PN-AAT-153
ISN 40129

EXPANDED ECONOMIC ANALYSES OF SENEGAL RIVER IRRIGATION PUMPING ALTERNATIVES

PRESENTED AT:

A Planning Meeting on Improved
Water-Pumping/Water-Lifting Systems for Africa

FUNDED BY:

Office of Regional Affairs
Africa Bureau
Agency for International Development

000013
S

PREPARED BY:

Energy/Development International
1015 18th Street, N.W.
Suite 802
Washington, D. C. 20036

000471

August 1985

I. INTRODUCTION

In late 1984, the Energy Initiatives for Africa (EIA) Project (AID Project No. 698-0424) produced a study entitled "Assessment of the Relative Economy of Alternative Options for Irrigation Pumping in Identified IDP Project Areas" (hereafter referred to as the "Senegal Pumping Study"). This study was well received by the immediate audience in Senegal and contained a wealth of information on agricultural water supply and pumping. Much of this was presented in a site- and project-specific format. In order to make the technical and economic information more useful to a wider and less technical audience, several additions and changes were suggested by personnel in the USAID engineering office. As a result of these recommendations, discussions with others, and in-house planning, E/DI has initiated a small effort to add to the background on agricultural water supply and enhance the usefulness of the economic analyses in the Senegal Pumping Study.

We have undertaken a short-term small-scale study effort to accomplish the above. This effort involved reorganization, expansion and generalization of the economic analyses presented in the Senegal Pumping Study. This involved two basic steps.

The first step was to focus a literature search on identifying components of existing economic analyses which can be used to expand and generalize the analyses presented in the Senegal Pumping Study. As this effort progressed, the second step was started. This step, an expansion and reorganization involved:

- Identification and inclusion of factors not originally a part of the economic analyses;
- Additional data to support and broaden that which was used;
- Preparation of additional economic comparisons; and
- Correction of errors and alteration of some of the original study assumptions.

As a result of these steps, an expanded economic analysis section has been prepared for the Senegal Pumping Study. The following document is the first draft of this section.

Original Study Scope

The terms of reference of the Senegal Pumping Study called for the analysis of pumping options for three specific regions in the Senegal River Valley; namely the Bakel and Podor regions in Senegal and the Kaedi region in Mauritania; all in or near the northeastern border of Senegal and Mauritania.

In the Bakel region, two specific sites were identified; the Collenga site and the Balou site. These sites are slated for development of medium perimeter irrigation. For Collenga, the study was to address the option of using electrically driven pumps supplied from the new SENELEC's diesel-powered plant near the town of Bakel, and compare this option with the diesel pumping system on floats presently used on a number of irrigated perimeters. For Balou, a similar comparison of pumping options was to be made with consideration being given to an electricity supply from a dedicated diesel generator set.

In the Podor region, the study was to evaluate the pumping option proposed by the GERSAR master plan for the Podor medium perimeter, and recommend improvements, if necessary, in the proposed design.

For the Kaedi region, the study was to review the preliminary study of the Dirol plain, west of the town of Kaedi, and assess alternative pumping options, especially from the Dirol stream and from wells or boreholes around the plain.

The above scope was addressed by a three-person team working several weeks in Senegal, and a report was prepared and circulated in November of 1984. This report was very thorough and presented a series of engineering-type project economic analyses. Of necessity, the analyses were constrained by timing restrictions, budget limitations, and the availability of data. These analyses focused entirely on costs, and certain governmental subsidies or infrastructure contributions were not accounted for.

Study Team

The expanded analyses, which follow, were prepared by an E/DI team composed of Mr. Gregoire Genot, Mr. John Gallup and Dr. James D. Westfield. This team drew heavily on the original study and the data contained therein. Additional sources of data are identified in the bibliography.

Expanded Economic Analyses

Figure 1 is a schematic representation of the process which was followed in upgrading the economic cost analyses. The figure also describes the process followed to include the benefit data in our analyses. We have allowed for both a project analysis (as was done in the original study) and a broader or national perspective. The economic analyses at the cost only level essentially ignore a number of factors including infrastructure costs, and assume that the least cost alternative will supply a level of services and benefits which is minimally acceptable although not necessarily as great as other alternatives. The least cost optimization approach to selecting alternative projects is often satisfactory if:

- Infrastructure improvements are needed and to be supplied, whether or not the projects are implemented; or
- Benefit levels from all alternatives, though different, are acceptable.

However, it is sometimes important to consider the total range of costs and economic benefits from projects in order to select the one which has the optimum return on investment. For this type of analysis, it is necessary to include all attributable costs and benefits, and to compare returns using net present value or similar types of calculations.

The pumping schemes considered in the Senegal Pumping Study involve such things as irrigation parameter upgrading, fuel subsidies and tax exemptions. There are also a variety of crop and planting season alternatives to consider. Because of this and the definable uncertainties associated with agriculture, it was deemed useful to expand the economic analyses of Senegal pumping schemes to include national costs and farmer and project benefits.

II. DATA

A. Types of Variables and Parameters

This section of the analysis presents the site data used in computing costs and benefits. For the Bakel site, two types of data are presented; decision variables and state variables. This classification places those variables such as site, pumping system, crop type and cultivation season, which are under the control of the decision maker in one group (decision variables), and those such as head, water requirements, and costs which are outside the control of the decision maker or are fixed by the choice of decision variable quantity in a second group (state variables). There are nine possible pumping systems selected for consideration, two growing seasons (contre saison and hivernage), and up to 15 crop combinations. Tables 1, 2 and 3 present the range of state and decision variables selected for use in the economic analyses of the Bakel site.

B. Sites

The site data for Bakel are for two irrigation perimeters, and at Collenga for an area of 250 hectares of which 90 are currently irrigated. The new perimeter considered in this analysis will occupy approximately 160 hectares. The Balou perimeter will have approximately 120 hectares of which 100 is the proposed extension.

The static parameters that are directly related to the choice of the site are the following:

- Static head; and
- Dynamic head (function of pipe length, bends, etc.).

These data are presented for the site in Table 1. Static head is determined from IGN (Institut Geographique National) data for the Senegal River, minus the elevation of the site. The total head is then calculated every month as the sum of both the static and the dynamic heads (Table 1).

C. <u>Pumping Options</u>

Three generic pumping system options which have been considered include:

- Floating platform -- mounted diesel pumps;
- Floating platform -- mounted electric submersible pumps; and
- Fixed on-shore pumping options.

The first option consists of a floating raft with a prepackaged diesel engine/water pump unit (GMP). Two diesel engines are already in common use in Senegal, the HR2 (21 Hp) and HR3 (34 Hp) manufactured by Lister. The Lister HR6 model (76 Hp) has also been included for consideration. Many pumps are used in Senegal and we have attempted to represent this mix by selecting an efficient pump as representative of what will actually be used in the perimeter development.

The second option consists of a floating raft and one or more electric submersible pumps mounted under the platform. Two options have been considered: either one raft with three pumps (12.5 kW each), or two rafts with 6 pumps (and a spare pump on each raft as a back-up). On the energy supply side, there are two choices: either a dedicated diesel generator (110 or 180 Hp), or a connection to the SENELEC isolated diesel powered distribution systems. Only one such system is currently in use along the Senegal River (at Guede).

The third option has been considered only at Podor (low head, high area irrigated) because of its cost, and it was proposed by GERSAR. This option considers the same two alternatives for electricity supply as above.

