult woman, not more than one-third of her time may be allocated to field work.

LABOR AVAILABILITY

The Family module calculates the number of man-days of family labor available for farm work, based on the total number of persons available for farm labor working an average of 23.3 days each month. This is equivalent to 5.5 days of work every week, plus six additional holidays per year. Friday afternoons and all day Mondays are normally non-working times. The other holidays are religious, and following the Moslem lunar calendar they progress from one month to another over time. For this reason, no effort has been made to establish month-specific labor availability, other than a standard monthly figure of 23.3 days per month.

There may be a time in the future when the irrigated crop is the top priority for the family's labor. That is not the situation at present; irrigation is an "add-on." First priority goes to the dieri (rainfed) crops, and when the rains come, everything else has to wait its turn. The problem is to determine when and how much time is to be so allocated, and thus withheld from irrigated farming.

The Socio-Economic Survey recorded, for a number of fields, crops and concessions, the time spent working at various jobs. Tabulation of these data for several concessions provides a measure of the total amount and distribution of labor allocated to rainfed (dieri) crops. The average of this subsample is shown in the Family Module (Table 2.1) under Labor used for Dieri. Most of the dieri labor is from June through November, and it amounts to some 272 Man-Days of labor expended on 1.35 ha of Dieri crops, or about 201 M-D/ha. This amount of time is not available for irrigated crops, being preempted for the rainfed crops.

In this typical concession, the remaining time available for use in irrigated farming is approximately 1700 man-days per year, in amounts varying from month to month, from a low of 77 to full time of about 160 Man-Days per month. These data, shown in Table 2.1, are utilized in calculation of the area that the concession could handle in a program of multicropping.

SUBSISTENCE NEEDS

A common complaint among villagers in the Bakel region is that their parcels of land in the irrigated perimeters are so small that they cannot produce enough rice to feed their families. One of the objectives in the design of the analytical model was to facilitate analysis of subsistence, specifically the calculation of subsistence needs relative to production of cereals. It is clear that in a subsistence economy, calculation of the family's aggregate needs provides a benchmark and a threshold amount of cereal that must be produced before there is anything left over to sell. This can reveal the potential for surplus, and therefore marketable, production.

Parcels of land in the irrigated perimeters are allocated on the basis of a variety of parameters. The size of the family (concession) apparently is used less often than other bases, such as allocating a strip of standard width to each actif. Sometimes only males receive an allocation; sometimes women receive half as wide a strip. Such allocative systems may relate well to the manpower available, but they have little relation to the subsistence needs.

Insufficient time is available to investigate the self-sufficiency aspect at this time. If the potential for profitability of irrigation can be shown to be strongly positive, so that there is real reason for farmers to be attracted to production of irrigated crops, subsistence is likely to become an academic issue. The region may move into commercial production, and sale of crops for money to buy food may become the norm.

Chapter 3

THE FARM MODULE AND MULTICROPPING

THE MODULE

The Farm Module was originally conceived as a device to facilitate examination of the aggregate of activities and operations of a given family, including their dieri (rainfed) and walo (recession) cropping, livestock raising, and other family-based activities as well as irrigated cropping. However interesting and challenging such examination and analysis would be, it has been necessary, in consideration of the priorities of the SAED/Harza project and the limitations on resources for this consultancy, to focus the current analysis on irrigation. That focus would appear to reduce the scope of feasible analysis using the Farm module, but it by no means obviates the utility of the module, for it is an appropriate device for examination of the challenges and possibilities of multicropping. That examination and analysis is presented in this section.

MULTICROPPING

Multicropping is the practice of growing more than one crop per year in a given field, so as to produce a cropping intensity of something more than 1.0. The most obvious case of multicropping, although not necessarily the best way to start, is simply the addition of some second crop in the counterseason, after the rice crop is harvested.

Considerable time and effort has been spent by project agronomist Cal Burgett in the conceptual development, scheduling and budgeting of various crop sequences that seem adapted to the Bakel situation or specific geographic parts thereof. Five such programs have been developed, as follows:

RICE, double culture, especially for Faleme.

RICE, triple culture, for Upper and Lower Goye and Sebou in Faleme.

MAIZE, NIEBE AND ONIONS, quadruple culture with two crops of niebe, for all zones (with certain exceptions).

ONIONS, NIEBE AND SORGHUM, quadruple culture with two crops of onions, for all zones with certain modifications for Faleme.

SORGHUM AND ONIONS, triple culture with two crops of sorghum, for all zones, except no onions in parts of Faleme.

All of these multicropping patterns have been developed with much care and with consideration for all foreseeable variables such as soils, local climate (more rain in Faleme), seasonable availability of water for irrigation (restricted in parts of Faleme), and the necessary operations for production of the crops. Some of the technical aspects of this intensive program are presented below. The economics of multicropping is still under study, although it appears clear in the early stages of analysis that counterseason rice crops will be financially feasible only if water costs can be reduced significantly.

Production Technology

The production technology to be used for producing rice and other crops in the multicropping program envisioned for the Bakel area will be significantly different from what is currently practiced in a number of respects, but only in those respects where changes are necessary in order to achieve the production goals of the program.

A highly significant feature of the new program, and perhaps its most important single change from current production practices, is the rigid schedule for operations. The objective of the program is to get the maximum of profitable production from the land, and to that end the land must be fully utilized. Operations must be done on time, because falling behind schedule will delay maturity of the crop, delay harvest, and delay starting the next crop. The high level of management skill required for successful operation of such a program is an attribute that must be learned, so in the early years of the new system, all operations must be closely monitored.

High-quality seed of selected varieties will be used. Planting dates will be changed -- in some cases changed drastically. All rice will be transplanted, not because the method is intrinsically superior, but because it reduces the time that the crop occupies the field and permits some overlapping of crops; it is also amenable to rigid control of timing. All operations will be performed on a precise schedule, which is essential to the double, triple and quadruple intensity of the multicropping program and the resulting year-round use of the land.

Tillage operations will be performed in more or less the same manner as currently practiced. Hired traction for plowing will not be required, but it will be permissible and will be encouraged if operations fall behind schedule; it probably will be used much more extensively than in the past. Irrigation, like other operations, will be closely monitored as to schedule and adequacy.

Heavier use of fertilizer will be an integral part of the program, and near-optimal yields will be expected.

Labor Requirements

The new production technology will demand the time and attention of laborers in every month of the year; the new program will exploit labor resources with thoroughness comparable to its exploitation of the land. For any given crop, less labor will be needed than with current, traditional methods of production, because shortcuts will be sought and training in the use of labor-saving methods will be provided. However, labor needs per hectare are now estimated as being greater than was estimated in an earlier study in the same area.

The consultant, in an earlier report entitled Determinants of Success of Irrigated Perimeters in the Bakel Delegation (Reeser, March 1990) estimated labor needs for rice production at 177 man-days per hectare (1150 hours at 6.5 hours per man-day). This requirement is shown in Table 3.1, in the middle column headed Improved Methods. As stated in the referenced source document, these figures represented the consultant's judgement of labor use that could be achieved with improved methods: better water control, some mechanization and use of weedicides. The program now envisaged does not entail all of those conditions.

Water control will be better in the rehabilitated perimeters, but more precise control of irrigation and in some cases more frequent watering will offset the labor gains along that line. Mechanization certainly will not be obstructed, and is to be expected later, but on the initiative of the farmers themselves. Mechanization of plowing, land preparation, and threshing is not included in the program, nor is the use of weedicides. Therefore the labor economies expected (in the earlier report) to arise from such technology will not take place. Instead, the more laborious full transplant method of rice production (sometimes referred to as the Japanese or Chinese system) will be used, and conventional land preparation, weed control and harvesting techniques will be used.

Production in the counterseason will require a bird protection program, or at least a bird-scaring activity. In some area wild pigs also constitute a threat to counterseason production. In both cases, the problem will be most severe at the outset; as more farmers in more perimeters produce counterseason crops, pest control programs will be more widely supported and therefore more effective.

Tight schedules for planting the next crop will in some cases require that a crop be removed from the field as soon as it is harvested (before threshing). This, too, raises labor requirements. Earlier estimates of harvesting labor were low because they were based on records of the Project Farm, now known to be unreasonably low because of irregularities in record-keeping and because of unusual skill of the harvest crew. Correction for that error, plus allowance for different technology, additional tasks, and also for the higher yields accompanying the improved

LABORREQ

Table 3.1

Labor Requirements for Production of Irrigated Rice
(Man-Days per Hectare)

<table>
<tr><th rowspan="2">Task</th><th colspan="2">Project Farm</th><th>Improved</th><th colspan="2">New Standard</th></tr>
<tr><th>Dir Seed</th><th>Transplnt</th><th>Methods</th><th>Normal</th><th>Out-of-season</th></tr>
<tr><td>Land preparation</td><td>32</td><td>32</td><td>31</td><td>20</td><td>20</td></tr>
<tr><td>Nursery</td><td>0</td><td>12</td><td>0</td><td>10</td><td>10</td></tr>
<tr><td>Transplant</td><td>0</td><td>112</td><td>23</td><td>45</td><td>45</td></tr>
<tr><td>Dir Plant/Trnsplnt</td><td>18</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Irrigate</td><td>51</td><td>51</td><td>61</td><td>60</td><td>60</td></tr>
<tr><td>Weed</td><td>31</td><td>31</td><td>31</td><td>30</td><td>30</td></tr>
<tr><td>Guard</td><td>0</td><td>0</td><td>0</td><td>0</td><td>30</td></tr>
<tr><td>Harvest</td><td>9</td><td>9</td><td rowspan="2">31</td><td>20</td><td>30</td></tr>
<tr><td>Thresh</td><td>31</td><td>31</td><td>35</td><td>35</td></tr>
<tr><td>TOTAL</td><td>172</td><td>278</td><td>177</td><td>220</td><td>260</td></tr>
</table>

Note: Direct Planting involves transplanting/relocation of field-grown plants to fill empty spaces in the field, but no nursery.

