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Introduction

This report summarizes the results of additional cost allocation studies for the proposed Senegal River development program. The procedures used in the analyses are based upon those contained in the report titled, "Cost allocation alternatives for the Senegal River development program" (Riley, et al., August 1978). That report (herein referred to as the First Report) describes several different cost allocation methods, but recommends use of the adjusted separable costs-remaining benefits (adjusted SCRB) procedure. The first report also describes an economic model which was developed to estimate the net benefits of the proposed project for each economic sector and each participating country. For review purposes, a brief description of the adjusted SCRB procedure and of the economic model are included as Appendix A of this report.

Following adoption of the First Report by the OMVS Council of Ministers, all subsequent studies were based upon the adjusted SCRB procedure and the economic model described by that report. The results of these studies, which were requested by the OMVS, Direction de la Planification et de la Coordination, are reported herein. It is emphasized that there is still much which is indefinite or not clearly defined regarding the nature of the proposed Senegal River development program. For example, the rate of agricultural development, the rate of river traffic development, the pumping demands for irrigation, the market for electric power, and the costs of the Manantali Dam itself are but a few of the quantities which need to be projected or assumed in order to conduct an economic study. For these reasons, it is not realistic, or even possible, at this time to identify a specific cost allocation for the project between the three countries involved. However, the model is useful in: (1) identifying those data and assumptions which are necessary to form the basis of a cost allocation formula, and (2) examining the relative effects on the project economy including cost allocation proportions of various possible system management alternatives and development assumptions. Its important role in defining those system characteristics or parameters which are important in influencing the cost allocation proportions make the model a highly useful technique long before it might be applied in the selection of a final cost allocation formula.

This report (the Second Report) is organized in four main sections as follows:

1. The first section describes the modifications and improvements to the economic model which have been incorporated since the first report. These improvements were designed to increase the capability of the model for examining the effects on the cost allocation of various possible development and system management alternatives.

2. The second section of the report outlines the input data used for the several studies conducted.

3. The third section of the report describes the computer runs and discusses the results of the model studies based on the assumptions and input data described in section 2.

4. The final section of the report presents some suggestions for possible future cooperative activites between the OMVS and the cost allcoation team.

SECTION 1

Modifications to the Economic Model

The First Report (Riley, et al., 1978), describes the economic model which was developed for cost allocation studies for the proposed Senegal River Basin Project, the agriculture and mining economic sectors, and the adjusted separable costs-remaining benefits cost allocation procedure. It has been accepted by the OMVS Council of Ministers. Since that time, the model has been improved and its capabilities have been expanded. It is emphasized, however, that the basis for the model is unchanged and remains the same as described in the First Report. A list of the model changes and a brief discussion of the purpose of these changes follows.

1. *Automatic calculation of the cost allocation.* With the earlier version of the model it was necessary to execute it twice to perform a cost allocation under a given set of assumptions. The first model run provided estimates of the remaining benefits to the agriculture and mining economic sectors after they pay for the separable project costs but not the joint cost of the Manantali dam. Calculation of the cost allocation was performed manually based on the estimated remaining benefits from the first run. A second model run was then necessary to estimate the net primary returns to the economic sectors after they pay for both the separable project costs and their allocation of the joint project costs. The modified model now has the capability of performing both runs and the cost allocation calculation, and thus saves user time and effort.

2. *Provision for consideration of government subsidies to project services.* It may be desirable for the member countries to supplement project revenues from users fees by government subsidies. The economic model can be used to calculate the level of subsidies required to balance the revenues and costs to each project service using predetermined user fees. Alternatively, predetermined subsidies can be input and the model can be used to calculate the user fees required to balance the revenues and costs.

3. Capability for considering delayed installation of power. A model option is now available for delaying the capital costs associated with the installation of power generation facilities at Manantali, and the development of power and navigation by the mining sector. The length of the delay is input by the user. The construction of the penstocks and power plant foundations at Manantali dam are assumed to take place when the dam is constructed.

4. Addition of a project loan account for calculating loan changes and net cash flow. This account contains, for each year after commencement of the project, the following information:

a. withdrawals from the loan account, where withdrawals are the capital costs of the project during the period of construction;
b. repayments made against the loan;
c. interest and other loan charges;
d. amount of the loan; and
e. net project cash flow calculated as follows:

$$C_i = R_i - O_i + S_i - P_i$$

in which

C_i = net project cash flow in i^{th} year
R_i = total project revenue from user fees in i^{th} year
O_i = total OM&R in i^{th} year
S_i = total government subsidy in i^{th} year
P_i = total repayment on the loan in i^{th} year

The model has the capability of using two alternative terms of lending:

a. hard loan with the following terms which are similar to those of the World Bank:
i) interest rate of 4 percent which is assumed to include all loan charges;
ii) interest paid after the first draw;
iii) twenty year period to repay loan after first draw;
iv) five year grace period commencing at first draw;
v) interest paid every six months during grace period; and
vi) equal repayments made every six months commencing six years after the first draw and continuing through the twenty year period.

b. soft loan with the following terms which are similar to those of the International Development Association's (IDA) credits:
i) interest free;
ii) fifty year period to repay loan after the first draw;
iii) 0.75 percent per annum service charge on the outstanding amount throughout the period of the loan;
iv) ten year grace period after the first draw;
v) 1 percent of the principal (i.e., the total amount of the loan) to be repaid each year during the second ten year period; and
vi) in the remaining thirty year period 3 percent of the principal to be repaid each year.

Other loan terms can be incorporated into the model through relatively minor program changes. Thus, when final loan terms are agreed between OMVS and the lending agencies these can be incorporated into the model. Since any delay in the installation of a power generation plant at Manantali would almost certainly necessitate a separate loan to cover the separable capital costs of these facilities, a separate loan account is used for the power generation plant. Thus, there are two loan accounts:

Account 1 for project capital costs excluding the costs of the hydropower generating facilities if they are delayed, but including the power plant foundations and penstocks which will be built at the time of construction of Manantali dam.

Account 2 for the project capital costs of the power generating facilities which are delayed.

When analyzing the case of no delay in power, only Account 1 is used. Interest and loan charges are included in the total cost of project services as follows:

a. for Account 1 they are divided between the three project services in the same proportions as the joint costs.
b. for Account 2 they are assigned to the power service.

5. Capability for varying agricultural development rates. The Groupement Manantali report (Annexe 4: Agriculture) contains three agricultural development rates (p. 69 and Annexe 6):

a.	slow rate - approximately	1800 ha/yr
b.	medium rate - approximately	4800 ha/yr
c.	rapid rate - approximately	7120 ha/yr

These three development rates lead to total irrigated areas of 99,978 ha, 255,163 ha, and 375,223 ha, respectively in 2028 (assuming the project is begun in 1979). The model can use any one of these agricultural development rates or, if desired, an alternative development rate specified by the user. Therefore, the model can be used to study the sensitivity of the cost allocation and the net primary returns to the economic sectors to variations in the rate of agricultural development. Growth of agricultural and other navigation quantities are assumed to be directly related to the increase in the area of irrigated agriculture.