The choice of the pumping option determines the following state variables:

- Efficiency of the system (i.e., fuel consumption); the efficiency will vary with the head at the site and therefore, two global efficiencies have generally been considered: one for the hivernage period (low head), and one for contre saison (high head). These efficiencies are presented for the 3 following groups of options: GMP diesel, floating rafts with dedicated diesel, or with SENELEC supply (Table 3).
- Fixed costs such as investment cost, depreciation cost (function of the life and method used), and O&M costs; all of these costs are presented in Table 4. Explanations on the method of calculation are given later. These costs are generally the same for all sites except Bakel.
- Area irrigated; the area irrigated by a pumping option is a function of both the power of the pump and the maximum head at which power will be supplied (site dependent). Calculations are presented at the bottom of Table 4 for each site and option.

D. Crop Choices

A calendar of monthly water requirements for each crop has been established at each site, depending on soil characteristics, cultivation, evapotranspiration, rainfall, etc. Because of the numerous variations in estimates from different documents, the "base case" reflects the team's best judgment of variable values for both rice and mixed crops during hivernage and contre saison. Other options are also presented.

The water requirements per site, cultivation, and month are given for each site in Table 2. These water requirements, coupled with the head at the site and the efficiency of the pumping options considered, will allow the derivation of the fuel cost per ha or per m^3 in Table 3.

E. Other Variables

The only parameter which is not a function of the water requirement, the pumping option, or the site, is fuel cost. There are two kind of fuels; diesel and electricity.

Diesel can be used to drive the GMPs or the dedicated diesel generator for the electric submersible pumps on rafts. The price that the farmer will pay for this fuel is presented in Table 3 (see Note 4). Diesel can also be used to run the SENELEC power stations, and the price that SENELEC pays for it is presented in Table 3 (see Note 5). This price is derived from data contained in the IBRD Energy Assessment Report for Senegal. The price for electricity supplied by SENELEC to the consumer is presented in Table 3 (see Note 6).

It should be noted that the amount of electricity charged to the farmers is established from the fuel consumption/ha data for SENELEC. This is converted into kWh using the assumptions presented in Table 3 (see Note 2). This represents "normal" operating conditions for SENELEC.

III. COSTS

Costs have been divided into variable (fuel) and fixed (motors, pumps, etc.) categories. The following sections describe the basic data presented and the methods used to arrive at the calculated costs.

A. Variable Costs

Fuel cost derivation has been described previously. The fuel consumption is calculated using the efficiency, the water requirements, and the head for each month, and summing to arrive at a total. Given the fuel consumption, the fuel cost is presented in Table 3, and is calculated by multiplying consumption by the appropriate cost of fuel. It should be noted that for the floating GMP (diesel and dedicated generator) and SENELEC (at SENELEC charge), the cost is the one incurred by the farmer. Under the category SENELEC (at fuel cost), the amount paid by SENELEC to purchase the fuel to supply the necessary electricity is presented. This latter cost does not incorporate SENELEC's capital or overhead costs to handle, transport or store fuel, nor their general costs of operation, maintenance, generation, transmission and distribution.

B. Fixed Costs

There are three categories of fixed costs:

- Investment Costs;
- Depreciation Costs; and
- O&M Costs.

For each pumping option, investment costs are listed in Table 4 (left column). The useful life of each item and its salvage value is also presented. Table 5 presents the total investment per option as well as per hectare irrigated. In Table 6 (representing the total cost), only 10% of the total investment cost of Table 5 has been included to represent the cost of money (interest). The Senegal Pumping Report used this 10% to represent the cost of money. For a national perspective economic cost evaluation, the real cost of money and possibly an opportunity cost could be used. This would be higher than 10%. It is also important to note that in the case of connection to SENELEC, the cost to the project may not reflect SENELEC's long-run marginal costs for their isolated diesel stations.

Depreciation is handled by incorporating a sinking fund payment. This payment corresponds to an annual payment of such size as to allow for the repurchase of the initial equipment at the end of its life; annual payments bear an interest and there is also a salvage value for the investment at the end of its life. If I is the initial value, S the salvage value (in % of I), n the life cycle, and i the interest, then the annual payment is given by:

$$I \ (1 - S) \quad \frac{i}{(i+1)^{n}-1}$$

All the values are included in Table 4 for each option. The total annual payment is also presented.

Operations and maintenance costs (O&M) include labor, oil and material. Labor varies according to the option (dedicated diesel generators require more electricians and mechanics than connection to SENELEC) and the calculation method. There is no breakdown of O&M over time (except for the GMP option) even though it is recognized that some years will be more costly than others (scheduled overhaul). The analysis uses an average cost per year.

C. Total Cost

Table 6 presents, for each site and each crop, the total cost of irrigation of one hectare using one pumping option. The same comments as in the section on fuel costs apply for the cost to the farmer and the real cost at SENELEC's cost of fuel. The difference between both fuel costs gives an idea of the subsidy associated with a connection to the grid. (Because capital costs and overhead are not included in SENELEC's costs, the subsidy may be much larger than this difference.) Table 7 presents the same results as in Table 6, but per cubic meter.

IV. ANALYSIS

A. Selection of an Irrigation System Based Only on Costs

The final part of the cost analysis consists of selecting a perimeter size for each site and a cultivation calendar over the year. The cultivation calendar consists of a description of the number of hectares cultivated with different crops. This is presented in Table 8 by incorporating the percentage of hectares planted with various crops. Following this, a number of net hectares to be irrigated is selected (top of Table 8) and the appropriate number of pumping systems (for each option) are chosen in order to match or come close to the water needed for irrigation. Table 8 also presents the total cost of each option selected and the fuel component cost.

The calculations are discussed at the bottom of the table. The fuel cost is calculated as follows:

$$\sum_{\text{Cultivation Choices}} \underbrace{(\%\text{ in crop}) \times (\text{Total Area})}_{\text{number of hectares}} \times \underbrace{\text{cost per hectares}}_{\text{from Table 3}}$$

The fixed cost is given by the formula:

$$\text{number of sets} \times [\underbrace{\text{investment} \times 10\%}_{\text{capital cost burden}} + \text{Depreciation} + \text{O\&M}]$$

B. Benefits

The remaining three tables present information necessary for the calculation of net present value (NPV) and internal rate of return (IRR). The first table presents all non-pumping variable costs associated with the project when rice is the crop. These are essentially the farmers' annual costs to grow rice. The column labeled Percent Indirect Taxes represents the percentage difference between what the farmer pays and the actual market costs. This is an indication of the subsidy given to the farmer (project). The Percent Foreign Exchange column is not used in the calculations but shows the amount of foreign exchange inherent in each item.

The second table presents fixed costs of growing rice with irrigation supplied by Lister HR. 3 pumps. It also summarizes the variable costs by year for the total area irrigated. The fixed pumping costs are taken from earlier tables and spread over the operating period chosen for the analysis. The Percentage Indirect Taxes column is used to calculate the tax on fixed costs, and the tax on variable costs (actually a subsidy) comes from the previous table. The last row in the table presents the economic costs of the project.

The final table presents the project benefits which are the price paid for the crop. The "Plus Indirect Taxes On Benefits" row is not a value added tax but the difference between the price paid to the farmer by the government and the market value of the crop. For this example involving a rice crop, it is the 45% shown in the Percent Indirect Taxes column. The net financial and net economic benefits by year are shown. Economic and financial IRR and NPV are presented at the bottom of the table.

