AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT PAPER FACESHEET

TO BE COMPLETED BY ORIGINATING OFFICE

1. TRANSACTION CODE (X APPROPRIATE BOX)
[X] ORIGINAL [ ] CHANGE [ ] ADD [ ] DELETE

PP

DOCUMENT CODE 3

2. COUNTRY/REGIONAL ENTITY/GRANTEE

3. DOCUMENT REVISION NUMBER

4. PROJECT NUMBER 6852 (625 0618)

5. BUREAU
A. SYMBOL: AFR
B. CODE: 06

6. ESTIMATED FY OF PROJECT COMPLETION
FY 82

7. PROJECT TITLE - SHORT (STAY WITHIN BRACKETS)
MATAM IRRIGATED PERIMETERS

8. ESTIMATED FY OF AUTHORIZATION/OBLIGATION
A. INITIAL MO. YR. 9 76 B. FINAL FY 81

9. SECONDARY TECHNICAL CODES (MAXIMUM SIX CODES OF THREE POSITIONS EACH)

064	022	010			

10. ESTIMATED TOTAL COST ($000 OR EQUIVALENT, $1 = ____)

A. PROGRAM FINANCING	FIRST YEAR B. FX	C. L/C	D. TOTAL	ALL YEARS E. FX	F. L/C	G. TOTAL
AID APPROPRIATED TOTAL						
(GRANT)	(1,290)	(1010)	(2,300)	(1,850)	(1,250)	(3,100)
(LOAN)	(2,920)	(1,400)	(4,320)	(18,600)	(3,400)	(22,000)
OTHER 1.						
2.						
HOST GOVERNMENT	-	1,510	1,510	1,400	6,900	8,300
OTHER DONORS						
TOTALS	4,210	3,920	8,130	21,950	11,550	22,400

11. ESTIMATED COSTS/AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION SYMBOL	B. PRIMARY PURPOSE CODE	C. PRIMARY TECH. CODE	FY 77 D. GRANT	E. LOAN	FY 78 F. GRANT	G. LOAN	FY 79 H. GRANT	I. LOAN	ALL YEARS J. GRANT	K. LOAN
FN	144	070	1,700	4,320	400	870	400	11,800	2,500	22,000
FN	121	091	600						600	
TOTALS			2,300	4,320	400	870	400	2,470	3,100	22,000
ESTIMATED EXPENDITURES			2,075	1,270	400	2,100	400	12,180		

12. PROJECT PURPOSE(S) (STAY WITHIN BRACKETS) [ ] CHECK IF DIFFERENT FROM PID/PRP

#1. Develop irrigated agricultural lands through the establishment of a perimeter of sprinkler, surface and flood irrigation systems.

#2. Improve the subsistence and overall income of small farmers in a Sahelian area of Senegal.

#3. Demonstrate the feasibility of groundwater irrigation.

13. HAVE CHANGES MADE IN THE PID/PRP FACESHEET DATA NOT INCLUDED ABOVE? IF YES, ATTACH CHANGED PID AND/OR PRP FACESHEET.

[ ] YES [ ] NO

15. ORIGINATING OFFICE CLEARANCE

SIGNATURE

TITLE John Withers
Director, AFR/DR

DATE SIGNED MO. DAY YR.

16. DATE RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION

MO. DAY YR.

AID 1330-4 (5-75)

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MATAM IRRIGATED PERIMETERS

Part 1. Project Summary and Recommendations

A. Face Sheet Data

B. Recommendations

- - Grant	$ 3,100,000
- - Loan	$ 22,000,000
(Terms: 40 years -- 10 years grace, 2% during grace -- 3% thereafter)	
- - Waiver of competitive selection for ongoing consulting services	
Total new AID obligations	$ 25,100,000

C. Description of the Project

The project that is herein proposed will be the first major AID capital investment in the Senegal River Basin. The composition of the proposed AID contribution comprises 75% of the total project costs and 100% of the foreign exchange components for physical development of the perimeter.

The project will provide equipment, materials and initial services for the irrigation of 3,875 hectares of light and heavy soils in the Matam Department of the Fleuve Region in northern Senegal. The land to be developed is all within ten kilometers of the Senegal River, adjacent to the towns of Matam and Ouro Sogui. Total potential irrigable land in the project area is 7,290 net hectares.

A feasibility study carried out on the project area is recommending development of the total area in four phases. The AID assisted project will provide for the development of Phases I and III, which are contiguous parcels of land, of the recommended development plan. The estimated capital costs are $18,652,000 (does not include contingencies and escalation). These two phases of the project area include 768 hectares of Hollaldé (heavy) Soils which are to be developed for flood irrigation, 2,370 hectares of Fondé (light) Soils to be developed for surface irrigation, and 740 hectares of Fondé Soils to be developed for sprinkler irrigation.