Source: Columns 1, 2 and 3: Robert M. Reeser: Determinants of Success of Irrigated Perimeters, March 1990, p. 8a.

technology, will increase the labor requirements above earlier estimates.

The foregoing changes rationalize an increase in estimates of overall labor needs from 177 man-days per hectare to 220 man-days for normal, rainy-season rice production, and to 260 man-days per hectare for production in other seasons. It will be observed that this labor-intensive system maximizes employment in the region, and avoids certain non-labor costs, such as hired traction, that were included in the earlier budgets. Labor requirements for rice are shown as the New Standard labor requirements, in Table 3.1. Labor requirements for other crops using comparable methods and technology are shown in Table 3.2.

Calendar Distribution of Labor.

Cal Burgett, agronomy and extension adviser for the SAED/Harza project, who developed the intensive multicropping program described above, has also developed the cropping calendars for that program. Working from those cropping calendars and from labor requirements as measured or estimated in other studies and at the project farm, labor requirements by task from the aforementioned table have been allocated within the crop cycle of each successive crop. The result is presented as Table 3.3a and 3.3b, which also presents the monthly labor-per-hectare requirements for each crop and the total for the multicropping program.

Labor availability in a typical concession (household) of the region has been calculated from the results of the Socio-Economic Survey; this was presented in Chapter 2 of this report. Month-by-month availability of family labor within the concession in Table 2.1 permits calculation of the capacity of the labor supply: the area of crop that can be handled by available (family) labor. Also facilitated is the determination of the amount of labor that must be hired, if the area of crop has been independently established.

From the presentation in Tables 3.3a and 3.3b, it should be clear that the typical concession has sufficient labor to cope with most of the labor demands of 3 ha under the Rice Double Culture program in Faleme, with hired labor being needed only in February and August. Such a typical concession could handle 2 ha of the Rice Triple Culture program in Upper and Lower Goye, with significant need for hired labor only in July and December. The quadruple multicropping program of Onions, Niebe (two crops) and Maize, adapted to all zones, can be applied to 1.5 hectares by the labor of the typical concession, with need for hired labor in four months -- January, February, April and August. Thus a basis is established for allocation of land to each concession, and relatively full employment is provided for the full labor contingent of the family.

TASKLABR.wk1
19-Jul-90

Table 3.2

LABOR REQUIRED FOR CROP PRODUCTION, BY TASKS
(Man-Days per Hectare)

TASK	RICE Rainy	RICE Dry	MAIZE Rainy	MAIZE Dry	MILLET Rainy	MILLET Dry	SORGHUM Rainy	SORGHUM Dry	NIEBE Dry	ONIONS Dry
Nursery	10	10	0	0	0	0	0	0	0	40
Land Prep	20	20	10	10	10	10	10	10	10	50
Plant/Trnsplnt	45	45	5	5	5	5	5	5	5	160
Irrigate	40	80	10	20	6	16	8	18	15	70
Weed	30	30	21	21	10	10	10	10	15	40
Guard	0	10	0	10	0	10	0	10	0	0
Apply Chem	0	0	2	2	2	2	2	2	0	0
Harvest	20	20-30	25	25	20	20	22	22	25	150
Thresh	35	35	35	35	30	30	31	31	22	0
Store/Dry	0	0	0	0	0	0	0	0	0	100
TOTAL	200	270-280	108	128	83	103	88	108	92	610

CALENDAR
19-Jul-90

Jan-June: RICE, Vari
95-day cycle, 250

Task		MD Labor	January	February	r	November	December
Nursery		10	!!--10- !		!	! !	
Land Prep		20	!! --20- !		!	! !	
Transplant		45	!!	!-45-	!	! .!	
Irrigate		40-80	!!-----15-------	-25----		! !	
Weed		30	!! !	==10==		! !	
Guard	0	10	!! !		!	! !	
Harvest	20	30	!! !		!	!----20---!	
Thresh		35	!! !		!	!	!----35---
TOTAL/CROP		220-240	45	80	5	20	35
		445 MD for two crops					
Fam. Labor Available			163	163	8	152	161
Labor capacity, ha			3.6	2.0	5	7.6	4.6
M-D hired for		3 ha	0	77	0	0	0
M-D hired, TOTAL/YR			240				

Nov-Mar: RICE, Var. Tachimoucl
95 day cycle, cold-tolerai

Task	MD Labor	January	February	ır	November	December
Nursery	10	!! !		!	! -10- !	
Land Prep	20	!! !		!	!	!-20-
Transplant	45	!! !		!	!	! -45-
Irrigate	40-80	!!---35-----20-		!	!	!----25---
Weed	30	!!---22--- !		!	!	! -8
Guard	0-10	!! --5------5--		!	!	!
Harvest	20-30	!! !	-30-!	)-	!	!
Thresh	35	!! !		!	!-35-	!
TOTAL/CROP	200-260	62	55	25	45	98
	720 MD for three crops					
Fam. Labor Available		163	163	38	152	161
Labor capacity, ha		2.6	3.0	.5	3.4	1.6
M-D hired for	2 ha	0	0	0	0	35
M-D hired, TOTAL/YR =		162				

13c

Jan-Apr: ONIONS Nov-Jan: NIEBE

Task	MD Labor Onions	January	February		November	December
Nursery	40	---40-----				
Land Prep	50	5- -35-			--10-	-10-
Plant/Trnsplnt	160	-60-	-100-		--5--	
Irrigate	70	----20---	----25---		--8----	7--
Weed	40	5-	----20---		-10--	5-
Apply Chem						
Guard						
Harvest	150	----25--		5-		
Thresh			-----22---		-35--	
Store/Dry	100					
TOTAL ONIONS	610	165	145	)	0	10
TOTAL NIEBE	184	25	22	)	33	12
TOTAL MAIZE	108	0	0	5	35	0
M-D ALL CROPS	902	190	167	5	68	22
Fam. Labor Available		163	163	3	152	161
Labor capacity, ha		0.9	1.0	5	2.2	7.3
M-D hired for	1.5 ha	122	87.5	)	0	0
M-D hired, TOTAL/YR =		298.5				

Determination of the economics of these multicropping programs utilizes two main components: the crops budgets, and the Farm module.

CROP BUDGETS FOR MULTICROPPING

The crops module used at this point is significantly different and simpler than the version used in the previous reports. The changes result from reorganization of the presentation, and from elimination of the distribution of labor requirements by months. Analysis of such a labor distribution still seems to be a good idea, but except for crops raised under village conditions, data on labor distribution are simply unavailable at present. The additional refinement of the analysis that would be possible through the use of labor calendars must be deferred because of time constraints.

Considerable proliferation of crop modules has taken place -- more than foreseen and enough to be unwieldy. In the new series are more than twenty production options for eight different crops. The full range is shown in Table 3.4. Grouping of the crops facilitates comparison and contrast, as will be revealed by the following discussion of options for rice.

Six options are available for production of rice. These options differ principally in the length of cycle, the dates of production, and (as a consequence of season) different water requirements and costs of irrigation water. One of them embodies the production technology and yield typically used and obtained in the villages. For crops maturing outside the normal harvest season, additional labor is required for protection of the crop against birds, and in some cases to carry the crop off the fields immediately after harvest (before threshing).

Of these six rice programs, two show a profit of 58 to 110 thousand F CFA; four show losses of 51, 50, 144 and 153 thousand F CFA, with village rice being the worst loser. The losers have higher labor requirements, greater water needs and higher water costs, both per M3 and per hectare. It is not a coincidence that counterseason rice is a losing proposition. The profitability of these crops is quite sensitive to water requirements and costs; at rainy-season water use and costs, the losers might well be winners. Village rice is always a loser because of low yields. Note that the cost of water per M3 delivered to the field has already been reduced from what is believed to be the current situation, by raising pump life from 6000 to 12000 hours while maintaining water conveyance efficiency at 75 percent. Clearly the challenge for economic production of rice lies in reducing water use and water costs -- or simply avoiding production of rice outside of the rainy season.

Crops data are also presented in Table 3.4 for Sorghum, Millet, Maize, Wheat, Niebe, Onions, and Bananas. A few comments

Niebe N2-1102	Niebe N3-??+3	Onions O1-0104	Onions O2-1012	Onions O3-1203	Onions O4-0105	Bananas B1-1212
		Seed Adj	Seed Adj	Seed Adj	Seed Adj	
150	150	50	50	50	50	0
0	0	300	300	300	300	0
0	0	345	345	345	345	1,800
50	--	100	100	100	100	600
0	0	0	0	0	0	0
92	92	610	610	610	610	3,600
0	0	0	7,400	0	0	4,000
6,000	6,000	15,400	8,000	15,400	18,500	12,500
5,000	5,000	5,000	5,000	5,000	5,000	10,000
0	0	0	0	0	0	0
1,500	750	40,000	40,000	40,000	40,000	40,000
160	160	125	125	125	125	175
0	150,000	0	0	0	0	0
28,800	28,800	7,500	7,500	7,500	7,500	0
0	0	28,500	28,500	28,500	28,500	0
0	0	32,085	32,085	32,085	32,085	167,400
4,500	4,500	9,000	9,000	9,000	9,000	54,000
0	0	0	0	0	0	0
33,300	33,300	77,085	77,085	77,085	77,085	221,400
69,000	69,000	457,500	457,500	457,500	457,500	2,700,000
59,103	59,103	151,698	131,360	151,698	182,234	151,540
5,000	5,000	5,000	5,000	5,000	5,000	10,000
0	0	0	0	0	0	0
166,403	166,403	691,283	670,945	691,283	721,819	3,082,940
24,960	24,960	103,692	100,642	103,692	108,273	462,441
191,363	191,363	794,975	771,587	794,975	830,092	3,545,381
240,000	120,000	5,000,000	5,000,000	5,000,000	5,000,000	7,000,000
240,000	270,000	5,000,000	5,000,000	5,000,000	5,000,000	7,000,000
48,637	78,637	4,205,025	4,228,413	4,205,025	4,169,908	3,454,619
529	855	6,893	6,932	6,893	6,836	960
254	411	5,290	5,480	5,290	5,023	974
8	13	273	275	273	225	209
16	8	66	66	66	66	11
0.3	0.1	2.6	2.6	2.6	2.2	2.4
75	149	7	6	7	8	11
128	255	20	19	20	21	89

about these crops are appropriate:

* Maize is a popular crop in Bakel, being raised as a vegetable (the immature ears are harvested for roasting) with some residual grain production. Its potential as a grain crop, and especially as an irrigated, grain-oriented crop, is largely unexploited locally. Extensive worldwide production and local trials support the budget data presented.