C. Remarks

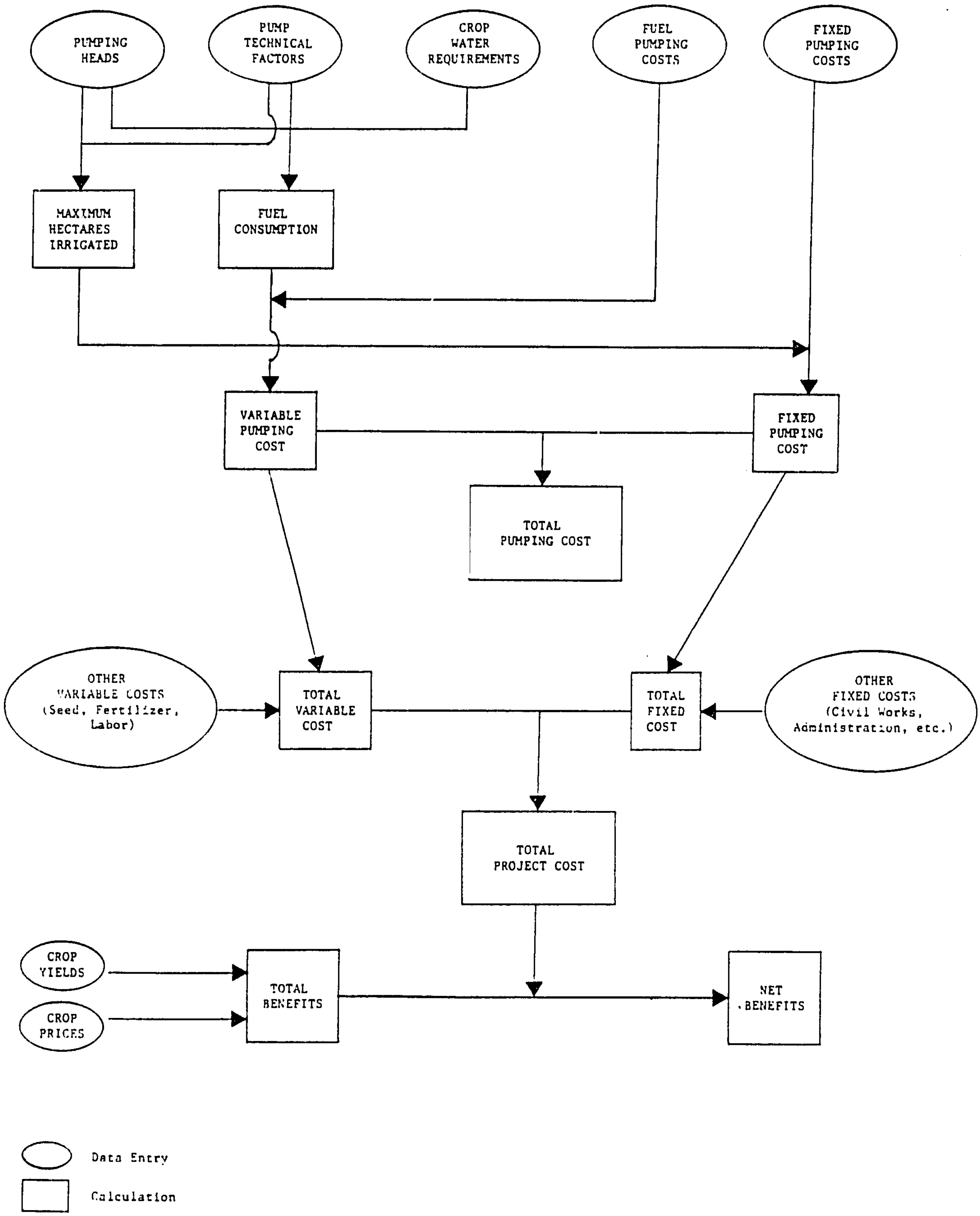
The above cost-benefit analysis, although straight forward, contains a large number of variables. The Bakel case used for display purposes was well researched and many site specific data were available, but the analysis still required a large number of assumptions. The Bakel perimeter is not large -- less than 250 hectares -- and with crop splitting, smaller areas are to be used for each crop. This apparent smallness in size, however, is not often matched by the size of the annual and cumulative net benefits (see NPV values for Bakel). The Bakel example is not important for the bottom line number but rather for displaying that routine cost and benefit analysis is feasible, and with this type of analysis it is possible to:

- Evaluate even small irrigation projects using a rigorous approach.
- Quickly and cost effectively perform sensitivity analyses of various parameters to determine critical variables. In this case, for example, land value (cost) is very powerful in influencing the outcome of the C/B analyses.

There is still much to do to make cost-benefit analysis of the type displayed here available to and useful for routine irrigation decisions. However, the above example helps reinforce the feeling that this goal is worth working towards.

FIGURE 1

SCHEMATIC OF COST AND BENEFIT ANALYSIS PROCEDURE



SITE :
BAKEL - COLLENGA

Table 1 - PUMPING HEADS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
STATIC LIFT (m)	9.0	9.0	9.0	9.0	9.0	9.0	8.0	4.0	2.5	3.5	6.5	8.5
DYNAMIC LIFT (m)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
TOTAL HEAD (m)	11.5	11.5	11.5	11.5	11.5	11.5	10.5	6.5	5.0	6.0	9.0	11.0

Table 2 - PUMPING REQUIREMENTS PER HA AND PER MONTH
in m3 / Ha / Month

Type of cultivation:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	SOURCE
CONTRE SAISON														
RICE C.S. BASE		2750	4200	4500	4750	1600							17,800	Engr N.Guyen
RICE C.S. OPTION1	4400	3000	4800	5900	2500								20,600	IDP (main section)
MIXED CROP BASE	1200	1300	1700	1000								200	5,400	IDP (main section)
MIXED CROP OPTION 2	500										2100	2700	5,300	IDP (Appendx B)
MIXED CROP OPTION 3	3500	2150									1100	1550	8,300	Engr N.Guyen - 100% corn
MIXED CROP OPTION 4	1700	2400	2900	1800									8,800	IDP (Appx A) - 100% corn
MIXED CROP OPTION 5			1600	2700	5200	2600							12,100	100% corn - C.S. - (CHAUDE)
HIVERNAGE														
RICE BASE CASE							1000	1600	2000	3100	1100		8,800	ENGR. N'GUYEN
RICE OPTION 1							2500	3100	3200	3400	1100		13,300	N. (NO RAIN ASSUMPTIONO
RICE OPTION 2							2800		900	3400	1400		8,500	IDP (MAIN SECTION)
MIX CROP BASE CASE							800	50	350	700	1800		3,700	IDP (MAIN SECTION)
MIXED CROP OPTION 3						100	1150	50	300	1100			2,700	IDP (APPX B)
MIXED CROP OPTION 4									700	1400			2,100	ENGR N'GUYEN - 100 % CORN
MIXED CROP OPTION 5							700	1600	2900	1800			7,000	N. 100 % CORN (NO RAIN)
MIXED CROP OPTION 6							1400	1700	1850	1850			6,800	IDP (APPX A) - 100 % CORN

(1) Static lift derived from IGN data - cf p.47 (after Manantali) and p.69
(2) Dynamic lift related to the configuration of the piping system (see p.70)