The primary source of water for the project (Phases I and III) will be ground water coming from lower (Maestrichtien) aquifer wells, on land farthest from the River, and from upper aquifer wells in areas nearest to sources of recharge, e.g., the river and adjacent marigots. Two large marigots (old river channels) traverse the project area and border a section of the area proposed for AID funding. These marigots contain the same level of water as the river, and can provide a supplemental water source by being pumped. Phase III will receive supplemental water in just such a manner, and Phase I is to receive supplemental water from a channel alongside its protective dike during the highwater season. Approximately 13.6 kilometers of protective dikes are to be constructed as part of the project along three sides of the AID financed perimeter. To improve the recharge of the shallow aquifer and assure proper drainage as well, the Diamel marigot next to the Phase III area of the project area will be dredged at its mouth to improve its intake from, and drainage to the river. This will also aid in the dilution of drainage waters.

To introduce irrigated agriculture to the farmers of the area a training farm of approximately 100 hectares is to be developed with grant funds. The farm is to be constructed in early 1977 on high ground which requires minimal clearing and leveling for sprinkler and surface irrigation of Fonde Soils. Farmers from project beneficiaries' villages will be brought to the Training Farm for orientation to the methods of irrigated agriculture being introduced.

Also in early 1977, additional groundwater drilling is to be conducted. Though confident that sufficient groundwater exists for the project, the consultants who carried out the feasibility study feel that the extent of the aquifer underlying the project area should be determined. These groundwater drillings are to be grant funded as a follow-on to the feasibility study already concluded.

Twelve man-years of technical assistance are likewise included for grant funding. The requirements call for a general agriculturist experienced in irrigation (flood, surface and sprinkler), an irrigation engineer, an equipment mechanic and an agriculture extension (cooperative) specialist. These consultants will assist in the establishment of the training farm and provide the initial services to the irrigation project. They will work alongside GOS (SAED) counterparts to assure continuance of assistance to farmers at the end of their project contracts.

The project and beneficiaries will be organized around the irrigation plan. Each well is to have an organization of farmers which will take responsibility for maintenance of the well and the dikes, canals and irrigation systems on the plot of land drawing water from the well. It has been established that a village in the Fleuve Region of Senegal (depending on size of course) can be expected to effectively manage up to 100 hectares of irrigated perimeters. For this project, each well established will be able to irrigate from a minimum of 25 hectares (in flood irrigation) to a maximum of 70 hectares (for sprinkler irrigation). Thus it is expected that around each well will be organized a village or village quarter. This will effectively bring the village farmers into the decision-making process thereby permitting the establishment of a solid socio-economic foundation for this activity.

The project is in advance of the major infrastructure development of the Senegal River Basin, namely the Diam Salt Water Intrusion Dam and the Manatali Dam and Reservoir. These two major structures will greatly increase and control water availabilities for use in irrigation, particularly the Manatali Dam which will assure a year-round minimal mainstream flow of 300 cubic meters per second. This proposed project, like others being developed concurrently by other donors (IBRD, FED, FAO, FRG and PRC), is to provide people of the riverain region experience in irrigated agricultural practices. This will create the wherewithal by which such methods of crop cultivation can be essentially extended throughout the river basin.

The total cost to physically develop the entire perimeter of 7,290 net hectares (Phases I, II, III and IV) is estimated to be $38.4 million (before inflation and contingencies allowances). The first portion to be developed with AID assistance is estimated to be $18.7 million (before inflation and contingencies) with a foreign exchange component of $12.3 million. Including factors for inflation and contingencies, the total cost for physically developing this first portion is estimated to be $24.3 million, with a foreign exchange component of $16.3 million. In addition, the final engineering and design, and construction expansion are estimated to be $2.3 million. The AID loan will be allocated to cover all foreign exchange costs to develop the perimeter, final engineering, design and construction supervision plus $3.4 million in local currency costs. The grant will be allocated to cover the hydrogeological studies, all costs related to the development of the training farm and technical assistance. The list of items selected for AID financing is as follows:

Grant Financing

Item	$ Thousands
Hydrogeological Drilling	$ 500
Supervision and Analysis of Drilling	100
Design and Establishment of Training Farm (Technical Assistance)	655
Training Farm Equipment	155
Project Technical Assistance	900
Training Farm Supplies	400
Construction of Training Farm	390
Total Grant	$ 3,100