6. Assignment of only some of the total agricultural benefits to the Manantali dam. The approximate ultimate areas of irrigated agriculture possible under various project configurations are given below:

a.	Manantali and Diama:	375,000 ha
b.	Manantali alone:	255,000 ha
c.	Diama alone:	42,000 ha

Therefore, the construction of both dams would make possible the development of more irrigated area (i.e., 375,000 ha) than the sum of the irrigated areas possible with each of the two individual dams (i.e., 255,000 + 42,000 = 297,000 ha). It is reasoned that the additional 78,000 ha (i.e., 375,000 - 297,000 = 78,000 ha) can be irrigated by water from Manantali which would be needed to prevent salt intrusion in the absence of the Diama dam. Clearly not all the benefits from agriculture can be attributed to the Manantali dam for the purpose of allocating the joint costs. The model assigns only 68 percent (i.e., 255/375), of the total agricultural benefits to the irrigation service provided by Manantali dam. The remaining 32 percent of the total agricultural benefits (i.e., 120/375, where 78,000 + 42,000 = 120,000 ha) are credited to Diama dam.

7. *Addition of flood control as an optional project service.* Although the Council of Ministers have chosen not to consider flood control as a project service (which thus would bear a share of the project costs) an option is available in the model to allocate costs to the flood control service should this be desirable in the future. No costs are assigned to the flood control service in the runs described in this report. If it were decided in the future to allocate costs to flood control, the model could be adapted to calculate user fees to repay flood control costs on the basis of the agricultural area protected from flooding through a supplemental charge on all irrigation water supplied by the project.

8. *The base year is 1979.* All prices and costs are expressed as 1979 F.CFA. In addition, all discounting is done using the base year of 1979 since this is planned as the first year of project construction.

SECTION 2

Data Base

This section summarizes the data used in the model studies reported herein. The purpose of a detailed description of the data base is to provide OMVS with the opportunity to suggest improvements and to make the team aware of data which might have been overlooked. Obviously, the model results are dependent on the input data, and therefore, it is important that OMVS agrees with the data base that is used. This section is divided into three subsections describing the project data, the agricultural economic sector data, and the mining economic sector data. "Other" irrigation not associated with either the agricultural or mining sectors is discussed in the subsection on the agricultural economic sector data.

Project data

Capital and operating, maintenance, and replacement (OM&R) costs for the project are given in Table 1. The costs are broken down into the joint cost of the Manantali dam and the separable costs of the water supply, navigation, and power project services. These data are the latest project cost estimates in 1979 CFA and were obtained from the sources referenced in Table 1. As improved estimates of project costs become available, these can easily be substituted for the existing estimates.

In order to estimate project benefits, it was necessary to assume both an economic life for the project and a time discount rate. By agreement with the Direction de la Planification et de la Coordination, OMVS, a discount rate of 10 percent was adopted. At this rate, discounted benefits after 50 years are very small, and so 50 years was taken as the economic life for the project.

Agricultural economic sector data

Prices, yields, production costs, cropping pattern, and water requirement data for the 14 project crops are given in Table 2 for both the wet and dry seasons. The principal source for these data is the Groupement Manantali report, Annexe 4: Agriculture. World prices are used. Production costs are given for both small and large perimeters. In addition to the variable production costs given in Table 2, the fixed costs associated with the development of the new irrigated lands, including the purchasing of irrigation and drainage pumps, are added. Based on the estimates in the Groupement Manantali report (Annexe 4: Agriculture, p. 123), updated to 1979 CFA, the cost of developing new irrigated lands is 1,189,900 CFA/ha with an additional fixed cost of 446,400 CFA/ha for pumping equipment which has a useful life of six years. These estimates do not include taxes and, therefore, net primary returns to agriculture include income received by the government through taxes levied on the agricultural sector. Thus, the model accounts for a total fixed cost of 1,636,300 CFA/ha (= 1,189,000 + 446,400) on each new area developed, and another 446,400 CFA/ha every six years, commencing six year after its initial development.

Different yields are used for irrigated farming, artificial flood farming, recession farming, and dry farming. Different cropping patterns based on a theoretical hectare are used for the valley and the delta under irrigated agriculture, the artificially flooded areas, the recession farmed areas, and the dry farmed areas. The percentages of the total agricultural area which are located in the delta are estimated from the team's First Report as:

Mali	0%
Mauritania	10.3%
Senegal	9.2%

The artificial flood described by Senegal Consult is scheduled for a five year period commencing in ~~1988~~ and will enable 25,000 ha to be irrigated as "recession" agriculture. Other computer runs will be made in which the following assumptions will be used regarding the artificial flood:

Rate of Agricultural Development (ha/yr)	Duration of Artificial Flood After Completion of the Manantali Dam (years)	Area of Full Irrigation Provided by the Project at Termination of the Artificial Flood (ha/yr)
Slow ~~(1,800)~~ 2500	~~17~~ 20	~~53,000~~ 58,000
Medium ~~(4,800)~~ 5000	10	50,000
Rapid ~~(7,120)~~ 7500	~~6~~ 7	~~48,000~~ 52,500

Estimates of the volume of the agricultural and "other" navigation services are taken from the Lackner report and are summarized in Table 3. The cost of

Table 1. Separable and joint project costs (1979 CFA).

Year	Capital Costs (F. CFA x 10^9): Separable Costs: Water	Navigation	Power[1]	Joint Costs	Operation, Maintenance, & Repair Costs (F.CFA x 10^9): Separable Costs: Water	Navigation[2]	Power[1]	Joint Costs
1979	1.712			2.777				
1980	4.280			13.851				
1981	5.885		4.840[3]	13.655				
1982	5.885		11.300	13.812				
1983	3.638	3.951	11.300	16.400				
1984		5.465	4.840	16.183	0.250			
1985		10.994		7.322		1.377 (1985)	0.365	
1986		9.740						0.170
1987		3.530						
1988		3.108						
1989								
.						4.192 (1992)		
.								
.						10.473 (2022)		
2028								
Total	21.400	36.800	32,280	84.000				
I Source of data	Economic Eval., Gibb, Aug. 1979	Navigability Study, Lackner, et al., Dec. 1977	Global Report, Gibb, 1978	Economic Evaluation, Gibb, Aug. 1979				
II Project Component	Diama Dam	Parts, stages, flottila, & dredging	Power generation plant & transmission	Manantali Dam	Diama Dam	Parts, stages, flottila, & dredging	Power, generation plant & transmission	Manantali Dam

[1]When power is delayed the costs in this column are postponed by the number of year of the delay.

[2]Navigation operating maintenance and repair costs are estimated at 8 F.CFA/Tonne-km as taken from the Lackner report.

[3]When power is delayed it is assumed that the cost of the penstocks and power plant foundation is incurred in 1981 as originally scheduled. This cost is 2.820 x 10^9 F.CFA and the remainder of the 1981 capital cost, i.e., 2.020 x 10^9 F.CFA, is postponed by the number of years of the dealy.

Table 2. Agricultural economic sector data by crops.