SITE :
BAKEL - COLLENGA

Table 3 - SUMMARY OF VARIABLE COSTS

	FUEL CONSUMPTION (liters / Ha)							FUEL COST in FCFA / ha				FUEL COST in FCFA / m3			
	GMP DIESEL		GMP DEDICATED SUPPLY		ELECTRIC SUPPLY SENELEC			FLOATING GMP		SENELEC OPTION		FLOATING GMP		SENELEC OPTION	
CONTRE SAISON	System effic. (1)	liters/ha	effic. (1)	liters/ha	effic. (2)	liters/ha	kWh/ha (3)	diesel (4)	dedicated gene. (4)	at fuel cost (5)	Senelec charge (6)	diesel	dedicated gene.	at fuel cost	Senelec charge
RICE C.S. BASE	16.80%	319.2	13.10%	409.4	16.00%	335.2	814.0	71,828	92,115	40,559	40,702	4.0	5.2	2.3	2.3
RICE C.S. OPTION1	16.80%	369.5	13.10%	473.8	16.00%	387.9	942.1	83,127	106,605	46,939	47,105	4.0	5.2	2.3	2.3
MIXED CROP BASE	16.80%	96.7	13.10%	124.0	16.00%	101.5	246.6	21,755	27,900	12,285	12,328	4.0	5.2	2.3	2.3
MIXED CROP OPTION 2	16.80%	84.8	13.10%	108.7	16.00%	89.0	216.1	19,071	24,458	10,769	10,807	3.6	4.6	2.0	2.0
MIXED CROP OPTION 3	16.80%	143.4	13.10%	183.9	16.00%	150.5	365.6	32,256	41,366	18,214	18,278	3.9	5.0	2.2	2.2
MIXED CROP OPTION 4	16.80%	157.8	13.10%	202.4	16.00%	165.7	402.5	35,510	45,540	20,052	20,123	4.0	5.2	2.3	2.3
MIXED CROP OPTION 5	16.80%	217.0	13.10%	278.3	16.00%	227.9	553.4	48,827	62,618	27,571	27,668	4.0	5.2	2.3	2.3
HIVERNAGE															
RICE BASE CASE	13.50%	115.3	13.10%	118.8	13.80%	112.8	273.9	25,938	26,730	13,646	13,694	2.9	3.0	1.6	1.6
RICE OPTION 1	13.50%	179.9	13.10%	185.4	13.80%	176.0	427.4	40,479	41,715	21,295	21,371	3.0	3.1	1.6	1.6
RICE OPTION 2	13.50%	129.8	13.10%	133.8	13.80%	127.0	308.5	29,213	30,105	15,369	15,423	3.4	3.5	1.8	1.8
MIX CROP BASE CASE	13.50%	59.9	13.10%	61.8	13.80%	58.6	142.4	13,482	13,894	7,093	7,118	3.6	3.8	1.9	1.9
MIXED CROP OPTION 3	13.50%	42.0	13.10%	43.3	13.80%	41.1	99.8	9,454	9,743	4,974	4,991	3.5	3.6	1.8	1.8
MIXED CROP OPTION 4	13.50%	23.1	13.10%	23.8	13.80%	22.6	54.9	5,196	5,355	2,734	2,743	2.5	2.6	1.3	1.3
MIXED CROP OPTION 5	13.50%	83.5	13.10%	86.1	13.80%	81.7	198.5	18,799	19,373	9,890	9,925	2.7	2.8	1.4	1.4
MIXED CROP OPTION 6	13.50%	89.5	13.10%	92.2	13.80%	87.5	212.6	20,130	20,745	10,590	10,628	3.0	3.1	1.6	1.6

Consumption in l/ha based on = $$\frac{(2.62 * 10^{-4})}{\text{system efficiency}} * \sum_{\text{months}} [\text{Head (m)} * \text{Water (m3)}]$$
(see report p.56)

(1) Based on report p.37
(2) Based on report p.58 (case 8), p.64 and p.99: diesel engine 28%, generator 90%, distribution 94%, motor 90%, pump 65 or 75%
(3) Based on previous columns and the following assumptions for SENELEC generation:
350 g/kWh (see p.100 or 104) and density = 0.85 kg/liter
(4) Calculated at cost of fuel to farmers = 225 FCFA/liter. (p.137)
(5) Calculated at cost of Gasoil to SENELEC = 121 FCFA/liter.- Based on july '82 costs from World Bank energy assesment p.41
using a conversion rate of US$1 = 400 FCFA and a density of .85
(6) Calculated at price of kWh charged by SENELEC to 50 FCFA/kWh
assumes no use during peak hours, includes fixed charge.

Table 4.1 - FLOATING GMP AND LISTER HR2

INVESTMENT COSTS FOR OPTION: Floating GMP and LISTER 2		DEPRECIATION COST (*) interest: 10.0% %			MAINTENANCE COST PER YEAR :	
ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
Engine	1,270	7	20.0%	107	LUB OIL	60
Pump	420	15	20.0%	11	LABOR	57
Chassis	740	15	20.0%	19	SPARE PARTS	62
Suction pipe	340	15	20.0%	9		
Other pipes	1,780	15	20.0%	45		
Float	820	10	20.0%	41		
Spare parts	340	15	20.0%	9		
Fuel tank	700	15	20.0%	18		
Transport / erection	220			0		
				0		
				0		
others (delivery,				0		
pipes,...) Bakel only	570			0		
				0		
				0		
				0		
				0		
				0		
TOTAL:	7,200	TOTAL:		257	TOTAL:	179

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	16.61	(p. 136)
Power of the pump in kW:	13.8	same - 20%
Pump efficiency (in %):	75.0%	(p. 136)
Maximum head at the site over the year (m):	11.50	table 1

The flow of water available from the pump is then calculated according to the following formula: $Q = \frac{\text{Pump Power} * 102 * \text{Effic.}}{\text{Head}}$

		Ha net	Ha gross
Therefore , Q =	91.8 l/s		
Assumes then a need for a flow of l/s/ha:		5.3	4
Therefore the area served is (Ha)		17.3	23.0

Table 4.2 - FLOATING GMP AND LISTER HR3

INVESTMENT COSTS FOR OPTION: Floating GMP and LISTER 3		DEPRECIATION COST (*) Interest: 10.0% %			MAINTENANCE COST PER YEAR :	
ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
Engine	1,870	7	20.0%	158	LUB OIL	95
Pump	530	15	20.0%	13	LABOR	89
Chassis	880	15	20.0%	22	SPARE PARTS	96
Suction pipe	430	15	20.0%	11	Pompiste	60
Other pipes	2,200	15	20.0%	55		
Float	930	10	20.0%	47		
Spare parts	680	15	20.0%	17		
Fuel tank	700	15	20.0%	18		
Transport / erection	220			0		
				0		
				0		
				0		
				0		
				0		
				0		
				0		
				0		
				0		
TOTAL:	8,440	TOTAL:		341	TOTAL:	340

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	24.9	(p. 136)
Power of the pump in kW:	20.75	same - 20%
Pump efficiency (in %):	75.0%	(p. 136)
Maximum head at the site over the year (m):	11.50	table 1

The flow of water available from the pump is then calculated according to the following formula: $Q = \frac{\text{Pump Power} * 102 * \text{Effic.}}{\text{Head}}$