Maize is also a profitable crop. Although it falls far short of the level of profitability show by onions, it beats rice decisively. The sequential cropping of niebe and maize probably has a beneficial effect on the maize, too; very important benefits to succeeding crops of millet and sorghum have been demonstrated in research in other countries of Africa.

* Sorghum is a common crop is this locality, but as a rainfed (dieri) rather than irrigated crop. The Socio-Economic Survey showed yields to be about the same for irrigated and rainfed maize, but this was because the irrigated crops were improperly tended, largely unfertilized, and not well irrigated. Sorghum has high potential under local irrigation, but its culture will have to be closely monitored at first to achieve the results shown in the budget.

* Millet is also a popular crop locally, but no records are available of irrigated production hereabouts. The figures in the budget are based on extrapolation from experience in other Sahelian countries.

* Niebe is a short-season crop with relatively low costs except for its seed, and relatively little income from the seeds (grain) because of low yields. Improved varieties of niebe yield twice as much grain, and are a profitable crop that can fit into a variety of situations. Traditional varieties of niebe produce less grain, but they produce large vines that make excellent animal feed. The leaves of niebe are also in demand as a kitchen staple. If one considers the value of the vines (as one of the budgeted options does), this dual- or triple-purpose crop looks good enough to justify its inclusion in many cropping programs. An additional benefit from niebe that apparently has escaped local attention is its favorable effect on the succeeding crop, as a result of its nitrogen-fixing capability.

MULTICROPPING PROGRAMS

Three of the five multicropping programs developed by Burgett are evaluated here; the others are deferred until more time is available. Double, Triple and Quadruple cropping programs are presented in Tables 3.5, 3.6 and 3.7.

Both of the multiple rice-culture programs, double culture in Faleme and triple culture in Upper and Lower Goye, show overall

Table 3.5 19-Jul

MODULE FOR MULTICROPPING

"Double"

Double Culture of Rice (Faleme)	Total All Crops	Rice R1-0106	Rice R2-0812
COSTS and RETURNS Calculations			
Seed	30,600	15,300	15,300
Fert: Urea	38,000	19,000	19,000
Fert: NPK (18-46-0)	27,900	13,950	13,950
Fert: KCL	18,000	9,000	9,000
Pesticides	12,000	6,000	6,000
Subtotal, Purchased Inputs	126,500	63,250	63,250
	0		
Labor cost if all hired labor	337,500	187,500	150,000
Water cost per hectare	234,094	158,100	75,994
Tools, annual cost per ha	10,000	5,000	5,000
Hired Traction, cost/ha	0	0	0
Subtotal, Production Costs	708,094	413,850	294,244
Credit cost at standard rate	106,214	62,078	44,137
	0		
TOTAL, ALL COSTS, F CFA	814,308	475,928	338,381
VALUE OF PRODUCTS, F CFA	850,000	425,000	425,000
ANALYSIS			
Net Income per Hectare	35,692	(50,928)	86,619
Net Income/MD total labor, cfa	229	(204)	433
Net Income/1000 CFA prod'n exp.	149	(107)	256
Net Income/M3 of water, cfa	5	(3)	8
Product/manday of total labor,	23	20	25
Product per m3 of water, kg	0	0.3	0.5
Cost of Production/kg of Product, F CFA:-			
- if all labor family/unpaid	43	52	33
- if all labor is hired/paid	81	95	68

Table 3.6 19-Jul
MODULE FOR MULTICROPPING
"Triple"

Triple Culture of Rice (U & L Goye, Bakel, Sebou)	Sum/Ave. 3 Crops	Rice R3-0611	Rice R4-1103	Rice R5-0306
COSTS and RETURNS Calculations				
Seed	43,350	15,300	14,025	14,025
Fert: Urea	57,000	19,000	19,000	19,000
Fert: NPK (18-46-0)	41,850	13,950	13,950	13,950
Fert: KCL	27,000	9,000	9,000	9,000
Pesticides	18,000	6,000	6,000	6,000
Subtotal, Purchased Inputs	187,200	63,250	61,975	61,975
Labor cost if all hired labor	555,000	165,000	195,000	195,000
Water cost per hectare	465,975	75,994	158,100	231,881
Tools, annual cost per ha	15,000	5,000	5,000	5,000
Hired Traction, cost/ha	0	0	0	0
Subtotal, Production Costs	1223175	309,244	420,075	493,856
Credit cost at standard rate	183,476	46,387	63,011	74,078
TOTAL, ALL COSTS, F CFA	1406651	355,631	483,087	567,934
VALUE OF PRODUCTS, F CFA	1275000	425,000	425,000	425,000
ANALYSIS				
Net Income per Hectare	(131,651)	69,369	(58,087)	-142934
Net Income/MD total labor, cfa	(458)	315	(223)	(550)
Net Income/1000 CFA prod'n exp.	(177)	195	(120)	(252)
Net Income/M3 of water, cfa	(3)	6	(4)	(6)
Product/manday of total labor,	20	23	19	19
Product per m3 of water, kg	0.3	0.5	0.3	0.2
Cost of Production/kg of Product, F CFA:-				
- if all labor family/unpaid	51	33	52	69
- if all labor is hired/paid	94	71	97	114
% Distribution Labor	100	30	35	35
Water M3	100	9	39	52
Water F CFA	100	16	34	50
Total Costs	100	25	34	40
Value of Product	100	33	33	33
Net Income	100	-53	44	109

Table 3.7 19-Jul
MODULE FOR MULTICROPPING
"Quad"

Quadruple Culture: Onions/Niebe/Maize/Niebe	Sum/Ave. 4 Crops	Onions O1-0104	Niebe N1-0507	Maize C1-0711
COSTS and RETURNS Calculations				
Seed	61,435	6,875	26,400	1,760
Fert: Urea	43,700	28,500	0	15,200
Fert: NPK (18-46-0)	46,035	32,085	0	13,950
Fert: KCL	18,000	9,000	0	9,000
Pesticides	0	0	0	0
Subtotal, Purchased Inputs	169,170	76,460	26,400	39,910
	0			
Labor cost if all hired labor	676,500	457,500	69,000	81,000
Water cost per hectare	312,517	151,698	59,103	42,613
Tools, annual cost per ha	20,000	5,000	5,000	5,000
Hired Traction, cost/ha	0	0	0	0
Subtotal, Production Costs	1178187	690,658	159,503	168,523
Credit cost at standard rate	176,728	103,599	23,925	25,279
	0			
TOTAL, ALL COSTS, F CFA	1354915	794,256	183,428	193,802
VALUE OF PRODUCTS, F CFA	5880000	5000000	240,000	400,000
ANALYSIS				
Net Income per Hectare	4525085	4205744	56,572	206,198
Net Income/MD total labor, cfa	10,034	6,895	615	1,909
Net Income/1000 CFA prod'n exp.	6,976	5,295	308	1,064
Net Income/M3 of water, cfa	326	273	9	34
Product/manday of total labor,	39	66	16	46
Product per m3 of water, kg	1.0	2.6	0.3	0.8
Cost of Production/kg of Product, F CFA:-				
- if all labor family/unpaid	41	7	69	20
- if all labor is hired/paid	76	20	122	39
% Distribution Labor	100	68	10	12
Water M3	100	46	18	18
Water F CFA	100	49	19	14
Total Costs	100	59	14	14
Value of Product	100	85	4	7
Net Income	100	93	1	5

losses, despite the fact that each includes one profitable crop. They also show achievement of cropping intensities or 2.0 and 3.0 respectively; production of large quantities of paddy; employment of large numbers of workers; and use of large quantities of water.

Policy makers will be delighted with the first three attributes and will be unconcerned about the last. However, unless ways can be found to reduce the high cost of counterseason culture of rice, local farmers will not maintain interest beyond their first awareness of the cost-returns relationship. There simply are too many other and more attractive alternative uses of the available resources of land, water, labor and capital.

The multicropping program including maize and onions and fitting in two crops of niebe, all in the same year on the same land area, achieves a cropping intensity of 4.0 and profit on every one of the crops. These crops do not appear to be particularly sensitive to the costs of water and labor. Maize, for example, would still be profitable if the currently-budgeted costs of BOTH water and labor were doubled. Niebe shows a profit both with and without consideration of the value of the vines and leaves as livestock feed, and without allowance for its beneficial effect on subsequent crops. The possibility of having all this and onions too makes this combination seem almost Utopian in its desirability -- and almost unbelievable in its profitability.