Index No.	Crop	Season	Weight Price (CFA/t)	Yields (t/ha) Irrigated	Artificial Flood	Recession	Dry	Production costs (CFA/ha) Small Perimeters	Large Perimeters	Fraction of agricultural hectare Valley	Delta	Artificial Flood	Recession	Dry	Water Requirement m³/ha
1	Rice	Wet	60,300	3.5	---	0	0	66,364	46,399	0.306	0.306	---	0	0	1.7533
		Dry		3.5	0	---	---	66,963	43,005	0.122	0.122	0	---	---	2.0827
2	Tomatoes	Wet	15,000	15.0	---	0	0	172,710	148,606	0.035	0.035	---	0	0	0.904
		Dry		---	0	---	---	---	---	0.	0.	0	---	---	---
3	Wheat	Wet	71,900	---	---	0	0	---	---	0.	0.	---	0	0	---
		Dry		3.5	0	---	---	82,668	55,437	0.173	0.173	0	---	---	0.852
4	Niebe	Wet	45,000	---	---	0.175	0.0875	---	---	0.	0.	---	0.025[2]	0.025[2]	---
		Dry		0.875	0.175	---	---	47,816	24,025	0.043	0.043		---	---	1.2027
5	Sugar Cane	Wet	7,200	100.	---	0	0	123,217	52,841	0.027	0.027	---	0	0	1.4092
		Dry		100.	0	---	---	123,224	49,447	0.027	0.027	0	---	---	1.7876
6	Sorgham	Wet	62,800	3.0	---	0.375	0.1875	47,816	27,466	0.286	0.286	---	0.255		1.0480
		Dry		3.0		---	---	47,823	24,025	0.125	0.125	0.255	---	---	0.6827
7	Corn (Maize)	Wet	65,800	3.0	---	0.375	0.1875	52,335	31,944	0.165	0.165	---	0.0533	0.0533	0.8467
		Dry		3.0	0.375	---	---	52,335	28,550	0.125	0.125	0.0533	---	---	0.7720
8	Cotton	Wet	66,700	3.0	---	0	0	47,816	---	0.030	0.030	---	0	0	0.9627
		Dry		---	0	---	---	---	---	0.	0.	0	---	---	---
9	Cattle-Milk	Wet	60	97.8	---	0	0	0[1]	0[1]	0.024	0.024	---	0	0	0[1]
		Dry		26.2	0	---	---	0[1]	0[1]	0.024	0.024	0	---	---	0[1]
10	Cattle-Meat	Wet	344,000	0.0414	---	0	0	80,858[1]	53,107[1]	0.024	0.024	---	0	0	0.2857[1]
		Dry		0.0111	0	---	---	80,858[1]	48,914[1]	0.024	0.024	0	---	---	0.2857[1]
11	Sheep-Milk	Wet	60	99.1	---	0	0	0[1]	0[1]	0.024	0.024	---	0	0	0[1]
		Dry		26.5	0	---	---	0[1]	0[1]	0.024	0.024	0	---	---	0[1]
12	Sheep-Meat	Wet	344,000	0.0201	---	0	0	80,858[1]	53,107[1]	0.024	0.024	---	0	0	0.2857[1]
		Dry		0.0054	0	---	---	80,858[1]	48,914[1]	0.024	0.024	0	---	---	0.2857[1]
13	Goats-Milk	Wet	60	73.0	---	0	0	0[1]	0[1]	0.024	0.024	---	0	0	0[1]
		Dry		19.6	0	---	---	0[1]	0[1]	0.024	0.024	0	---	---	0[1]
14	Goats-Meat	Wet	344,000	0.0105	---	0	0	80,858[1]	53,107[1]	0.024	0.024	---	0	0	0.2857[1]
		Dry		0.0028	0	---	---	80,858[1]	48,914[1]	0.024	0.024	0	---	---	0.2857[1]

Principal Sources of Data: Groupement Manantali Report (Annex 4, p. 117, 120, 52, 60)
Global Report (Annex 4, p. 284) adjusted to 1979.

[1]Total production costs and water requirements for livestock are allocated to meat and none to milk.

[2]Zero in Senegal.

[3]The Groupement Manantali report could not be used as a source of production cost data because it does not distinguish between production costs in different seasons or for small and large perimeters.

Table 3. Agricultural and other navigation.

Navigation User	Country / Year[1]	Mali Tonne - km x 10^6	Mali Tonnes x 10^3	Mauritania Tonne -km x 10^6	Mauritania Tonnes x 10^3	Senegal Tonne - km x 10^6	Senegal Tonnes x 10^3	Total Tonne - km x 10^6	Total Tonnes x 10^3
Agriculture	1985	2.490	2.80	16.462	35.30	8.768	19.30	27.720	57.4
	1992	5.337	6.0	14.093	31.57	15.691	34.33	35.121	71.90
	2002	31.956	36.15	33.239	64.10	54.293	101.35	119.488	201.6
Other	1985	127.408	205.6	3.511	6.45	13.488	52.05	144.405	264.1
	1992	461.401	500.4	6.186	11.43	21.237	77.53	488.824	589.36
	2002	1134.164	128.2	13.185	24.45	42.242	138.45	1189.591	1391.1
Total (not including mining)	1985	129.898	208.4	19.971	41.75	22.256	71.35	172.125	321.5
	1992	466.738	506.4	20.279	43.0	36.928	111.86	523.945	661.26
	2002	1166.120	1264.35	46.424	88.55	96.535	239.8	1309.079	1592.7

[1] The year given in the Lackner report are delayed by the years in this table to be considered with project in 1979.

loading and unloading agricultural products is 2,600 F.CFA/tonne (Lackner, 1978, Section A1-10, p. 3-12).

Mining economic sector

The production schedule, production costs, power requirements, and transport volumes for the mining sector are taken from the Miferso study, and were documented in the team's First Report. Production costs have been adjusted to 1979 F.CFA and are 8,700 CFA/tonne. The cost of loading and unloading iron pellets is 200 F. CFA/tonne (Lackner, 1978, Section A1-10, p. 11-4).

SECTION 3

Model Application

At the request of the Direction de la Planification et de la Coordination, OMVS, the sensitivity of the cost allocation was investigated with respect to the following three factors:

1. Alternative financing conditions.
2. Rate of agricultural development.
3. Deferred power production.

Both the hard and soft loan terms described in Section 1 of this report were analyzed. The slow, medium, and rapid rates of agricultural development discussed in the Groupement Manantali report were each considered. The cases of no power delay, and delays of 5, 10, and 15 years were examined. All combinations of these three factors were considered making a total of 24 runs. Each run is referred to using an identification code defined in Table 4. Results from these runs are summarized in Table 5 and graphically in Figure 1. User fees are calculated using Equation 33 in the First Report (Riley, et al., 1978). It is useful to note that the majority of analyses of project benefits completed in other studies correspond most closely to the SFO run i.e., soft loan, rapid rate of agricultural development, and no power delay. Therefore, run SFO should be used by the reader to provide a reference for comparisons with the results from other

Table 4. Definition of run identification code.