		Ha net	Ha gross
Therefore , Q =	138.0 l/s		
Assumes then a need for a flow of l/s/ha:		5.3	4
Therefore the area served is (Ha)		26.0	34.5

Table 4.3 - FLOATING 6MP AND LISTER HR6

INVESTMENT COSTS FOR OPTION: Floating 6MP and LISTER 6 — DEPRECIATION COST (*) interest: 10.0% — MAINTENANCE COST PER YEAR :

ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
Engine	3,200	7	20.0%	270	LUB OIL (1)	163
Pump	700	15	20.0%	18	LABOR (1)	152
Chassis	1,000	15	20.0%	25	SPARE PARTS(1)	165
Suction pipe	900	15	20.0%	23	Pompiste (2)	120
Other pipes	3,500	15	20.0%	88		
Float	1,800	10	20.0%	90		
Spare parts	800	15	20.0%	20	(1) approx. from	
Fuel tank	1,000	15	20.0%	25	total of 480	
Transport / erection	300			0	given on page	
				0	80	
				0		
				0		
				0		
				0		
				0		
				0		
				0		
				0		
TOTAL:	13,200		TOTAL:	559	TOTAL:	600

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	55.5	(p. 136)
Power of the pump in kW:	46.2	same - 20%
Pump efficiency (in %):	75.0%	(p. 136)
Maximum head at the site over the year (m):	11.50	table 1

The flow of water available from the pump is then calculated according to the following formula: Q= Pump Power * 102 * Effic. / Head

Therefore , Q = 307.3 l/s

	Ha net	Ha gross
Assumes then a need for a flow of l/s/ha:	5.3	4
Therefore the area served is (Ha)	58.0	76.8

Table 4.4 - FLOATING RAFT W. 3 PUMPS AND A DIESEL GENERATOR

INVESTMENT COSTS FOR OPTION: 1 floating raft with 3 pumps and a 110 HP diesel generator — DEPRECIATION COST (*) interest: 10.0% — MAINTENANCE COST PER YEAR :

ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
SUBMERSIBLE PUMPS				0	LABOR:	
Motor pump (4)	4,400	10	20.0%	221	1 full mechanic	960
Float	700	15	20.0%	18	1 part electric	120
Piping	2,100	15	20.0%	53	1 pompiste	60
Control panel, cables..	550	15	20.0%	14		
Transp. / erection	250			0	Materials	1,000
				0		
DIESEL GENERATOR				0	Oil	292
Diesel Generator	10,500	8	20.0%	735		
Relay/control/meters	2,500	15	20.0%	63		
Fuel tank	2,000	15	20.0%	50		
Spare parts	500	15	20.0%	13		
Tansp. / erection	5,000			0		
				0		
				0		
				0		
				0		
				0		
TOTAL:	28,500		TOTAL:	1,166	TOTAL:	2,432

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	78	(p. 94)
Power of the pump in kW:	37.5	(p. 93)
Pump efficiency (in %):	75.0%	(p. 57)
Maximum head at the site over the year (m):	11.50	table 1

The flow of water available from the pump is then calculated according to the following formula: Q= Pump Power * 102 * Effic. / Head

Therefore , Q = 249.5 l/s

	Ha net	Ha gross
Assumes then a need for a flow of l/s/ha:	5.3	4
Therefore the area served is (Ha)	47.1	62.4

Table 4.5 - 2 FLOATING RAFTS W. 6 PUMPS AND A DIESEL GENERATOR

INVESTMENT COSTS FOR OPTION: 2 floating rafts with 6 pumps and a 180 HP diesel generator

DEPRECIATION COST (*) interest: 10.0% %

MAINTENANCE COST PER YEAR :

ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
SUBMERSIBLE PUMPS				0	LABOR:	
Motor pump (8)	8,800	10	20.0%	442	1 full mechanic	960
Float	1,400	15	20.0%	35	1 part electric	120
Piping	4,200	15	20.0%	106	1 pompiste	60
Control panel, cables..	1,100	15	20.0%	28		
Transp. / erection	500	15	0.0%	16	Materials	1,300
				0		
DIESEL GENERATOR				0	Oil	471
Diesel Generator	13,500	8	20.0%	944		
Relay/control/meters	2,500	15	20.0%	63		
Fuel tank	3,000	15	20.0%	76		
Spare parts	600	15	20.0%	15		
Tansp. / erection	6,000	15		189		
				0		
				0		
				0		
				0		
				0		
TOTAL:	41,600		TOTAL:	1,913	TOTAL:	2,911

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	132	(p. 94)
Power of the pump in kW:	75	(p. 94)
Pump efficiency (in %):	75.0%	(p. 57)
Maximum head at the site over the year (m):	11.50	table 1

The flow of water available from the pump is then calculated according to the following formula: Q= Pump Power * 102 * Effic. / Head

Therefore , Q = 498.9 l/s

	Ha net	Ha gross
Assumes then a need for a flow of l/s/ha:	5.3	4
Therefore the area served is (Ha)	94.1	124.7

Table 4.6 - FLOATING RAFT W. 3 PUMPS CONNECTED TO SENELEC

INVESTMENT COSTS FOR OPTION: 1 floating raft with 3 pumps connected to SENELEC

DEPRECIATION COST (*) interest: 10.0% %

MAINTENANCE COST PER YEAR :

ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
SUBMERSIBLE PUMPS				0	LABOR:	
Motor pump (4)	4,400	10	20.0%	221		
Float	700	15	20.0%	18		
Piping	2,100	15	20.0%	53	1 pompiste	60
Control panel, cables..	550	15	20.0%	14		
Transp. / erection	250	15	0.0%	6	Other (not	
				0	described)	90
CONNECTION TO THE GRID				0		
Transfo at power plant	2800	15	20.0%	71		
				0		
Distribution line km:				0		
1.5				0		
at 3800 per km (6.6 kV)	5700	35	20.0%	17		
				0		
Transfo at pumps	5,400	15	20.0%	136		
				0		
				0		
				0		
TOTAL:	21,900		TOTAL:	536	TOTAL:	150

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	NA	(p. 94)
Power of the pump in kW:	37.5	(p. 94)
Pump efficiency (in %):	75.0%	(p. 57)
Maximum head at the site over the year (m):	11.50	table 1

The flow of water available from the pump is then calculated according to the following formula: Q= Pump Power * 102 * Effic. / Head

Therefore , Q = 249.5 l/s

	Ha net	Ha gross
Assumes then a need for a flow of l/s/ha:	5.3	4
Therefore the area served is (Ha)	47.1	62.4

Table 4.7 - 2 FLOATING RAFTS W. 6 PUMPS CONNECTED TO SENELEC

INVESTMENT COSTS FOR OPTION: 2 floating rafts with 6 pumps connected to SENELEC

DEPRECIATION COST (*) interest: 10.0 %

MAINTENANCE COST PER YEAR :

ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
SUBMERSIBLE PUMPS				0	LABOR:	
Motor pump (8)	8,800	10	20.0%	442		
Float	1,400	15	20.0%	35		
Piping	4,200	15	20.0%	106	1 pompiste	60
Control panel, cables..	1,100	15	20.0%	28		
Transp. / erection	500	15	0.0%	16	Other (not	
				0	described)	90
CONNECTION TO SENELEC				0		
Transfo at power plant	2800	15	20.0%	71		
				0		
Distribution line km:				0		
1.5				0		
at 3800 per km (6.6 kV)	5700	35	20.0%	17		
				0		
Transfo at pumps	5,400	15	20.0%	136		
				0		
				0		
				0		
TOTAL:	29,900		TOTAL:	849	TOTAL:	150