CONCLUSIONS REGARDING MULTICROPPING

This detailed examination and analysis of multicropping from various standpoints including technical feasibility, labor requirements, and anticipated cost of production shows several things:

1. Multicropping **CAN** be done. It is technically feasible, and budgeting shows that it is also financially feasible.

2. The whole program is dependent on close controls and timely operations, requiring a level of management skill that is yet to be demonstrated in the local society. Much training of farmers and a thorough extension program will be required.

3. Multicropping, if done, certainly will result in considerable increases in production of the selected crop or crops. These increases have implications for local consumption and also for marketing programs and facilities to accommodate the output.

4. Effects on labor will be to increase the total amount of labor needed for agricultural operations, but to increase the certainty of such employment and the advance knowledge of its timing. Waiting on the rains is NOT a feature of this program!

5. A commitment at this time to the further development and testing of multicropping in both concept and practice would appear to be fully justified by what has already been learned, demonstrated and presented.

6. The marginal profitability of rice production suggests that commitments to rice production should be delayed until experimental work and testing has found that water costs in fact can (or cannot) be reduced to a level that makes rice culture profitable. If water costs cannot be sufficiently reduced, then rice culture should be abandoned in this area, in favor of other crops that show promise of technical and financial success.

7. Appraisal of the local situation suggests that it is ripe for major changes in agriculture. Relevant aspects of the local situation include: (a) the existence of infrastructure and capability for irrigation, including at least rudimentary awareness and required skills; (b) some local experience (not all of it good) with organization into groupements, for some measure of collective action in agricultural programs; (c) local dissatisfaction with the failures of irrigated rice to provide sufficient food or income; (d) local concern about future employment of local persons who are currently working overseas in countries where foreign labor is being subjected to progressively tighter controls; and (e) strong desires, even expectations, that USAID will come forward with a program that will have a real and beneficial impact on the community.

Chapter 4

INVESTMENT AND AMORTIZATION

In the past, when SAED was in its heyday, the cost of developing a tract of land into an operable irrigated perimeter was not a matter of concern to the farmers who received allocations (parcels) of land in the perimeters. It was, or certainly should have been, a matter of great concern to SAED and to the funding agencies, whether GOS, USAID or other agencies.

Currently, with SAED's largess being phased out and with new programs focussing on privatization, development costs -- or at least a greater portion of them -- must be met by private investors. Therefore, it is desirable to inquire into the magnitude of the needed investment.

The cost of development of land for irrigation is one of two main cost categories of concern, the other being the high cost of production relative to market prices. It appears that production costs on a per-unit-of-output basis can be significantly reduced by heavier applications of various inputs (like fertilizer) that increase yields. It should also be possible to reduce the cost of water by extending the useful life of pumping sets and reducing water losses in the canals. These changes will leave investment costs as the main barrier to widespread investment -- and that barrier will not be insurmountable, if production is sufficiently profitable.

INVESTMENT COSTS

There are a few perimeters in the Delegation of Bakel that were developed by private individuals and groups, but the cost of such development were largely unrecorded, utilizing contributed labor and often other contributions from NGOs or emigrants. The larger-scale perimeters were all developed by SAED. "Large" is a relative matter, of course; the largest perimeters in this region would be considered medium or small size further down-river or in the Delta. At any rate, SAED is the best if not the only source available for data on the development of irrigation facilities in this region.

Two reports will serve as indicators of the costs of development. The first is a SAED estimate of costs, identical with subsequent billing to and payment by USAID, for development of three perimeters in 1989-90. This document was reported in an earlier report (Reeser: Determinants of Success, March 1990) when it was compared to data from a SAED instructional manual. The second document is an estimate of the costs of a village irrigation system in the Upper Valley, found in the Project Paper for the IWME-1 project but believed to be based on information from SAED.

Information from these two sources is compiled and presented in Table 4.1, both as "total" figures and reduced to a per hectare basis. Rather wide discrepancies are to be found in the two sets of estimates, undoubtedly due to differing circumstances and requirements of the locale. To establish an order-of-magnitude estimate useful for budgets and cost studies pending the development of information for specific perimeters, the consultant selected from within the range per hectare figures that seemed to him to be conservative and realistic. These estimates by the consultant are also presented in Table 4.1, and are expanded to express the costs of developing a 40-hectare perimeter.

These estimates have not been adjusted for the passage of time, changes in technology, effects of inflation, impact of privatization and competition in the private sector, etc., and such adjustments should be made in the interest of precision. However, under the circumstances of this analysis, it should be acceptable to consider these unadjusted figures as an estimate of the costs of rehabilitation of Pilot Perimeters, but new data should be sought for analysis of new perimeters.

The service life of each category of expense must be known, or at least estimated, in order to establish the depreciation or replacement schedule. Some of the items, such as reconnaissance survey and design, obviously will not be repeated, even if the site is used for a century. These items are considered to have a life equal to the period chosen as the duration of the project, which is also the expected life of the major elements of project investment. Some of the work, such as roads and dikes, will have to be redone -- rehabilitated or even reconstructed -- during the useful life of the perimeter. The service life assigned to each category is shown in the last column of Table 4.1.

AMORTIZATION

The cost categories and useful lives are carried forward to Table 4.2, the Amortization module. The annual amortization may be calculated from this information, and the amortization considered as an annual expense that assures funding for replacements for each item when its useful life has expired. Under the conditions of financing assumed for this model, depreciation or amortization of the elements of development is not used (except for the pumping set), but the service life of each item must be known so that a replacement schedule can be set up. This topic will be discussed in more detail in connection with financial analysis.

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19-Jul-90

Table 4.1

COSTS OF DEVELOPMENT OF PERIMETERS
(000 F CFA)

ITEM	PROJECT PAPER 25 Ha	Per Ha	SAED/FIG 2 95 ha	Per Ha	REESER ESTIMATES Per Ha	40 Ha	Life
Reconnaissance	190	7.6	30	0.3	5	200	15
Soils studies	100	4.0	0	0.0			
Topo Work	625	25.0	2755	29.0			
Design	100	4.0	--	0.0			
Subtotal	825	33.0	2755	29.0	31	1240	15
Layout/Staking	130	5.2	364	3.8	5	200	15
Land Clearing	--	0.0	1820	19.2	15	600	15
Levelling	2400	96.0	2000	21.1	100	4000	10
Canals Constr	1920	76.8	25304	266.4	150	6000	10
Dikes Constr	960	38.4	8974	94.5	60	2400	10
Roads Constr	1440	57.6	1616	17.0	30	1200	8
Culvert, Fords	800	32.0	0	0.0	15	600	8
Civil Works/Structures	1000	40.0	--	0.0			
Concrete Work	7500	300.0	2355	24.8			
Subtotal, Concrete	8500	340.0	2355	24.8	300	12000	15
Drainage	720	28.8	4277	45.0	35	1400	10
Supervision	500	20.0	1485	15.6	20	800	15
Contingencies	7813	312.5	--	0.0	300	12000	15
Profit	5352	214.1	--	0.0	200	8000	15
TOTAL	31550	1262.0	50980	536.6	1266	50640	--

Sources:
Project Paper is P. 27, Annex 9.7 of the IWME-1 Project Paper.
SAED/Fig 2 is a SAED billing to USAID, that was quoted and presented. in Reeser's "Determinants of Success" report, March 1990.

AMORTIZATION MODULE 19-Jul-90 | Table 4.2 | File: JUNEREV3

INVESTMENTS AND AMORTIZATION
(All financial data in thousands of F CFA)

ITEM	INVSTMT COSTS	LIFE YRS.	ANNUAL AMORT.	CUMULATIVE TOTAL	CUMULATIVE PERCENT
Reconnaissance	200	15	13	13	0.3
Soils Studies >					
Topographic Studies >	1240	15	83	96	2.4
Design >					
Layout, Staking	200	15	13	109	2.8
Land Clearing	600	15	40	149	3.8
Land Leveling	4000	10	400	549	13.9
Canals Construction	6000	10	600	1149	29.2
Dikes Construction	2400	10	240	1389	35.3
Roads Construction	1200	8	150	1539	39.1
Culverts and Fords	600	8	75	1614	41.0
Concrete and Structures	12000	15	800	2414	61.3
Drainage	1400	10	140	2554	64.8
Supervision	800	15	53	2608	66.2
Contingencies	12000	15	800	3408	86.5
Profit	8000	15	533	3941	100.0
TOTAL	50640	--	3941	3941	100.0

Total, 15 yr. Life Items	35040
Total, 10 yr. Life Items	19800
Total, 8 yr. Life Items	1800

Chapter 5

THE PERIMETER MODULE

The Perimeter Module facilitates the analysis of combinations of crops. Areas of each crop may be controlled and modified. The perimeter module has much in common with the Farm module. Both utilize data drawn from CROPS, and both produce aggregative data -- for one hectare in FARM and for whatever hectarage there is in PERI. The PERI module can, in fact, be used to accomplish the same objectives as FARM by simply entering the identical area for each crop, so that the weighted total is equally weighted. The strength of PERI is that different areas of the various crops can be accommodated.

PERI accepts as inputs the full complement of data from CROPS, and calculates the cost of each input required for the year's production, such as fertilizer, labor, water, etc. All of the data are shown on the screen, but for this report the input data are not printed because of the excessive size of the resulting tables. The tables in this chapter, therefore, show only the cost or value of the inputs and outputs, plus analysis of the data. (The inputs data can be seen in the print-out of the crops module, Table 3.4.)

Analytical factors reported in the tables reveal the aggregate net income for the perimeter; net income per unit of inputs; cropping intensity; and the percentage distribution of inputs, costs and benefits among the component crops.