Character 1	H	Hard loan
	S	Soft loan
Character 2	L	Low agricultural development rate
	M	Medium agricultural development rate
	F	Rapid agricultrual development rate
Character 3 (& 4)		Number of years after 1985 before power (e.g. 5 indicates power in 1990).
Example:	SM15	
	15	Power in year 2000 (i.e., 1985 + 15
	M	Medium agricultural development rate
	S	Soft loan

studies. However, run SFO does in the loan charges associated with a soft loan and these charges are not included in any other studies.

Before discussing the results in detail, it is again emphasized that because the model data base is not yet completely compatible with other studies accepted by OMVS, our results may not be identicial to the results obtained in these other studies. As the model data base is improved, these differences should be resolved. However, at this stage in the project and the model development, the qualatative value of the results, and the understanding of the system that they provide, are very useful. In other words, relationships and trends rather than absolute values are emphasized at present.

Rate of agricultural development

A comparison of the results from runs with the same loan terms and power delay but with different agricultural development rates (for example, HL5, HM5, and HF5 or SLO, SMO, and SFO) reveals the following effects:

Table 5. Net primary returns, project costs, and user fees -- cost of power delay allocation between all project series.

Loan (hard/soft)	Agricultrual development rate	Power delay (yrs.)	Net primary returns (F.CFA x 10^9)					Project Costs (F.CFA x 10^9)			User Fees (F.CFA/unit)		
			Agriculture				Mining	Water	Navigation	Power	Navigation (tonne-km)	Water (m^3)	Power (kw-hr)
			Mali	Mauritania	Senegal	Total							
H	L	0	0.781	4.678	14.367	19.826	-18.890	48.016	32.073	55.692	1.259	5.110	20.205
		5	0.736	4.618	14.247	19.602	-33.650	48.081	32.235	44.782	2.017	5.117	26.451
		10	0.320	3.500	11.328	15.148	-37.802	52.219	35.393	30.813	3.510	5.558	29.835
		15	-0.373	1.557	6.209	7.393	-34.874	59.609	33.632	21.039	5.240	6.344	33.782
H	M	0	6.949	21.935	68.581	97.466	-17.247	48.016	32.073	55.692	1.192	2.335	20.205
		5	6.852	21.819	68.360	97.030	-31.150	48.081	32.235	44.782	1.852	2.338	26.451
		10	6.285	20.658	65.260	92.203	-33.787	52.219	35.393	30.813	3.075	2.539	29.835
		15	5.667	19.478	62.206	87.350	-31.765	56.053	38.318	19.909	4.884	2.725	31.968
H	F	0	12.443	35.232	110.950	158.625	-16.091	48.016	32.073	55.692	1.145	1.644	20.205
		5	12.315	35.081	110.667	158.062	-29.481	48.081	32.235	44.782	1.741	1.646	26.451
		10	11.684	33.880	107.470	153.034	-31.306	52.219	35.393	30.813	2.806	1.788	29.835
		15	11.000	32.655	104.312	147.967	-28.417	56.053	38.318	19.909	4.282	1.919	31.968
S	L	0	1.268	6.147	18.297	25.712	-8.079	42.165	27.922	48.893	1.096	4.488	17.738
		5	1.238	6.123	18.268	25.628	-24.221	42.110	28.023	39.339	1.753	4.482	23.236
		10	0.884	5.171	15.784	21.839	-30.065	45.627	30.685	27.384	3.044	4.856	26.515
		15	0.311	3.580	11.598	15.488	-29.222	51.652	29.424	19.034	4.584	5.497	30.562
S	M	0	7.533	23.335	72.537	103.404	-6.649	42.165	27.922	48.893	1.038	2.050	17.738
		5	7.459	23.260	72.419	103.137	-22.047	42.110	28.023	39.339	1.610	2.048	23.236
		10	5.975	22.270	69.780	99.025	-26:584	45.627	30.685	27.384	2.666	2.219	26.515
		15	6.443	21.258	67.160	94.861	-26.235	48.912	33.171	18.028	4.228	2.378	28.946
S	F	0	13.056	36.620	114.924	164.600	-5.643	42.165	27.922	48.893	0.997	1.444	17.738
		5	12.955	36.515	114.753	164.223	-20.597	42.110	28.023	39.339	1.514	1.442	23.236
		10	12.417	35.491	112.031	159.938	-24.433	45.627	30.685	27.384	2.433	1.562	26.515
		15	11.828	34.440	109.321	155.589	-23.336	48.912	33.171	18.028	3.707	1.675	28.946