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	NA	(p. 94)
Power of the pump in kW:	75	(p. 94)
Pump efficiency (in %):	75.0%	(p. 57)
Maximum head at the site over the year (m):	11.50	table 1

The flow of water available from the pump is then calculated according to the following formula: Q= Pump Power * 102 * Effic. / Head

		Ha net	Ha gross
Therefore , Q =	498.9 l/s		
Assumes then a need for a flow of l/s/ha:		5.3	4
Therefore the area served is (Ha)		94.1	124.7

Table 4.8 - FIXED PUMPING STATION WITH DIESEL GENERATOR

INVESTMENT COSTS FOR OPTION: Fixed pumping station with dedicated diesel generator

DEPRECIATION COST (*) interest: 10.0 %

MAINTENANCE COST PER YEAR :

ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
COST OF STATION (*)				0	LABOR:	
Civil works	92,800	40	0.0%	210	1 full mechanic	960
Electrical	6,800	15	20.0%	171	1 full electric	1,400
Hydraulical/Mechanical				0		
Pumps	19,000	30	20.0%	92	MATERIALS	
Others	4,700	15	20.0%	118	pumps	1,000
				0	diesel gen.	3,000
DIESEL GENERATOR				0		
Diesel Generator	38,000	8	20.0%	2,658	OIL	525
Relay/control/meters	2,500	15	20.0%	63		
Fuel tank	4,000	15	20.0%	101		
Spare parts	1,000	15	20.0%	25		
Tansp. / erection	7,000	15	0.0%	220		
				0		
				0		
(*) from Gersar study at Podor				0		
				0		
				0		
TOTAL:	175,800		TOTAL:	3,659	TOTAL:	6,885

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	NA	
Power of the pump in kW:	NA	
Pump efficiency (in %):	NA	
Maximum head at the site over the year (m):	11.50	Table 1

The flow of water available from the pump is then calculated according to the following formula: Q= Pump Power * 102 * Effic. / Head

		Ha net	Ha gross
Therefore , Q =	NA l/s		
Assumes then a need for a flow of l/s/ha:		5.3	4
Therefore the area served is (Ha)		NA	NA

N.B.: this option has not been considered for Bakel (Podor only), but the cost data from Podor are given for information

Table 4.9 - FIXED PUMPING STATION CONNECTED TO SENELEC

INVESTMENT COSTS FOR OPTION: Fixed pumping station with connection to the grid		DEPRECIATION COST (*) interest: 10.0% %			MAINTENANCE COST PER YEAR :	
ITEM DESCRIPTION	COST (000 FCFA)	LIFE (years)	SALVAGE VALUE (%)	ANUAL PAYMENT (FCFA)	ITEM DESCR.	COST FCFA
COST OF STATION (*)				0	LABOR:	
Civil works	92,800	40	0.0%	210	1 full mechanic	960
Electrical	6,800	15	20.0%	171		
Hydraulical/Mechanical				0		
Pumps	19,000	30	20.0%	92	MATERIALS	
Others	4,700	15	20.0%	118	pumps	1,000
				0		
CONNECTION TO SENELEC				0		
Transfo at power plant	2800	15	20.0%	71		
				0		
Distribution line km:				0		
1.5				0		
at 3800 per km (6.6 kV)	5700	35	20.0%	17		
				0		
Transfo at pumps	5,400	15	20.0%	136		
				0		
(*) from Gersar at Podor				0		
				0		
TOTAL:	137,200		TOTAL:	815	TOTAL:	1,960

(*) Sinking fund method

TECHNICAL ASSUMPTIONS:

Power of the diesel engine in kW:	NA
Power of the pump in kW:	NA
Pump efficiency (in %):	NA
Maximum head at the site over the year (m):	11.50

Table 1

The flow of water available from the pump is then calculated according to the following formula:

$$Q = \frac{\text{Pump Power} * 102 * \text{Effic.}}{\text{Head}}$$

Therefore , Q = NA l/s

	Ha net	Ha gross
Assumes then a need for a flow of l/s/ha:	5.3	4
Therefore the area served is (Ha)	NA	NA

N.B.: this option has not been considered for Bakel (Podor only), but the cost data from Podor are given for information

Table 5 - SUMMARY OF FIXED COSTS

(IN 000 FCFA)

OPTION	TOTAL INVESTMENT (1)	DEPRECIATION / YEAR (1)	O & M / YEAR (1)	NET HA SERVED (2)	INVEST./ HA (3)
GMP, LISTER HR2	7,200	257	179	17.3	415.7
GMP, LISTER HR3	8,440	341	340	26.0	324.1
GMP, LISTER HR6	13,200	559	600	58.0	227.6
FLOATING (3), D/G	28,500	1,166	2,432	47.1	605.5
FLOATING (6), D/G	41,600	1,913	2,911	94.1	441.9
FLOATING (3), GRID	21,900	536	150	47.1	465.3
FLOATING (6), GRID	29,900	849	150	94.1	317.6
FIXED STATION, D/G	175,800	3,659	6,885	NA	NA
FIXED STATION, GRID	137,200	815	1,960	NA	NA

(1) Based on previous cost descriptions per option
(2) Based on previous technical assumptions per options; based on power of pump, maximum head and 80 l/s for 20 Ha gross (15 Ha net)
(3) = (1) / (2)

SITE :
BAKEL - COLLENGA

Table 6 - TOTAL COST / HA / YEAR
(in 000 FCFA) (1)

	AUTONOMOUS DIESEL SUPPLY (2)						SENELEC SUPPLY at fuel cost (3)			SENELEC SUPPLY at SENELEC charge (4)		
	GMP HR2	GMP HR3	GMP HR6	3 FLOAT. PUMPS D / 6	6 FLOAT. PUMPS D / 6	FIX. STATION D / 6	3 FLOAT. PUMPS	6 FLOAT. PUMPS	FIX. STATION	3 FLOAT. PUMPS	6 FLOAT. PUMPS	FIX. STATION
CONTRE SAISON												
RICE C.S. BASE	138.6	130.4	114.6	229.1	187.6	NA	101.7	82.9	NA	101.8	83.1	NA
RICE C.S. OPTION1	149.9	141.7	125.9	243.6	202.0	NA	108.1	89.3	NA	108.2	89.5	NA
MIXED CROP BASE	88.5	80.3	64.5	164.9	123.3	NA	73.4	54.7	NA	73.4	54.7	NA
MIXED CROP OPTION 2	85.8	77.6	61.8	161.4	119.9	NA	71.9	53.1	NA	71.9	53.2	NA
MIXED CROP OPTION 3	99.0	90.8	75.0	178.4	136.8	NA	79.3	60.6	NA	79.4	60.7	NA
MIXED CROP OPTION 4	102.3	94.1	78.3	182.5	141.0	NA	81.2	62.4	NA	81.2	62.5	NA
MIXED CROP OPTION 5	115.6	107.4	91.6	199.6	158.1	NA	88.7	70.0	NA	88.8	70.0	NA
HIVERNAGE												
RICE BASE CASE	92.7	84.5	68.7	163.7	122.2	NA	74.8	56.0	NA	74.8	56.1	NA
RICE OPTION 1	107.2	99.0	83.2	178.7	137.2	NA	82.4	63.7	NA	82.5	63.8	NA
RICE OPTION 2	96.0	87.8	72.0	167.1	125.5	NA	76.5	57.7	NA	76.5	57.8	NA
MIX CROP BASE CASE	80.2	72.0	56.2	150.9	109.3	NA	68.2	49.5	NA	68.2	49.5	NA
MIXED CROP OPTION 3	76.2	68.0	52.2	146.7	105.2	NA	66.1	47.4	NA	66.1	47.4	NA
MIXED CROP OPTION 4	71.9	63.7	47.9	142.3	100.8	NA	63.8	45.1	NA	63.9	45.1	NA
MIXED CROP OPTION 5	85.5	77.3	61.6	156.4	114.8	NA	71.0	52.3	NA	71.0	52.3	NA
MIXED CROP OPTION 6	86.9	78.7	62.9	157.7	116.2	NA	71.7	53.0	NA	71.7	53.0	NA