THREE PERIMETERS

Three perimeters are analyzed here, demonstrating the capability of this module: PERI1, an Intensive Perimeter; PERI2, a Rice-oriented Perimeter; and PERI3, a Cereals-oriented Perimeter. These are presented as Tables 5.1, 5.2 and 5.3, respectively. The names assigned to the perimeters suggest the cropping program and provide convenient identification. These perimeters are intended to illustrate the Pilot Perimeter concept foreseen for the next phase of the IWME-1 project. They show certain capabilities of the analytical system, and point out relationships observed while testing the model through its application to local conditions.

Each perimeter has 40 hectares, all of which is subjected to intensive cropping, i.e. multicropping. It is assumed that the perimeter has been rehabilitated so as to permit intensive use of the entire area. Further assumptions are that an intensive program of monitoring, farmer training and support not only will be a part of the next phase of the project but that all of these activities will be applied to this perimeter and will be effective in achieving their objectives. These objectives will include extending the life of GMPs to 12,00C hours (from 6,000); and improving the Water Conveyance Efficiency to 75%. (Earlier analyses used 75% as an estimate of the present WCE; that is now seen as a gross overestimate of the current situation but a reasonable goal for the future.) These changes will reduce the cost of water delivered to the fields.

Other elements of the farmer training and support program will introduce and bring about use of multicropping, and will also assure the necessary attendant characteristics: timeliness of planting and harvesting operations; use of the recommended levels of inputs such as fertilizers; adequate and timely irrigation, and a program of bird control to protect ripening crops in the counterseasons, as well as other measures as needed for successful intensive year-'round cropping.

PERI1, An Intensive Perimeter

The cropping program for PERI1 includes 25 hectares of quadruple culture: onions (O1-0104) in the cold dry season, maize (C1-0711) in the rainy season, and two crops of niebe (N1-0507 and N2-1103) as transition crops. The balance of the area, 15 hectares, is devoted to sorghum (S2-0710) in the rainy season, followed by wheat (W1-1103) in the cold dry season. Crop budgets for all of these crops can be seen in Crops module, where they are identified by the code numbers shown. (The codes were explained in Chapter 1.)

Perimeter Module PERI1 is presented as Table 5.1, which reveals the effect of selecting and combining crops of high productivity and high value. The Cost and Returns data in the upper half of Table 5.1 is per hectare data for the individual crops, but the total is weighted by the actual area of each crop. Study of the analytical factors that are automatically generated and presented below may help in understanding the relationships. The percentage distribution at the end of the table is particularly useful in showing where the money goes and where the profits come from.

In this perimeter, with the present assumptions regarding cropping program, inputs, yields etc., onions occupy 19% of the total crop area over the year, but they require 60% of the total labor and 39% of the water. However, they provide 87% of the net income, so their culture is well justified -- if indeed it can be handled, given the magnitude of the effort. On this perimeter, 1000 tons of onions would be produced; facilities for drying and storing that many onions, to say nothing of their transport and marketing, would have to be arranged. However, solving of such problems is a pleasure and privilege that is reserved for only those who are sufficiently productive to have something to sell.

The percentage of net income for each of the other crops is below the percentage of land used for the crop and below the percentage of total costs. That is not as bad as it seems; the data are

Range: Peri1

Table 5.1

COSTS, RETURNS AND ANALYSIS
FOR AN INTENSIVE PERIMETER: PERI1

		C R O P S		P R O	
Area, ha	40	25	25	25	
	Perimeter	Onions	Niebe	Maize	Ni
		O1-0104	N1-0507	C1-0711	N2
	Total	Per Hectare			
COSTS and RETURNS, F CFA					
Seed	1,951,260	7,500	28,800	1,920	2
Fert: Urea	1,548,500	28,500	0	15,200	
Fert: NPK (18-46-0)	1,429,875	32,085	0	13,950	
Fert: KCL	810,000	9,000	4,500	9,000	
Pesticides	0	0	0	0	
Subtotal, Purch. Inputs	5,739,635	77,085	33,300	40,070	3
Labor cost if all hired	19,117,500	457,500	69,000	81,000	6
Water cost	9,166,824	151,698	59,103	42,613	5
Tools, annual cost	575,000	5,000	5,000	5,000	
Hired Traction, cost	0	0	0	0	
Subtotal, Production Costs	18,998,514	691,283	166,403	168,683	16
Credit cost at 15% rate	2,849,777	103,692	24,960	25,303	2
TOTAL, ALL COSTS, F CFA	39,875,053	794,975	191,363	193,986	19
Value of Primary Product	161,100,000	5,000,000	240,000	400,000	24
TOTAL VALUE, ALL PRODUCTS	161,100,000	5,000,000	240,000	400,000	24
ANALYSIS					
Net Income, F CFA	121,224,947	4,205,025	48,637	206,014	4
Net Income/MD labor	4,756	6,893	529	1,908	
Net Income/1000 CFA exp.	3,040	5,290	254	1,062	
Net Income/M3 water	123	273	8	34	
Total Crops Produced, ha	130				
Cropping Intensity	3.25				
Product/manday of labor	--	66	16	46	
Product per m3 water, kg	--	3	0	1	
Cost of Production/kg of Product, F CF					
- if all labor is unpaid	--	7	75	20	
- if all labor is paid	--	20	128	39	
% Distribution Crop Area	100	19	19	19	
Labor	100	60	9	11	
Water M3	100	39	15	15	
Water F CFA	100	41	16	12	
Total Costs	100	50	12	12	
Value, Prod	100	78	4	6	
Net Income	100	87	1	4	

skewed by the overwhelming impact of the onion crop. Each crop is profitable in its own right, and each shows a healthy net income on a per hectare basis. After onions, the cereals crops of sorghum, wheat and maize are the major winners, with net incomes per hectare ranging from 300,000 down to about 200,000 F CFA per hectare. This combination of crops is very profitable, with an aggregate net income of over 121 million F CFA from the 40-hectare perimeter. This amounts to over 4700 F CFA in net income for each Man-Day of labor (in addition to the 750 F CFA paid for each such day's labor), or over 3000 F CFA in net income for each 1000 F CFA spent on production costs. All in all, the scenario looks very attractive.

PERI2. A Rice-oriented Perimeter

It may be observed that 25 hectares of onions is enough of a challenge to skew not only the income figures but one's entire perspective, especially since the current onion crop in all of Bakel Delegation probably is less than is planned here for one perimeter. PERI2 was devised to demonstrate another situation unbiased by onions and their extraordinary profitability. In this perimeter, which could be the same land, even the same groupement as PERI1 except for the assumption of a different cropping program, onions were excluded. The cropping program was built around the usual distribution of crops in the rainy season: 60% rice, 20% maize and 20% sorghum. This perimeter is presented in Table 5.2.

Because the Pilot Perimeter concept is assumed to have achieved intensification in this perimeter as well, the rainy season crops are produced using a desirable level of inputs, and good yields are obtained. Half of the rice is started early (in June) with pre-season irrigation, and half is postponed until August, for better distribution of the labor requirement. Counterseason crops are also produced. After harvest of the early rice crop, wheat is seeded in November. The later rice, being harvested in December, is too late for timely planting of wheat; niebe is planted instead.

The rainy-season maize and sorghum are also staggered to reduce the peak labor requirements. After maize in June-October, millet is produced in December-February, followed by niebe (May-July). Sorghum follows, after which another niebe crop is taken. In this manner, five crops can be harvested in two years. With two crops per year (totalling 24 ha) from the rice land, a total of 88 hectares of crops can be harvested from the 40 hectares of irrigated land in the perimeter, for an overall cropping intensity of 2.2. (The counterseason niebe crop could well be a series of niebe crops, planted at intervals so that the labor is well distributed and niebe vines are available for feeding livestock over a longer period of time.)

PERI2 is profitable, as shown by the net income of nearly 12 million F CFA, an average of about 295,000 per hectare of the

Range: Peri2

		C
Area, ha	40	
		Rice
	Perimeter	R3-061:
	Total	
COSTS and RETURNS, F CFA		
Seed	1,411,104	15,:
Fert: Urea	1,003,200	19,'
Fert: NPK (18-46-0)	706,800	13,'
Fert: KCL	540,000	9,'
Pesticides	144,000	6,
Subtotal, Purch. Inputs	3,805,104	63,
Labor cost if all hired	8,538,000	165,
Water cost	5,244,031	86,
Tools, annual cost	432,000	5,
Hired Traction, cost	0	
Subtotal, Production Costs	18,019,135	319,
Credit cost at 15% rate	2,702,870	47,
TOTAL, ALL COSTS, F CFA	20,722,005	367,
Value of Primary Product	32,520,000	425,
TOTAL VALUE, ALL PRODUCTS	32,520,000	425,
ANALYSIS		
Net Income	11,797,995	57,
Net Income/MD labor, cfa	1,036	
Net Income/1000 CFA exp.	569	
Net Income/M3 water, cfa	20	
Total Crops Produced, ha	88	
Cropping intensity	2.2	
Product/Man-Day of labor	--	
Product per m3 water, kg	--	
Cost of Production/kg of Product, F CF		
- if all labor is unpaid	--	
- if all labor is paid	--	
% Distribution Crop Area	100	
Labor	100	
Water M3	100	
Water F CFA	100	
Total Costs	100	
Value, Prod	100	
Net Income	100	

perimeter or about 134,000 per hectare of crop produced. Significant variations can be detected, however. One does not expect high profits from niebe, and the three crops of niebe collectively contribute only 11 percent of the net income -- as opposed to the greater (in every case) proportion of crop area and inputs. Rice is a crop from which one might hope for more, but its performance is a disappointment: both rice crops combined produce only (6 + 11) 17% of net income, despite claiming (19 + 19) 38% of area, 44% of total labor, and 37% of the water pumped. However, recalling the crops budgets, this really is no surprise: net income per hectare of rice is less than that of any other crop in the line-up. Why should this minor-league performance be tolerated, and why should star billing be given to a player with these statistics? Rationally, they should not. PERI3 is another combination that avoids rice.