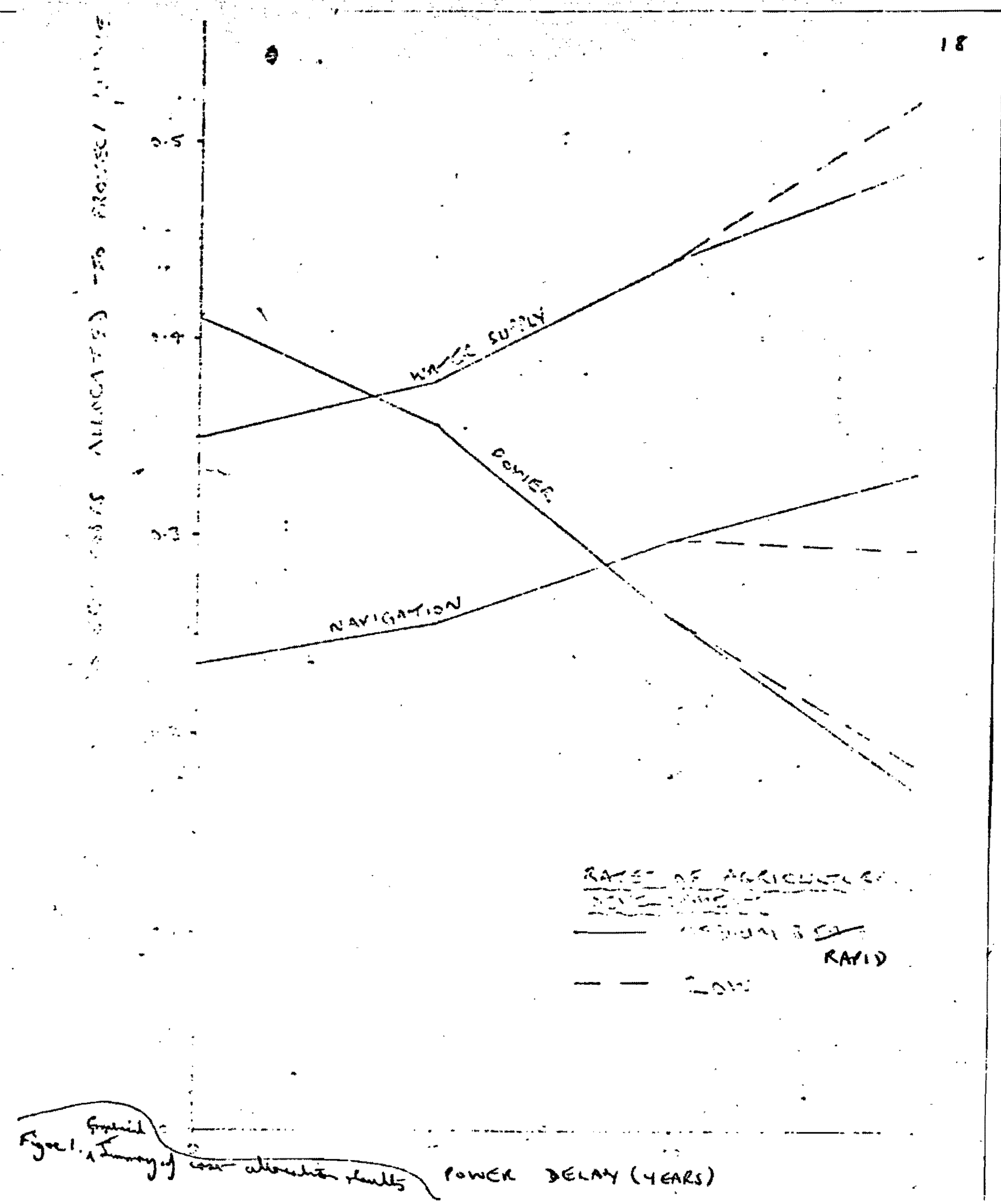


Figure 1. Graphical summary of cost allocation results.

1. Net primary returns to agriculture increase as the rate of agricultural development increases.

2. Net primary returns to mining increase as the rate of agricultural development increases.

3. User fees for navigation and water supply decrease with the increase in the rate of agricultural development.

4. The user fee for power remains unchanged except at the low rate.

5. There is no change in the allocation of joint costs between the three project services for the medium and rapid rates but at the low rate the allocation is different.

The allocation of joint costs is changed for the low rate of agricultural development because the navigation benefits fall below the alternative cost of a single purpose Manantali dam for navigation. The user fee for power is unchanged because the quantity of power and the cost allocated to the power service are unaffected by changes in the rate of agricultural development except at the low rate discussed above. Increases in the rate of agricultural development increase the present value of the volume of navigation and water supply in the denominator of Equation 3.3 of the First Report and, therefore, the user fees for navigation and water supply are reduced.

Deferred power production

The delay of power production is associated with postponement of the development of mining. Since these delays decrease the present worth of the project benefits to the power sector, the cost allocation changes, with the result that the power service and, therefore, the mining sector, be less of the project costs. Thus, agriculture is allocated a larger share of the project cost, with the result that the user fees for water and irrigation increase, and the net primary returns be agriculture decrease as power is further delayed. It can be seen that project costs allocated to power decrease as power is delayed and the net primary returns to mining decrease up to 10 years delay but increase after 15 years delay and will continue to increase at lower delays. This occurs because as the length of the delay increases more of the costs of power are borne by the other services and so less of the project costs are charged to mining and hence, the net primary returns to mining increase.

To avoid penalizing agriculture for delays in power production, two alternatives are available for paying the share of project costs allocated to power during the period of delay:

1. Non-reimbursable government subsidies during the period of the delay.
2. Government loans to be repaid through the user fee for power when it is produced.

Table 6 shows the amount of the subsidy required to remove the extra cost burden on other project services when power is delayed. If loans are used instead of subsidies, then the extra cost burden is placed on the power service as shown in Table 7. In this case, the user fee for power is measured to repay the loan and the net primary returns for mining consequently reduced. In this preliminary analysis, interest on the loan has been ignored.

SECTION 4

Future Collaboration Between the OMVS and the Cost Allocation Team

The current extended contract is scheduled to terminate on December 31, 1979. The work which might be accomplished through a continuation of this collaboration includes the following specific items:

A. *Training in the Use of the Cost Allocation Model*

1. *February through May 1980.* Provide training in the model structure and use for Mr. Moustapha Ould Maouloud. This training will will provided at Utah State University in Logan, Utah and will cover a period of four months.

2. *January through June 1980.*- Develop a final version of the users manual which currently is being drafted, translate to French, and duplicate.

3. *July, 1980.* Provide one week of training in the use of the model to professional people, such as engineers, economists, soils scientists, and others. These people will be selected from the OMVS and from the member states. The training will be conducted in Dakar, Senegal. The participants will be given an understanding of:
   a. The capabilities and limitations of the model.
   b. The structure of the model.
   c. The procedures for modifying the model in accordance with changing conditions and needs.

   The training format will include lectures, discussions, and demonstrations of the computer model. The text and reference materials will include the First Report (French version) and the three-part users manual for the model (also in French).

B. *Advice in Water Resource Management* (1980 - indefinite). Provide continuing advice to the OMVS in the following areas:

1. The practical utilization of the cost allocation.

2. Further development and modifications of the cost allocation model to provide for such items as:
   a. Additional use sectors in the model as needed.
   b. Simplification of the input procedures, for example, to provide flexibility in the assumptions concerning the commencement of power generation and the point of use for power (e.g. mining, Bamako, Dakar, agriculture).

Table 6. Net primary returns, project costs, and user fees - costs of power delay borne by government subsidies.

Loan (hard/soft)	Agricultural development rate	Power delay (yrs.)	Net Primary Returns (F.CFA x 10^9) Mali	Mauritania	Senegal	Total	Mining	Project Costs (F.CFA x 10^9) Water	Navigation	Power	Subsidy	User Fees (F.CFA/unit) Navigation (tonne-km)	Water (m^3)	Power (kw-hr)
H	L	0	0.781	4.678	14.367	19.826	-18.890	48.016	32.073	55.692	0.	1.259	5.110	20.205
		5					-33.650			44.782	0.225			26.451
		10					-37.802			30.813	4.678			29.835
		15					-34.874			21.039	12.433			33.782
H	M	0	6.949	21.935	68.581	97.466	-17.247	48.016	32.073	55.692	0.	1.192	2.335	20.205
		5					-31.150			44.782	0.434			26.451
		10					-33.787			30.813	5.273			29.835
		15					-31.765			19.909	10.116			31.968
H	F	0	12.443	35.232	110.950	158.625	-16.091	48.016	32.073	55.692	0.	1.145	1.644	20.205
		5					-29.481			44.782	0.563			26.451
		10					-31.306			30.813	5.590			29.835
		15					-28.417			19.909	10.657			31.968
S	L	0	1.268	6.147	18.297	25.712	-8.079	42.165	27.922	48.893	0.	1.096	4.488	17.738
		5					-24.221			39.339	0.083			23.236
		10					-30.065			27.384	3.873			26.515
		15					-29.222			19.034	10.223			30.562
S	M	0	7.533	23.335	72.537	103.404	-6.649	42.165	27.922	48.893	0.	1.038	2.050	17.738
		5					-22.047			39.339	0.267			23.236
		10					-26.584			27.384	4.381			26.515
		15					-26.235			18.028	8.546			28.946
S	F	0	13.056	36.620	114.924	164.600	-5.643	42.166	27.922	48.893	0.	0.997	1.444	17.738
		5					-20.597			39.339	0.377			23.236
		10					-24.433			27.384	4.662			26.515
		15					-23.336			18.028	9.011			28.946

Table 7. Net primary returns, project costs, and user fees - costs of power delay borne by power service through a loan.