(1) total cost = fixed cost (table 5; see notes for investment) + variable cost (table 3)
(2) Total cost per Ha for the project; includes 10% interest on investment, depreciation, O & M (table 5), as well as cost of fuel based on the price paid by the farmers, which is equal to 225 FCFA/liter
(3) Same as (2) but fuel cost is cost for SENELEC to generate the necessary electricity at a fuel price of 121 FCFA/liter
(4) Same as (2) but fuel cost is cost to farmers based on SENELEC charge per kWh, equal to 50 FCFA/kWh

SITE :
BAKEL - COLLENGA

Table 7 - TOTAL COST / m3 / YEAR
in FCFA (1)

	AUTONOMOUS DIESEL SUPPLY (2)						SENELEC SUPPLY					
							at fuel cost (3)			at SENELEC charge (4)		
	GMP HR2	GMP HR3	GMP HR6	3 FLOAT. PUMPS D / G	6 FLOAT. PUMPS D / G	FIX. STATION D / G	3 FLOAT. PUMPS	6 FLOAT. PUMPS	FIX. STATION	3 FLOAT. PUMPS	6 FLOAT. PUMPS	FIX. STATION
CONTRE SAISON												
RICE C.S. BASE	7.8	7.3	6.4	12.9	10.5	NA	5.7	4.7	NA	5.7	4.7	NA
RICE C.S. OPTION1	7.3	6.9	6.1	11.8	9.8	NA	5.2	4.3	NA	5.3	4.3	NA
MIXED CROP BASE	16.4	14.9	11.9	30.5	22.8	NA	13.6	10.1	NA	13.6	10.1	NA
MIXED CROP OPTION 2	16.2	14.6	11.7	30.5	22.6	NA	13.6	10.0	NA	13.6	10.0	NA
MIXED CROP OPTION 3	11.9	10.9	9.0	21.5	16.5	NA	9.6	7.3	NA	9.6	7.3	NA
MIXED CROP OPTION 4	11.6	10.7	8.9	20.7	16.0	NA	9.2	7.1	NA	9.2	7.1	NA
MIXED CROP OPTION 5	9.6	8.9	7.6	16.5	13.1	NA	7.3	5.8	NA	7.3	5.8	NA
HIVERNAGE												
RICE BASE CASE	10.5	9.6	7.8	18.6	13.9	NA	8.5	6.4	NA	8.5	6.4	NA
RICE OPTION 1	8.1	7.4	6.3	13.4	10.3	NA	6.2	4.8	NA	6.2	4.8	NA
RICE OPTION 2	11.3	10.3	8.5	19.7	14.8	NA	9.0	6.8	NA	9.0	6.8	NA
MIX CROP BASE CASE	21.7	19.5	15.2	40.8	29.5	NA	18.4	13.4	NA	18.4	13.4	NA
MIXED CROP OPTION 3	28.2	25.2	19.3	54.3	39.0	NA	24.5	17.5	NA	24.5	17.5	NA
MIXED CROP OPTION 4	34.3	30.4	22.8	67.8	48.0	NA	30.4	21.5	NA	30.4	21.5	NA
MIXED CROP OPTION 5	12.2	11.0	8.8	22.3	16.4	NA	10.1	7.5	NA	10.1	7.5	NA
MIXED CROP OPTION 6	12.8	11.6	9.2	23.2	17.1	NA	10.5	7.8	NA	10.5	7.8	NA

(1) total cost = fixed cost (table 5; see notes for investment) + variable cost (table 3)
(2) Total cost per Ha for the project; includes 10% interest on investment, depreciation, O & M (table 5), as well as cost of fuel based on the price paid by the farmers, which is equal to 225 FCFA/liter
(3) Same as (2) but fuel cost is cost for SENELEC to generate the necessary electricity at a fuel price of 121 FCFA/liter
(4) Same as (2) but fuel cost is cost to farmers based on SENELEC charge per kWh, equal to 50 FCFA/kWh

BAKEL

Table 8 - SPECIFIC SITE ANALYSIS

TOTAL NUMBER OF HA TO IRRIGATE (in net Ha): 112.5

Table 8 - A

CULTIVATION CHOICE	PERCENTAGE OF HA IN CROP (5)
CONTRE SAISON	
RICE C.S. BASE	
RICE C.S. OPTION1	
MIXED CROP BASE	35.0%
MIXED CROP OPTION 2	
MIXED CROP OPTION 3	
MIXED CROP OPTION 4	
MIXED CROP OPTION 5	
HIVERNAGE	
RICE BASE CASE	68.0%
RICE OPTION 1	
RICE OPTION 2	
MIX CROP BASE CASE	7.0%
MIXED CROP OPTION 3	
MIXED CROP OPTION 4	
MIXED CROP OPTION 5	
MIXED CROP OPTION 6	

Table 8 - B

OPTIONS	HA SERVED (1)	Enter number of systems considered: (2)	Excess Irrigation Capacity (3)	TOTAL COST (4) (in thousand dollars)	of which fuel (in thousand dollars)
GMP, LISTER HR2	17.3		NA	NA	NA
GMP, LISTER HR3	26.0	5	17.7	10,571	2,947
GMP, LISTER HR6	58.0	2	3.5	7,905	2,947
FLOATING (3), D/G	47.1		NA	NA	NA
FLOATING (6), D/G	94.1	1	-18.4	12,237	3,253
FLOATING (3), GRID	47.1		NA	NA	NA
FLOATING (6), GRID	94.1	1	-18.4	5,579	1,589
FIXED STATION, D/G	NA		NA	NA	NA
FIXED STATION, GRID	NA		NA	NA	NA

NA = not available

(1) Data from Table 5
(2) Correspond to choice made in report p. 150 with the following differences
5 HR2 instead of 6 and 2 HR6 instead of 3 have been considered since they were sufficient
(3) (2) times (1) minus quantity to irrigate
(4) Total cost is equal to :
number of systems * (total invest * 0.1 + depreciation + G & M) + Fuel Cost
and fuel cost is equal to the sum over all cultivation of:
percent in crop * total area irrigated * fuel cost / ha (table 3)
(5) from report table 11.7 p.142

VARIABLE COST
(CFA/ha)