PERI3. A Cereals-oriented Perimeter.

PERI3 is another perimeter with the same basic resources, which avoids both onions and rice. It is presented in Table 5.3. The highest-profit crops among the cereals have been selected to make up PERI3's cropping program: sorghum, wheat, millet. Maize was excluded because of schedule interference, a problem that may eventually resolved. The basic program of rainy-season sorghum and millet followed by cold dry season wheat and sorghum would leave the land incompletely utilized in the hot dry season, so 20 ha of niebe is inserted into the program. The cropping intensity is 2.5.

The net income for the whole perimeter is about 22 million F CFA, or over 550,000 per hectare of the perimeter's land and 220,000 F CFA per hectare of crop produced. All of these figures represent increases of more than 50% over the comparable figures for PERI2. Net income per Man-Day of labor and net income per 1000 F CFA of expenses are both more than twice the comparable figures for PERI2.

In this line-up, there are three heavy hitters, but no single crop dominates the statistics. Percentage distributions of resources and revenues are meaningful, but show little variation except for the small proportion of amount and cost of water required for rainy-season crops. The distribution of net income is relatively uniform; sorghum, wheat, millet and dry-season sorghum produce 27, 24, 24 and 17 percent respectively of net income. Only the niebe crop (at 7%) appears to produce less than a reasonable share, and in this case that should be acceptable since niebe is a "fill-in" crop. It is designed to utilize the interstices, which it does effectively, more than paying its own expenses and making a respectable contribution to the overall program.

19-Jul

Range: Peri3

Table 5.3

COSTS, RETURNS AND ANALYSIS
FOR A CEREALS-ORIENTED PERIMETER: PERI3

	C R O P S	P R O D U C E D				
Area, ha	40	20	20	20	20	20
		Sorghum	Wheat	Millet	Sorghum	Niebe
	Perimeter	S2-0710	W1-1103	M2-0710	S3-1102	N3-??+3
	Total	Per Hectare Data				
COSTS and RETURNS, F CFA						
Seed	959,040	384	18,000	384	384	28,800
Fert: Urea	1,216,000	15,200	15,200	15,200	15,200	0
Fert: NPK (18-46-0)	744,000	9,300	9,300	9,300	9,300	0
Fert: KCL	450,000	4,500	4,500	4,500	4,500	4,500
Pesticides	0	0	0	0	0	0
Subtotal, Purch. Inputs	3,369,040	29,384	47,000	29,384	29,384	33,300
Labor cost if all hired	7,185,000	66,000	81,000	62,250	81,000	69,000
Water cost	4,721,442	21,307	68,953	17,756	68,953	59,103
Tools, annual cost	480,000	5,000	5,000	4,000	5,000	5,000
Hired Traction, cost	0	0	0	0	0	0
Subtotal, Production Costs	15,755,482	121,691	201,953	113,390	184,337	166,403
Credit cost at 15% rate	2,363,322	18,254	30,293	17,008	27,651	24,960
TOTAL, ALL COSTS, F CFA	18,118,805	139,944	232,246	130,398	211,988	191,363
Value of Primary Product	37,200,000	440,000	500,000	400,000	400,000	120,000
TOTAL VALUE, ALL PRODUCTS	40,200,000	440,000	500,000	400,000	400,000	270,000
ANALYSIS						
Net Income	22,081,195	300,056	267,754	269,602	188,012	78,637
Net Income/MD labor, cfa	2,305	3,410	2,479	3,248	1,741	855
Net Income/1000 CFA exp.	1,219	2,144	1,153	2,068	887	411
Net Income/M3 water, cfa	43	100	38	108	27	13
Total Crops Produced, ha	100					
Cropping intensity	2.5					
Product/Man-Day of labor	--	63	46	60	46	8
Product per m3 water, kg	--	2	1	2	1	0
Cost of Production/kg of Product, F CF						
- if all labor is unpaid	--	12	28	12	24	149
- if all labor is paid	--	25	46	26	42	255
% Distribution Crop Area	100	20	20	20	20	20
Labor	100	18	23	17	23	19
Water M3	100	12	27	10	27	24
Water F CFA	100	9	29	8	29	25
Total Costs	100	15	26	14	23	21
Value, Prod	100	22	25	20	20	13
Net Income	100	27	24	24	17	7

ADDITIONAL PERIMETERS

The analysis of other combinations of crops and areas, or of real-life perimeters, can be done using the same methods used for analysis of perimeters PERI1, PERI2, and PERI3. Crops inputs and costs, if different from those already shown, would be entered in columns of the CROPS module, to be grouped into perimeters in the PERI module. Crops data can be called up to PERI by the simple expedient of a formula (such as +AB105) with the cell number of the appropriate column head where the crops data are entered. Copying the formula to the remainder of the column brings the rest of the column to PERI. The formulas in PERI2 accommodate and aggregate as many as nine separate crops simultaneously, and those crops can be used or others substituted, with the formulas remaining as they are. The properly-weighted totals will appear, as the formulas multiply the individual cell data (kg of urea, for example) by the appropriate price from the crop inputs data or from the "control panel" table, weighting this by the area (hectares) shown at the top of the column, and entering the aggregate amount or cost in the correct cell.

The calculations of perimeter totals and percentage distributions are automatic, provided that the formulas have not been disturbed in the copying process. (It is well to keep a back-up copy of the spreadsheet. Abandoning a partially-demolished table with all its formulas, in favor of starting over, could be less wasteful and more efficient than reconstructing the interlocking formulas.)

If additional perimeters or additional multicropping combinations or other modules are desired, layout of the spreadsheet accommodates "shouldering aside" of the existing modules to make room for new ones. The modules that are different in format are strung together corner-to-corner, rather than edge-to-edge or side-to-side. This arrangement means that additional rows and columns can be inserted as necessary to make room for additional modules, without interfering with existing modules. An example of this concept can be found in TRIPLE and QUAD, which use the same arrangement and column width as DOUBLE, and so could be conveniently located directly below the first of this series of modules. This replication of format is true also of PERI1, PERI2 and PERI3 and of FIN1, FIN2 and FIN3.

Because of the identity of format, formulas can be copied from one of these modules to another of the same set; the relative location of many of the referenced cells is identical. However, because some of the cell references must be absolute, very close attention is needed to avoid error and the need for corrections after copying.

Adequate capacity exists in the LOTUS program for considerable expansion. At the present stage of development, well under half of the 250-odd available columns in the LOTUS spreadsheet are being used, and about one-eighth of the 8000-plus available rows.

CONCLUSIONS

Examination of three perimeters appears to confirm everything that was indicated by individual crops budgets about the relative profitability of the various crops. The feasibility of multicropping, indicated by the FARM module, is confirmed; the next logical step is testing under real-life conditions. It is perfectly clear that multicropping itself is not a panacea: the combination of crops, to be profitable, must combine crops that are individually profitable. Rice does not fare well in this analysis, and multicropping with emphasis on rice is either unprofitable or much less profitable than multicropping of cereals crops such as sorghum, maize, millet and wheat. Niebe, being a short-cycle crop, fits into a number of niches to increase overall production, income and employment of the perimeter.

The analysis of perimeters shows that irrigated multicropping can be profitable, when one assumes that the perimeter is already there. Nothing has yet been revealed about the feasibility of new investment in the development of new perimeters. In other words, what has been considered so far is the continuation, rather than the expansion, of irrigated farming.

What remains to be done is an examination of the financial requirements and financial consequences of development of an irrigated perimeter, and determination of the financial feasibility of the investment possible. This financial analysis is the subject of the next chapter.

Chapter 6

FINANCIAL AND SENSITIVITY ANALYSIS

Financial analysis is undertaken to provide a measure of the desirability of a project or an investment. Sensitivity analysis consists of varying the assumptions or estimates that are inputs in the financial analysis, to determine the degree of sensitivity to those changes. Both of these analyses are applied to the three perimeters that have already been presented as representing intensive, rice-oriented and cereals-oriented perimeters in Bakel Delegation.

FINANCIAL ANALYSIS

As already explained, all three perimeters are built on the same resource base, and have the same cropland area, the same water costs, the same levels of productivity, etc. All three have the same burden of investment costs and loan repayment obligations, which were determined through the AMORT module. Operational costs and returns for each perimeter are drawn from PERI modules. These investment and operating costs are shown in Tables 6.1, 6.2 and 6.3, which present the financial analyses of the three perimeters.

The operation of the Financial Analysis (FIN) module is automated.

Only a few steps are required to set it up, and subsequent operation requires no explicit action on the part of the operator. If the format of AMORT is preserved, the requirement for investment in the development of the perimeter is supplied automatically to FIN, and the cost of the pumping set is supplied as easily from WATER. The combined total represents the initial investment. Financing through CNCAS or on similar terms is assumed, so a 20% down payment is required, and the loan must be repaid in five equal annual installments. These details are calculated automatically by the model, using the default rate of interest (15%), unless the operator changes the interest rate deliberately.

In the year of construction, no operating expenses are incurred. Such expenses, brought forward from the PERI module, are phased in at 50% the second year and 100% the third year. Income from products of the perimeter begin at 25% of the amount calculated in PERI in the second year, rising to 60% the next year and 100% in the fourth and subsequent years. If changes are made in expenses or income (as they are in sensitivity tests), these data are automatically phased in also.