Loan (hard/soft)	Agricultural development rate	Power delay (yrs.)	Net Primary Returns (F.CFA x 10^9)					Project Costs (F.CFA x 10^9)			User Fees (F. CFA/unit)		
			Mali	Mauritania	Senegal	Total	Mining	Water	Navigation	Power	Navigation (tonne-km)	Water (m^3)	Power (kw-hr)
H	L	0	0.781	4.678	14.367	19.826	-18.890	48.016	32.073	55.692	1.259	5.110	20.205
		5					-33.115			45.007			26.585
		10					-42.430			35.491			34.365
		15					-77.307			33.472			53.745
H	M	0	6.949	21.935	68.581	97.466	-17.247	48.016	32.073	55.692	1.192	2.335	20.205
		5					-31.584			45.216			26.707
		10					-39.060			36.086			34.941
		15					-41.881			30.025			48.211
H	F	0	12.443	35.232	110.950	158.625	-16.091	48.016	32.073	55.692	1.145	1.644	20.205
		5					-30.044			45.345			26.784
		10					-36.896			36.403			35.248
		15					-39.079			30.566			49.080
S	L	0	1.268	6.147	18.297	25.712	-8.079	42.165	27.922	48.893	1.096	4.488	17.738
		5					-24.304			39.422			23.285
		10					-33.938			31.257			30.265
		15					-39.445			29.257			46.977
S	M	0	7.533	23.335	72.537	103.404	-6.649	42.165	27.922	48.893	1.038	2.050	17.738
		5					-22.314			39.606			23.394
		10					-30.965			31.765			30.757
		15					-34.781			26.574			42.668
S	F	0	13.056	36.620	114.924	164.600	-5.643	42.165	27.922	48.893	0.997	1.444	17.738
		5					-20.974			39.716			23.459
		10					-29.095			32.046			31.029
		15					-32.347			27.039			43.414

c. An enlarged debt retirement subroutine which provides information on the retirement of loans from various sources, and accommodates loans of differing terms, such as interest rates.

d. Capability to readily accommodate various possible assumptions pertaining to the costs of updating, maintaining and operating the Bamako to Dakar railroad line.

3. Bases for the establishment of user fees under the project.

4. Problems relating to loan guarantees.

5. Bases for allocating the resources of the project in a legal/institutional sense. For example, what might be the bases for allocating the electric power and/or the irrigation water between the three countries? What "water rights" problems might be encountered? What institutions should be recommended for implementing decisions?

6. Operational hydrology studies on the Senegal River to identify reservoir operating rules for the purpose of optimizing the distribution of the available water resource between the various project service areas. The studies would consider the physical, sociological, political, and environmental constraints existing for the system.

7. Possible organizational structures for administering the various components of the proposed Senegal River development project.

The various activities of step B above and others as deemed desirable from time to time would extend through the calendar year 1981 and beyond. To enable the work plan outlined above to proceed, a new contract will need to be negotiated between US/AID and Utah State University.

APPENDIX A

The Cost Allocation Procedure and the Economic Model

The adjusted separable costs-remaining benefits method of cost allocation is a modification of extension of the separable costs-remaining benefits (SCRB) procedure. Thus, an understanding of the adjusted procedure requires first that the SCRB method be understood. This cost allocation procedure assigns to each project service or function the separable costs of including the function in the multi-purpose project plus a share of the joint or common costs. Joint costs are allocated on the basis of the remaining benefits (or remaining justifiable expenditures) accruing to each function. The method is illustrated by means of the following example (Table A-1).

A mutli-purpose project involving flood control, power, irrigation, and navigation is proposed with a total estimated cost of 1765 units. Project benefits associated with each use are estimated, and these are shown in row 1 of Table A-1. The alternative costs (row 2) are those for a single purpose project designed to provide services only for a particular use. For example, another way of providing for flood control, other than through the proposed project, would cost an estimated 400. The justifiable costs (row 3) then are either those benefits provided by the proposed project (row 1) or the alternate cost (row 2), whichever is smaller. The separable costs for a particular purpose (row 4) are found by subtracting the cost of the project without that purpose from the total project cost. For instance, in this example the cost of the project without providing for flood control is 1,385, thus yielding a separable cost of 1,765 minus 1,385, or 380. The remaining benefits (row 5) are found by subtracting separable costs from limited benefits (row 3 minus row 4). The total of the separable costs is 1,180 or 585 less than the total project cost. These unallocated costs are distributed to each use (row 6) in the same proportion as the remaining benefits (row 5) which are associated with each service. For example, the proportion of the unallocated costs which are apportioned to flood control is given by: $\frac{20}{650} \times 585 = 18$. The total cost assigned to each use (row 7) is the sum of the separable costs (row 4) and the allocated joint costs (row 6). The total of the costs assigned to each service is equal to the cost of the entire project.

Because the separable project costs are not credited with a part of the savings resulting from a multiple-purpose project, none of the usual cost allocation procedures, including the SCRB method, are entirely equitable. A more realistic and equitable basis may be to attribute a part of the project savings to the separable costs. Equity in cost allocation dictates that the savings allocated to each function in the project be proportioned to the savings from the inclusion of each function.

Consider the illustration of Table A-1. The justifiable costs total 1,830 (project benefits by purpose limited by cost of single purpose alternatives). Total costs (line 7) are 1,765. Thus, project savings are 65 units. For the procedure illustrated, all 65 units of the savings from the multiple-purpose project are credited to joint costs (line 5 minus line 6, where 65 units of remaining benefits are allocated to joint costs, or 650 - 585 = 65). A solution to the problem of equity, then, is to attribute a portion of the project savings to the separable costs.

Loughlin (1977) proposed adjusting for the inequity in the SCRB formula by applying a credit to the separable costs so that separable costs are subtracted from justifiable costs on a greater than 1:1 basis. The credit is in the same ratio as that of the justifiable costs for a purpose plus justifiable costs for all other purposes to the total project costs. This procedure provides better results than the existing SCRB method for meeting the equity criterion. The method is illustrated by Table A-2.

The rationale for this method is that it adjusts separable costs to reflect the assignment of a portion of project savings from multiple-purpose projects (as compared to single-purpose projects) to the separable costs. This adjustment decreases remaining benefits, joint costs, and total costs for those services with higher separable costs. Since allocated savings would increase to those purposes with higher separable costs, a more appropriate relationship emerges between the savings allocated to each purpose and the savings from purpose inclusion. As a result of this change in the SCRB method, each purpose is assigned a more reasonable proportional share of the savings resulting from multiple-purpose development.