CROP: RICE (Base Case) AREA-BASED EXPENDITURE	Amount (*) Hiv	CS	Price (CFA)	Financial Cost (CFA/ha)	Percent Indirect Taxes	Economic Cost (CFA/ha)	Percent Foreign Exchange
Seed: 1)							
Traditional (2/3)	60	60	63.6	7,632	0%	7,632	0%
Improved (1/3)	30	30	69.2	4,152	-30%	5,398	20%
Fertilizer: 1)				0			
Trical. Phosphate	50	50	25	2,500	-96%	4,900	74%
KCl	-	-	25	0	-362%	0	74%
Urea	125	125	25	6,250	-566%	41,625	74%
Chemicals: 1)				0			
Azodine	0.5	0.5	1275	1,275	0%	1,275	70%
Endosulfan	-	-	2875	0	0%	0	70%
Decis	-	-	7357	0	0%	0	70%
Manebe	-	-	575	0	0%	0	70%
Diazianon	-	-	495	0	0%	0	70%
Land **	0.25	0.25	15367	7,684	0%	7,684	0%
Labor 1)	100	105	500	102,500	0%	102,500	0%
Small Tools 1)	-	-	8380	0	3%	0	25%
Farm Transport *** 1)	4	4	1000	8,000	0%	8,000	0%
Gas Oil 2)	115	319	225	97,766	31%	67,458	
Electricity 2)	-	-	50	0	0%	0	
Total Variable Cost				237,758		246,471	

* For seed, fertilizers, and chemicals, kg/ha; for land, ha; for labor, man-days/ha; for farm transport, days/ha; for gas oil, l/ha; for electricity, kwh/ha.

** The opportunity cost of land is the rent on recession farmland which equals 50% of the value of the nonirrigated yield. The opportunity cost indicates that the benefit derived from irrigation is not the entire irrigated yield, but only the improvement in the yield over and above the nonirrigated yield. It is assumed that 1/4 of the Collenga perimeter was built on recession lands and the rest on dryland which has no opportunity cost.

***Farm transport entails the rental of a donkey cart that can transport one tonne per day from the field to the village. Consequently, "Amount"(days/ha) is a function of crop yield(t/ha).

Sources:

1) Quantities: p. 66, vol. III, section 1.0, Economic and Financial Analysis, Integrated Development Project, USAID, Dakar, October, 1983.
   Prices, Indirect Taxes: p. 90-93, Ibid.
   Foreign Exchange Component: p. 162, vol. II, Project Paper, Integrated Development Project, USAID, Dakar, October, 1983.
2) Quantities and Prices: "Summary of Variable Cost" Table, this report.
   Indirect Taxes: p. 41, Senegal: Issues and Options in the Energy Sector, UNDP/World Bank Energy Assessment Program. July 1983.

TOTAL IRRIGATION COST
(000 CFA)

PUMP: GMP, LISTER HR3
CROP: RICE

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 -2013	Percent Indirect Taxes 1)	Percent Foreign Exchange 1)
No. of ha irrigated ** 2)	90	90	150	150	150	200	200	200	250	250		
VARIABLE COST	21,398	21,398	35,664	35,664	35,664	47,552	47,552	47,552	59,440	59,440	*	*
FIXED COST												
Pumping Costs												
No. of Pumpsets ***	4		2			2			2			
Excess Capacity (ha)	14	14	6	6	6	8	8	8	10	10		
Investment Costs	33,760	0	16,880	0	0	16,880	0	0	16,880	0	18%	58%
Depreciation	1,363	1,363	2,045	2,045	2,045	2,727	2,727	2,727	3,408	3,408	18%	58%
O & M	1,360	1,360	2,040	2,040	2,040	2,720	2,720	2,720	3,400	3,400	35%	52%
Civil Works 3)												
Construction Costs	0	0	0	0	0	0	0	0	0	0	0%	0%
Farmer Construction Labor	0	0	0	0	0	0	0	0	0	0	0%	0%
Farmer Maintenance Labor**	5	5	5	5	5	5	5	5	5	5	0%	0%
Extension Service ** 3)	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	5%	10%
Operating Costs ** 3)	2,592	2,592	2,592	2,592	2,592	2,592	2,592	2,592	2,592	2,592	10%	42%
FINANCIAL COSTS	62,079	28,319	60,826	43,946	43,946	74,075	57,195	57,195	87,325	70,445		
INDIRECT TAX												
Less Tax on Variable Cost	(784)	(784)	(1,307)	(1,307)	(1,307)	(1,743)	(1,743)	(1,743)	(2,178)	(2,178)		
Less Tax on Fixed Cost	7,137	1,061	4,460	1,421	1,421	4,820	1,782	1,782	5,181	2,143		
ECONOMIC COSTS	55,725	28,042	57,673	43,831	43,831	70,998	57,156	57,156	84,322	70,481		

* See Variable Cost Table
** Values extrapolated from reports: not hard figures.
***The replacement of pumps is paid for by sinking fund depreciation. No. of pumps is calculated to minimize excess capacity (given pumpset capacity from Fixed Cost table).

Sources:
1) Indirect taxes and foreign exchange: p.162, Project Paper, vol.II, Integrated Development Project. USAID, Dakar, October, 1983.
2) Ha irrigated: p.19 of main body of this report.
3) Cost of civil works, extension, operations: p. 162, vol. II, Project Paper.

PUMP: GMP, LISTER HR3
CROP: RICE

TOTAL IRRIGATION BENEFITS
(000 CFA)

Crop	% of Area Planted	Irrigated Yield (t/ha) 1)	Price (CFA/t) 2)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 -2013	Percent Indirect Taxes 2)	Percent Foreign Exchange
Rice	100%	8.5	51,500	0	39,398	65,663	65,663	65,663	87,550	87,550	87,550	109,438	109,438	45%	0%
Corn		2.5	69,500	0	0	0	0	0	0	0	0	0	0	0%	0%
Sorghum		2.5	50,000	0	0	0	0	0	0	0	0	0	0	37%	0%
Niebe		1.8	85,000	0	0	0	0	0	0	0	0	0	0	0%	0%
Vegetables		18.0	?	0	0	0	0	0	0	0	0	0	0	?	0%
FINANCIAL BENEFITS				0	39,398	65,663	65,663	65,663	87,550	87,550	87,550	109,438	109,438		
FINANCIAL COSTS				62,079	28,319	60,826	43,946	43,946	74,075	57,195	57,195	87,325	70,445		
NET FINANCIAL BENEFITS				(62,079)	11,079	4,837	21,717	21,717	13,475	30,355	30,355	22,113	38,993		
Plus Indirect Taxes on Benefits				0	17,729	29,548	29,548	29,548	39,398	39,398	39,398	49,247	49,247		
ECONOMIC BENEFITS				0	57,126	95,211	95,211	95,211	126,948	126,948	126,948	158,684	158,684		
ECONOMIC COSTS				55,725	28,042	57,673	43,831	43,831	70,998	57,156	57,156	84,322	70,481		
NET ECONOMIC BENEFITS				(55,725)	29,084	37,538	51,379	51,379	55,950	69,791	69,791	74,362	88,204		

ECONOMIC IRR: 71.4%
ECONOMIC NPV: 234,073 (000 CFA)
(rate of interest = 10%)

FINANCIAL IRR: 23.9%
FINANCIAL NPV: 46,427 (000 CFA)
(rate of interest = 10%)

Sources:
1) Crop Yields: p.162, Project Paper, vol.II, Integrated Development Project. USAID, Dakar, October, 1983.
2) Crop Prices and Indirect Taxes: All crops except niebe, p.60, Ibid.
niebe, p.90, Ibid.