At the end of the 15-year life of the project, some of the investments will have

FINANCIAL ANALYSIS MODULE #1 Table 6.1 Range: FIN1

16-Jul-90

FINANCIAL ANALYSIS OF A TYPICAL PERIMETER: PERI1

(Thousands of F CFA)

Annual Capital Cost 15 Percent

		PROJECT YEAR															
	Base Amt.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cost of Development (from AMORT)	50,640																
Cost of Pumping Set (from WATER)	8,460																
Total First Investment	59,100																
Replacement, Rehabilitation		0	0	0	0	0	0	0	0	1,800	0	19,800	0	0	0	0	0
Down Payment, 20% of Loan		11,820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Repayment of Loan (Five Equal Annual Payments)	17,630	0	17,630	17,630	17,630	17,630	17,630	0	0	0	0	0	0	0	0	0	0
Annual Operating Costs (from PERI1)	39,875	0	19,938	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875
TOTAL Annual Costs	--	11,820	37,568	57,505	57,505	57,505	57,505	39,875	39,875	41,675	39,875	59,675	39,875	39,875	39,875	39,875	39,875
Value of Products (from PERI1)	161,100	0	40,275	96,660	161,100	161,100	161,100	161,100	161,100	161,100	161,100	161,100	161,100	161,100	161,100	161,100	161,100
Residual Value at end of project		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10,125
Cash Flow (C.F.)	--	(11,820)	2,707	39,155	103,595	103,595	103,595	121,225	121,225	119,425	121,225	101,425	121,225	121,225	121,225	121,225	131,350
Cash Flow, discounted at	15 %	(11,820)	2,354	29,606	68,115	59,231	51,505	52,409	45,573	39,040	34,460	25,071	26,056	22,658	19,702	17,133	16,142
Cumulated Value of C.F.		(11,820)	(9,466)	20,140	88,256	147,486	198,991	251,400	296,973	336,013	370,473	395,543	421,600	444,258	463,960	481,093	497,235
Fin. IRR (Financial Internal Rate of Return)	1.926	192.6 percent															

FINANCIAL ANALYSIS MODULE #2 Table 6.2 Range: FIN2

17-Jul-90

FINANCIAL ANALYSIS OF A RICE-ORIENTED PERIMETER: PERI2

(Thousands of F CFA)

Annual Capital Cost 15 Percent

	Base Amt.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		P R O J E C T Y E A R															
Cost of Development (from AMORT)	50,640																
Cost of Pumping Set (from WATER)	8,460																
Total First Investment	59,100																
Replacement, Rehabilitation		0	0	0	0	0	0	0	0	1,800	0	19,800	0	0	0	0	0
Down Payment, 20% of Loan		11,820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Repayment of Loan (Five Equal Annual Payments)	17,630	0	17,630	17,630	17,630	17,630	17,630	0	0	0	0	0	0	0	0	0	0
Annual Operating Costs (from PERI2)	20,722	0	10,361	20,722	20,722	20,722	20,722	20,722	20,722	20,722	20,722	20,722	20,722	20,722	20,722	20,722	20,722
TOTAL Annual Costs	--	11,820	27,991	38,352	38,352	38,352	38,352	20,722	20,722	22,522	20,722	40,522	20,722	20,722	20,722	20,722	20,722
Value of Products (from PERI2)	32,520	0	8,130	19,512	32,520	32,520	32,520	32,520	32,520	32,520	32,520	32,520	32,520	32,520	32,520	32,520	32,520
Residual Value at end of project		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10,125
Cash Flow (C.F.)	--	(11,820)	(19,861)	(18,840)	(5,832)	(5,832)	(5,832)	11,798	11,798	9,998	11,798	(8,002)	11,798	11,798	11,798	11,798	21,923
Cash Flow, discounted at	15 %	(11,820)	(17,271)	(14,246)	(3,835)	(3,335)	(2,900)	5,101	4,435	3,268	3,354	(1,978)	2,536	2,205	1,918	1,667	2,694
Cumulated Value of C.F.		(11,820)	(29,091)	(43,337)	(47,172)	(50,506)	(53,406)	(48,306)	(43,870)	(40,602)	(37,248)	(39,226)	(36,690)	(34,485)	(32,568)	(30,900)	(28,206)

Fin. IRR 0.051 5.1 percent

Financial Internal Rate of Return

FINANCIAL ANALYSIS MODULE #3 Table 6.3 Range: FIN3

17-Jul-90

FINANCIAL ANALYSIS OF A CEREALS-ORIENTED PERIMETER: PERI3

(Thousands of F CFA)

Annual Capital Cost 15 Percent

	Base Amt.	P R O J E C T Y E A R 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cost of Development (from AMORT)	50,640																
Cost of Pumping Set (from WATER)	8,460																
Total First Investment	59,100																
Replacement, Rehabilitation		0	0	0	0	0	0	0	0	1,800	0	19,800	0	0	0	0	0
Down Payment, 20% of Loan		11,820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Repayment of Loan (Five Equal Annual Payments)	17,630	0	17,630	17,630	17,630	17,630	17,630	0	0	0	0	0	0	0	0	0	0
Annual Operating Costs (from PERI3)	18,119	0	9,059	18,119	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875	39,875
TOTAL Annual Costs	--	11,820	26,690	35,749	57,505	57,505	57,505	39,875	39,875	41,675	39,875	59,675	39,875	39,875	39,875	39,875	39,875
Value of Products (from PERI3)	40,209	0	10,050	24,120	161,600	161,600	161,600	161,600	161,600	161,600	161,600	161,600	161,600	161,600	161,600	161,600	161,600
Residual Value at end of project		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10,125
Cash Flow (C.F.)	--	(11,820)	(16,640)	(11,629)	104,095	104,095	104,095	121,725	121,725	119,925	121,725	101,925	121,725	121,725	121,725	121,725	131,850
Cash Flow, discounted at	15 %	(11,820)	(14,469)	(8,793)	68,444	59,516	51,753	52,625	45,761	39,204	34,602	25,194	26,164	22,751	19,784	17,203	16,204
Cumulated Value of Cash Flow		(11,820)	(26,289)	(35,083)	33,361	92,878	144,631	197,256	243,017	282,221	316,822	342,017	368,181	390,932	410,716	427,919	444,122

Fin. IRR 1.085 108.5 percent

Financial Internal Rate of Return

have five years of utility remaining five years later, and the 8-year investments replaced in year 9 will still have one year of usefulness at the end of the project's 15-year life. The residual value can be calculated using straight-line depreciation, and entered as a benefit in the last year of the project. This aspect of the module has not been automated, and must be done manually.

Cash Flow (CF) is the difference between the total of benefits and the total of costs. This figure for each year, whether positive or negative, represents the value at that time, and its importance for present decision-making is reduced by its being removed from the present. This is in keeping with the long-established concept of discounting; a dollar today is more valuable than a dollar tomorrow or next year. Therefore, the Present Value (PV) of any year's CF is less that the value of that CF at some time in the future, when it actually materializes. The module calculates the PV of Cash Flow, discounting each year's CF at 15%, compounded annually. The PV becomes less and less valuable as compound interest builds up; this can be seen clearly by comparing Cash Flow and Discounted Cash Flow in Table 6.1.

INTERNAL RATE OF RETURN

The Internal Rate of Return (IRR) is that rate of interest at which the sum of discounted CFs is equal to z PERI2 ero. Oversimplified, it is the rate of return earned by the funds invested in a project. One who is considering such investment would normally be interested only if the IRR was at least equal to the return available from whatever alternative uses were available for the same funds. For example, one would not be likely to withdraw funds from a savings account paying 10 percent interest, to invest in a project with an IRR of less than 10%. On the other hand, if the funds were being held in the "Banque de Maison" (under the mattress), a return of 5% might sound very interesting.

Normally, any IRR less than the bank rate of interest is considered unacceptable.

Cumulated CF shown in as a running total in the financial analysis tables. In the case of PERI1 it is large -- nearly 500 million F CFA. A much higher discount rate is needed to reduce the PV of all that income sufficiently that the total is zero. At the same time, the cumulated total PV of CF for PERI2 in Table 6.2 is negative. Therefore IRR in Table 6.1 must be greater, and in Table 6.2 less, than the 15% discount rate used.

The module calculates IRR automatically, by repeated adjustments of the discount rate, until a rate is found that results in a total PV of CF that is equal to zero. The result -- the Financial Internal Rate of Return -- is entered at the bottom of the table. (To further facilitate sensitivity tests, IRR for each of the three perimeters is also displayed on the "Control Panel," the Prices table.)

Financial analysis by FIN1 shows that PERI1 has an IRR of 193%. This is an amazing rate of return, and is believable only because the net income figures for onions as a crop, for QUAD as a multiculture scheme and for PERI1 as an application of onion culture all show extreme profitability.

PERI2, focussing on rice, is far less profitable: 5 percent. It should be noted that the perimeter has a cropping intensity of 2.2, and that much of the income of this perimeter comes from other crops that are individually more profitable than rice. Were it not for the support of other crops, the rice perimeter would have a negative IRR (and with only minor changes in assumptions it does have a negative IRR; see the sensitivity tests that follow).

PERI3, the cereals perimeter, is more profitable than the rice perimeter, but less so that the onion perimeter. That much was expected; any other result would be unacceptable. The actual rate shown, 23.2 percent, is believable when compared to the extremes shown by the other perimeters, and at the same time high enough that investors should think seriously about this kind of development on a privately-financed basis.

Because of the complexity of the formulas necessary to perform the needed calculations automatically, there are many opportunities for errors to creep in, and the source or even the existence of the errors may be difficult to detect. For that reason, combined with the "crash" nature and limited time allowance of this consultancy, it is acknowledged that IRR as determined here is far from definitive. However, even as illustrative or indicative IRRs, they have merit, and the utility of the model is confirmed. The general relationships among the IRRs presented appear to be valid, and therefore can serve as a guide for policy and planning decisions.