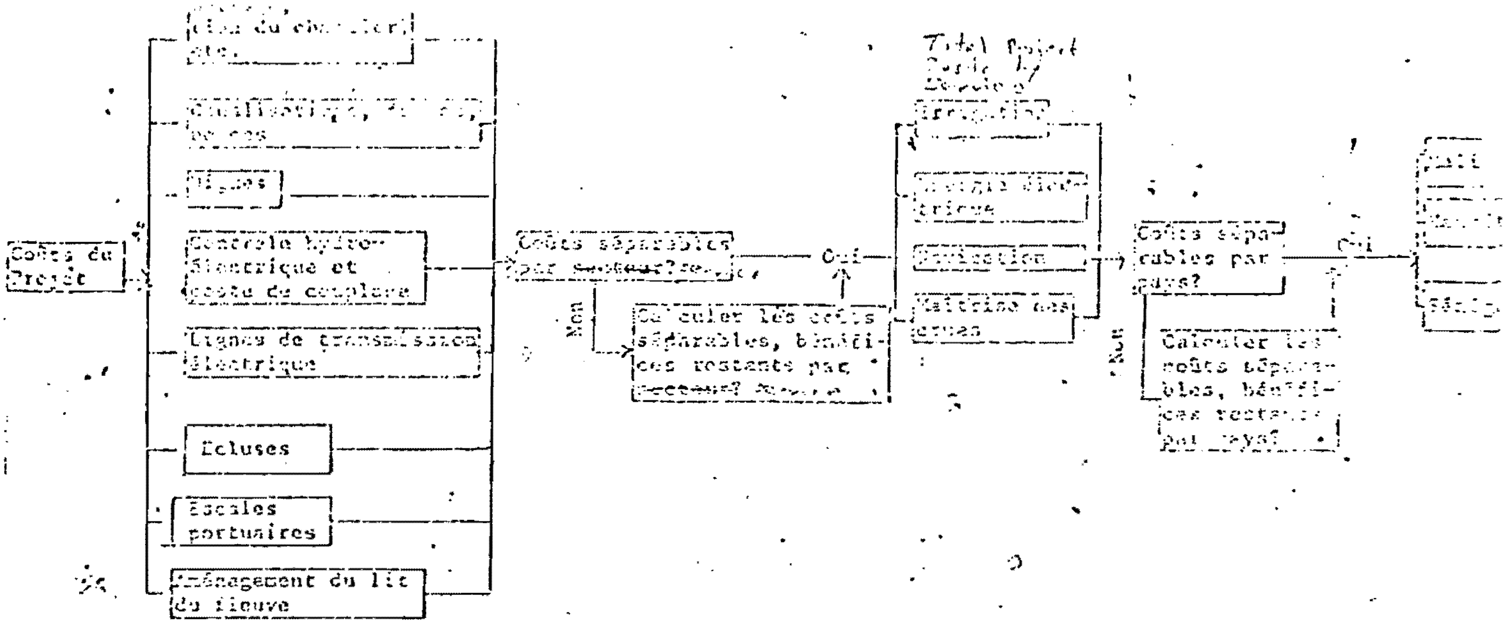
The various steps involved in the cost allocation procedure used for the studies of this report are illustrated by Figure A-1. The economic model used in these studies is depicted by Figure A-2, and is described in detail by Chapter III of the First Report. As illustrated by Figure A-2, both the joint and separable costs are assigned to the various service areas provided by the project (see also Figure A-1). The total of these costs for each service area is recovered through the application of an appropriate user fee which is paid by the economic sector being served. The user fees and other production costs are then subtracted from the revenues to the particular economic sector to provide an estimate of the net revenues accruing to that sector.

Table A-1. The separable costs-remaining benefits method of cost allocation.

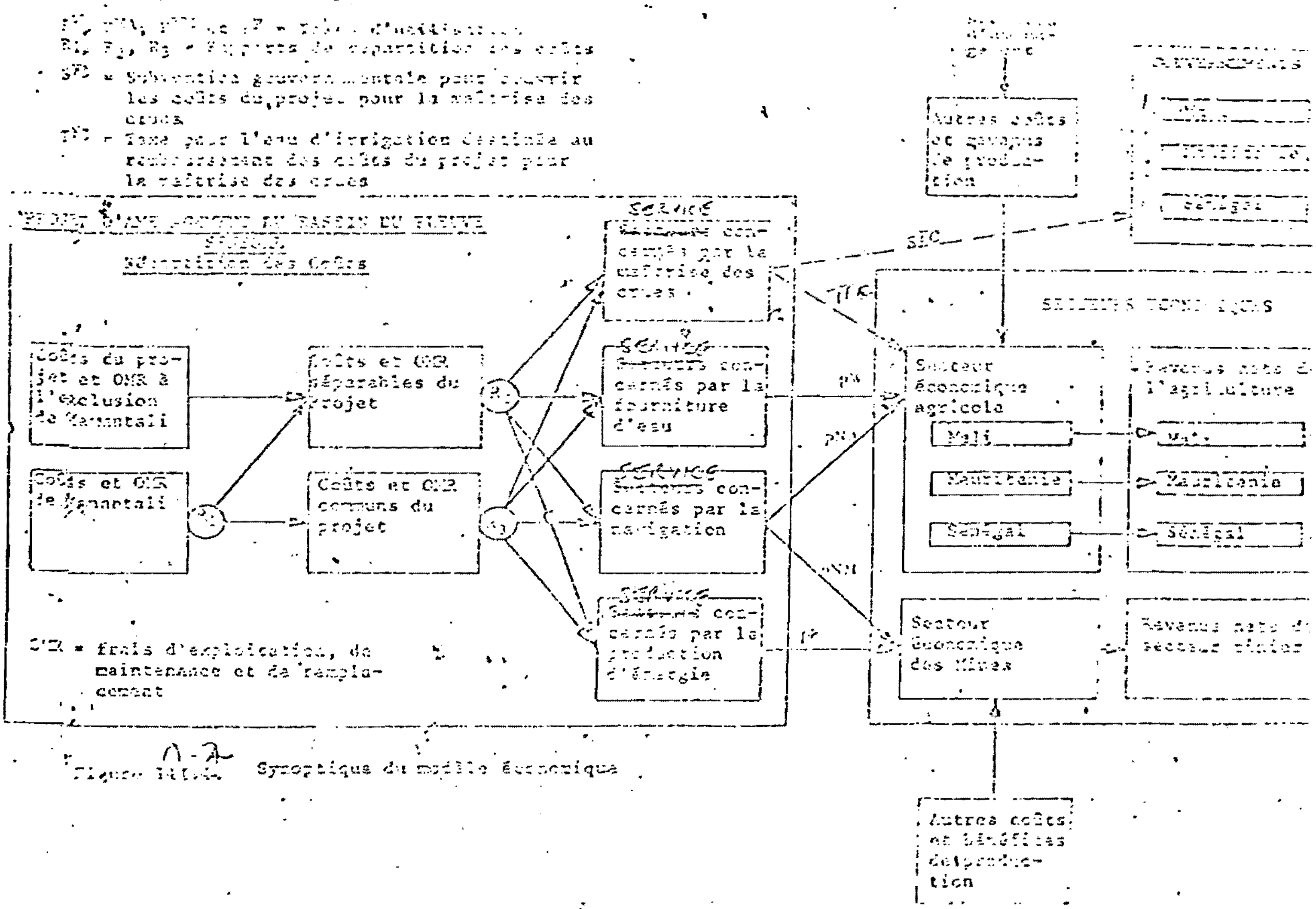
Row No.	Item	Flood Control	Power	Irrigation	Navigation	Totals
1	Project benefits	500	1500	350	100	2450
2	Alternative costs (single purpose project)	400	1000	600	80	2080
3	Justifiable costs (lesser of 1 or 2)	400	1000	350	80	1830
4	Separable costs	380	600	150	50	1180
5	Remaining benefits (3-4)	20	400	200	30	650
6	Allocated joint costs	18	360	180	27	585
7	Total allocated costs (4+6)	398	960	330	77	1765

Table A-2. The adjusted separable costs-remaining benefits method of cost allocation.