SENSITIVITY TESTS

Sensitivity tests are a desirable way of determining what will happen to the projected success of a project if there have been incorrect assumptions or if problems are encountered. Commonly, tests are run to find the effect of lower yields than projected, higher costs and/or lower prices for products than expected, etc. In this case, the following factors seem to be natural candidates for testing, for the reasons discussed:

Labor. While 750 F CFA per day is more than the Socio-Economic Survey reported as being paid, there are indications that the "commercial" rate for hired labor is actually higher, perhaps twice as high, as the figure used. The test should set labor cost at 1500 F CFA per Man-Day (Test A).

Water Cost. The difficulty of maintaining machinery in a frontier environment suggests that doubling SAED's estimate of the useful life of a pumping set may be impossible. S:

there is strong feeling in some quarters that the real Water Conveyance Efficiency is closer to 20 percent than to 75 percent. A test with pumping set life at 6000 hours and WCE at 40% will show the vulnerability of the project to high water costs (Test B).

Product Prices. Prices used are not guesses, but observed market prices. However, the possibility can hardly be denied that saturation of the local market and lack of well-developed outlets could drastically reduce prices received by farmers, especially seasonally. A test should be made with product prices at 90% of the budgeted prices (Test C). To test a worst-case scenario, onion prices may be reduced by 50% and other product prices reduced by 25% (Test D).

Input Prices. The influence of government in setting of prices for inputs was not investigated, but it is recognized that both government policy and market conditions influence a wide range of prices. To measure the impact on profitability of increased prices for inputs (other than the labor and water costs already mentioned), prices of all inputs may be set at 110% of the base prices (Test E).

Yields. Considering that local peasants will be tending the crops, even though under supervision, targeted yields may not be achieved. Alternative yield levels of 80% will be tested: this amounts to 4000 kg of paddy instead of 5000, 32 tons of onions instead of 40, and other yields in proportion (Test F). Another test might be run measuring the effect of severe miscalculation as to achievable yield levels, putting yields at 50% of those budgeted (Test G).

Combinations. Some combination of the listed disasters might strike the project. Lower yields and simultaneous lower prices would be expected to have serious results, but how serious? Selected combinations, shown in the table following, are tested for their effect on IRR (Tests H, I, J, K, and L).

Table 6.4 presents the Sensitivity Analysis of IRR for the three perimeters under examinatd below in terms of two categories: phys
ical /
infrastructural, and institutional problems.

Table 6.9

SENSITIVITY ANALYSIS OF IRR FOR THREE PERIMETERS
Showing Internal Rate of Return under Modified Conditions

		PERI1	PERI2	PERI3
	Normal situation (Standard costs and relationships)	192.6	5.1	23.2
A.	High labor costs (Labor at 200%, or 1500 F CFA/M-D)	143.4	-16.7	7.9
B.	High water costs (GMP life 6000 hrs; WCE 40%)	144.9	-24.7	3.1
C.	Low Product Prices (All prices at 90% of base levels)	162	-0.6	17
D.	Very low product prices (Prices at 75%; Onion prices at 50%)	61.7	-10.7	7.7
E.	High input prices (Inputs, labor, interest at 110%)	181.7	1.7	19.7
F.	Low yields of crops (Yield levels at 80% of base)	130.9	-7.8	10.5
G.	Very low yields (Yield levels at 50% of base)	46.4	-48	-12.1
H.	C + E: High inputs, low prices (Inputs 110%, Prices 90%)	152.1	-4.2	13.8
I.	D + E: High inputs, very low prices (High inputs; prices 75%, onions 50%)	56.8	-15.1	4.6
J.	C+E+A: Like H plus high labor (H, plus labor at 200%)	114.5	-31.4	0.1
K.	C+E+F: Yields & prices low, inputs high (Yields 80%, prices 90%, inputs 110%)	122.2	-11.8	7.3
L.	C+E+F+A: Like K plus labor at 200%) (Or like J with yields at 80%)	73.5	-75.6	-14.3

Physical / Infrastructural Problems.

6. Bakel is a remote place which is reached only after a long and hard day's drive from Dakar. It is a small town with a minimal commercial base. Difficulties with logistics and communications have proven to be significant for the project team.

7. The local climate is also a problem. The extreme heat saps one's energy, and special precautions are necessary to avoid endangering one's health. One can acclimatize, but comfort and a working environment conducive to reasonable productivity come only at some cost.

8. One accepts that Bakel is a distant point in a Third World country. However, many projects in many LDCs have better water supply, more dependable electricity and fuel supply, better mail service, telephones that work, access to medical facilities, and better road and transportation networks than those availant capital or for operating
expenses. This precarious level of profitability is hurt badly by changes of 10% in prices and costs, at which point IRR teeters on the brink between profit and loss. All other changes tested, singly or in combination, push IRR into negative status. The basic problem appears to be that the perimeter's resources dedicated to rice are insufficiently productive, and the other crops cannot carry the load.

One would therefore expect a higher return from a perimeter that selects crops for their profitability, as PERI3 does. In fact, PERI3 bears up well under the various tests of sensitivity; only two of the tests (G, where yields were halved, and L, with a four-way knockout punch) pushed IRR into negative territory. Ten percent higher input costs, lower product prices, 20% lower yields, even combinations of these difficulties, leave PERI3 with a respectable and positive IRR. The contrast with PERI2 is striking: only two of the 12 sensitivity tests of PERI3 (cereals) showed a negative IRR, while only one test of PERI2 (rice) avoided a negative IRR. This is further demonstration that cereals other than rice must provide the thrust of further development of irrigated agriculture in the Bakel region.

Chapter 7

SIGNIFICANCE OF THE EXERCISE AND THE FINDINGS

ACCOMPLISHMENTS

The scope of work for this assignment appears to have been completed in respect to all three of its elements:

* An operable engine of analysis has been developed and brought to the functioning level. "The model" is capable of performing rather complicated analyses of a variety of aspects of the organization and functioning of irrigated perimeters.

* A Senegalese national staff member of SAED has been trained in the use of the analytical system. His competence is less than complete, because he started from a base of little knowledge of computers and only academic training in project analysis, but his incremental achievement has been impressive. A highly important start has been made.

* Analysis has been performed of the current and possible future feasibility of development of irrigated perimeters in the Bakel region. This analysis has demonstrated the capabilities of the model, while at the same time producing results (findings) that sketch out what may be achieved, and suggest the path to be followed.

COMMENTS

A few comments, in the nature of a postscript, may be permitted the consultant who has poured himself into this work intermittently over a period of nearly nine months.

1. The model, despite the fact that it is "up and running," can still use constructive input from users. Amazing developments have taken place: capabilities have been built in that were not even dreamed of at first, and operations are now automated that were scarcely even possible or at best laborious at first. No doubt further refinements can be made. Current and potential users are encouraged to build on the base already established, and to continue the process of improvement and refinement.

2. The availability of this engine of analysis may stimulate the collecting of empirical data for specific situations and specific perimeters, so that analysis like that done here for hypothetical perimeters can eventually be done for real-life situations. Empirical data for the specific perimeters or situations concerned will be needed. Agronomic, economic, sociological and engineering

data should be obtained: crop areas, inputs, production and prices; labor use and costs; pump output, engine fuel consumption, water losses in conveyance, and water needs by crops under local conditions; family size, organization, labor availability and priorities for use of labor; and other factors and details as needed.

3. Use of the model for analysis using new information need not await complete or full information. It is easy to plug in bits of new data, so frequent updates of analyses may be entirely appropriate.

4. The findings of the analyses done during the course of three consultancies at Bakel may have (and the consultant feels strongly that they DO have) real meaning for the future of irrigation, privatization, commercial production, land development, employment, and a host of other aspects of the situation at Bakel.

Some of the implications and foreshadowings are mentioned in the following paragraphs.

5. It very probably was a mistake, from the outset of irrigation development at Bakel, to push for production of rice there. It would be a greater mistake, on the order of a disaster, to push for rice production at Bakel now. On the other hand, there are crops that are well adapted, that can be produced in quantity, and for which markets are available. Those are the crops that should be promoted by any sound and reasonable project at Bakel.

6. There is no need to be pessimistic or negative regarding the future of irrigated agriculture in the Bakel region. This consultant believes that irrigated agriculture can be successful there, at a level and to an extent that will literally dazzle the eyes of observers a few years from now. True, Bakel is not the Garden of Eden, and one must be selective of crops and methods in order to be financially successful. Some of the crops and much of the technology on which success depends are new to the region. A strong program of research and extension will be needed to install successful and profitable irrigated agriculture. The important thing is that it can be done, and the elements of the program to achieve it are known.

7. Successful establishment of commercial crop production will provide a strong stimulus to the entire privatization movement. When farmers are making money, they will not only have more money to spend but will be far less reluctant to spend it. They will buy all kinds of agricultural inputs, including yield-enhancing items like high-powered seeds and fertilizers, and mechanical aids that will reduce labor requirements (by substituting capital for labor). An agricultural service sector will come into being, providing not only tractor plowing, land levelling and mechanical threshing but also canal compacting service and sales and repair of pumps and farm equipment. Marketing of crops will be handled through the

Some of the profits from farming will be available for consumer purchases: new clothes, bicycles, radios, better housing. The resulting flow of funds will result in better-stocked stores and more aggressive merchants, and eventually there will be television salesmen in Bakel.

The foregoing "dream" is based on a lot of hard work, and on study of agriculture and its problems and possibilities in Bakel. The form and structure have been taking shape over a period of several months, and little by little, successive elements fall into place. The vision is not yet complete, and details are always changing, but optimism is one of its vital characteristics. There can be a real future for irrigated agriculture in the region of Bakel.