Row No.	Item	Flood Control	Power	Irrigation	Navigation	Totals
1	Project Benefits	500	1500	350	100	2450
2	Alternative Costs (single purpose project)	400	1000	600	80	2980
3	Justifiable costs (lesser of 1 or 2)	400	1000	350	80	1830
4	Separable costs	380	600	150	50	1180
5	Cost for all other purposes (total cost less row 4)	1385	1165	1615	1715	---
6	Justifiable costs for all other purposes (lesser of 5 or Σ of row 3)	1385	1165	1615	1715	---
7	Adjustment factor (3 + 6 ÷ total costs)	1.01	1.23	1.11	1.02	---
8	Adjusted separable costs (row 4 x row 7)	384	738	166	51	---
9	Remaining benefits (row 3 - row 8)	16	262	184	29	491
10	Joint cost proportions (row 9 ÷ Σ row 9)	0.032	0.534	0.375	0.059	1.000
11	Allocated joint cost row 10 x (total project cost - Σ row 4)	20	311	220	34	385
12	Total allocated costs (row 4 + 11)	400	.911	370	84	1765



A-1
Figure [illegible]. Démarche adoptée dans cette étude pour la répartition des coûts du projet de mise en valeur du Bassin du Fleuve Sénégal.



A-2
Figure [illegible]. Synoptique du modèle économique

APPENDIX B

Updating of Single-Purpose Alternative Costs

These costs are presented by the First Report, but since then improved estimates are possible because of additional information which has been obtained, particularly for the Diama and Manantali dam structures. Accordingly, the following revised estimates are based on information which is available from the Global Report (1978), the OMVS Financial Plan (January, 1979), and the Economic Evaluation report by Gibb and Partners (August, 1979). To be consistent with the First Report, the revised costs below are expressed in 1976 prices. However, in application to the studies of the Second Report, where the 1979 price level was used, the cost estimates were brought forward to 1979 on the basis of a 10 percent inflation rate.

1. *Storage* - Gourbassi and Diama sites

Manantali dam capital cost (not discounted) without power station, 208 m retention level

(i) First Report, p. 39	$= 42 \times 10^9$ CFA
(ii) From Evaluation of Bids by Alexander Gibb, Aug. 1979, (adjusted to 1976 at 10% inflation)	$= 63.110 \times 10^9$ CFA
Gourbassi dam 1976 investment cost (First Report, p. 55)	$= 19.448 \times 10^9$ CFA
Adjusted cost of Gourbassi (1976 investment) cost = 63.11/42.0 x 19.448	$= 29.222 \times 10^9$ CFA
Discounted (p. 55 of First Report - rate = 10%)	$= 17.504 \times 10^9$ CFA
Discounted adjusted cost of Diama (based on a 1979 capital cost of 21.4×10^9 CFA - Gibb, 1979, without right dike)	$= 21.400 \times 10^9$ CFA
Total discounted single purpose cost	$= 38.904 \times 10^9$ CFA

2. *Navigation* - Manantali site

Manantali investment cost (1976), (First Report, p. 56)	$= 29.546 \times 10^9$ CFA
Adjusted Manantali investment cost (1976) 63.11/42.0 x 29.546	$= 44.396 \times 10^9$ CFA
Discounted Manantali investment cost (First Report, p. 55)	$= 26.593 \times 10^9$ CFA
Discounted project works (Table 4.2, First Report)	$= 10.856 \times 10^9$ CFA
Total adjusted discounted single purpose cost	$= 37.449 \times 10^9$ CFA

3. *Flood control* - Manantali site

Single purpose discounted cost (from First Report, p. 57)	$= 14.562 \times 10^9$ CFA
Adjusted single purpose discounted cost = 63.11/42.0 x 14.562	$= 21.881 \times 10^9$ CFA

4. *Power* - Oil fired thermal-electric plant.

Comparisons are made on the basis of fixed 1976 monetary units. Inflation is not taken into account because it is assumed that all values would be affected by approximately the same factor, and that comparisons thus would remain essentially unchanged. However, during the past few years oil costs have risen at a rate considerably in excess of the standard inflation rate, and it is considered that this rising trend in excess of the inflation rate should be reflected in the annual cost of an oil-fired thermal-electric plant which is used as a single-purpose alternative to hydro-electric power generated at Manantali (see pages 56 and 57 of the First Report). Assume that the annual increases in oil prices exceeds the annual inflation rate by 5 percent. The annual fuel cost is 1976 is 3.06×10^9 CFA (Table 5.10, p. 57 of First Report). In 1985, this cost would be $1.63 \times 3.06 = 5 \times 10^9$ CFA. Assuming a power plant life of 40 years and a discount rate of 10 percent and an oil price increase in excess of inflation of 5 percent, the 1985 capital value of oil is:

"Net" interest rate, $i = 1 \frac{(1 + r)}{(1 + j)} = 1 - \frac{1.1}{1.05} = 0.0476$

r = 10% discount rate

j = 5% oil price increase rate

The capital recovery factor, CRF

$$= \frac{i\ (1 + i)^N}{(1 + i)^N - 1} = \frac{0.0476\ (1 + .0476)^{40}}{(1 + .0476)^{40} - 1}$$

$$= \frac{0.0476\ (6.4242)}{6.4242 - 1} = 0.056638$$

The present value in 1985 - 5×10^9/CRF $= 88.684 \times 10^9$ CFA

Discounted to 1976 at 10% this sum is:

$$\frac{88.684}{(1.1)^{10}} = 34.192 \times 10^9 \text{ CFA}$$

In view of the escalating oil prices, hydro-electric power from the Niger River-possibly should be explored as a possible least cost alternative to hydro-power generation at the Manantali site. However, by 1985 it is expected that the capacity of this new plant will be fully utilized by Bamako.

Table B-1.

Item	Investment Cost (CFA x 10^9)	Annual Investments (CFA x 10^9) 1981	1982	1983	1984	Present Values 1976 (CFA x 10^9)
Power Plant	7.975		3.987	2.991	0.997	3.865
Distribution Network	2.600	1.300	0.800	0.500	---	1.395
Fuel Cost	---					34.190
OM&R (see Note below)						0.40
TOTAL 1976 value						39.85

NOTE: OM&R costs are taken at 1% of the capital investment (10.575) = 0.10575 x 10^9 CFA. The 1985 value of this annual cost for 40 years at 10% discount = $\frac{0.10575}{0.10226}$ = 1.034 x 10^9 CFA

Discounted to 1976

$$= \frac{1.034 \times 10^9}{(1.1)^{10}} = 0.399 \times 10^9 \text{ CFA}$$

Use 0.4 x 10^9 CFA