Loan Financing

Item	$ Thousands
Flood Dikes	$ 3,000
Pumping Plants	800
Drainage Channels	70
Surface Irrigation Canals	180
Access Roads	350
Sprinkler Equipment & Materials	1,350
Pumps, Engines & Drivers	1,960
Wells	1,250
Land Clearing & Leveling	2,920
On-Farm Surface Facilities and Structures	450
Local Currency Contribution	3,400
Engineering, Design & Supervision	2,300
Total Basic Cost	18,000
Physical Contingencies	1,600
Price Contingencies	2,400
Total Loan	$22,000
Total AID Financing	$25,100

D. Summary Findings

The analyses in this paper are based on the findings of the feasibility study team fielded during the months of February to June 1976, as supplemented by verbal explanations and elaboration. The technical elements of the project have been thoroughly studied and adequately designed to maximize production. It is recognized that an entirely different method of agriculture is to be introduced to the people of the Matam Department, and the project design and implementation takes this into account in attempting to minimize attendant risks and possible adverse effects.

Financial arrangements have been agreed upon for funding all elements of the project with AID responsible for all foreign exchange costs and the GOS for all local currency costs. The GOS Ministry of Rural Development's "Societé d'Amenagement et d'Exploitation des Terres du Delta" (SAED) will be responsible for insuring the timely application of financing to the successive elements of project implementation.

Implementation of the project and operation of the eventual new facilities require considerable administrative ability. Since the capacities of the SAED staff are presently overextended, the project requires the use of consulting services to reinforce the services and management of SAED. The GOS agents responsible for project implementation will be closely monitored by USAID and assistance provided where necessary, i.e., in following AID procurement procedures.

E. Project Issues

The project as herein proposed has evolved into something considerably different than was envisioned at the time of the PRP. The feasibility study team found that the proposed damming up of marigots in the area for water storage was not feasible as the marigot beds were very permeable.

Extended drilling showed that this permeability extended throughout the perimeter and aquiferous sands found underlying the entire area. Observation and test wells were drilled to determine the feasibility of using groundwater for irrigation. These hydrogeological findings were positive and thus the physical nature of the project changed as herein presented.

Using groundwater (i.e. pumped wells) gives the project a natural focal point around which to organize farmers and bring them into the decision making process. The fact that engineering and economic priorities have taken precedence over such sociological factors in previous SAED undertakings in the delta has been a concern of AID from the inception of this project.

The cost of developing irrigated agriculture along the Senegal River has also raised questions relative to the benefits received and capital intensive technology being proposed. Analyses of this and other projects in the Senegal River Basin have shown that people of the basin are willing to accept innovation, but not at the expense of an additional workload which does not substantially improve their harsh economic plight. Whatever cash crops are introduced must not be at the expense of assured subsistence for the basin population. Agricultural productivity can be increased dramatically in the basin, and an assured source of water for double-cropping provides the fundamental means for achieving this. At the same time, incentives must be provided to participants to accept the advantages and assume the risks of innovative interventions. These have been taken into account in determining the optimum farm size according to soil classification and crop patterns needed to provide minimal cash crop incentives over and above improved subsistence levels.

The project provides for 12 man-years of technical assistance. It is anticipated that, with the general manpower assistance to SAED proposed through the bilateral AID mission, adequate management of the project can be developed.

Finally, this is a Senegal River Basin project, with implications for U. S. policy towards river basin development in the entire Sahelo-Sudan region. The "Organization pour la Mise en Valeur du Fleuve Senegal" (OMVS) has been involved in project planning from its inception. The project provides OMVS the opportunity to look at a more flexible approach to irrigation other than the polder type projects for basin flood irrigation which, with their massive pumping stations and elaborate canal systems, have characterized this river's development thus far. The scheme of development proposed here for Matam will allow for much wider disposal of future irrigation projects in the valley and upper basin portion of the river. Drilled wells will allow small irrigated perimeters to be constructed, village by village, on the upper reaches of the river's flood plain minimizing the usual heavy investment in protective dikes. It also fulfills a U. S. offer to provide a capital contribution to the Senegal Basin development plan, enables AID to have an influence on the style and management of irrigated agriculture in the development, and responds to the GOS priority for developing the basin to overcome Senegal's critical food deficit.

Part 2. Project Background and Detailed Description

A. Background

Agriculture is the mainstay of the Senegal economy. Small-scale farms account for 70 percent of the population and 95 percent of the country's agricultural production. The rural sector accounts for 30-35 percent of gross domestic product and has considerable leverage on the national economy, through its impact on exports and rural demand for locally produced goods and services. Agricultural exports account for about 60 percent of total exports and 25 percent of the country's export earnings, and of imports of agricultural inputs. It also directly provides 20 percent or more of the Central Government's budget revenue in the form of export taxes and transfers to the Price Stabilization Fund. Since only about 10 percent of Government revenue is spent on agriculture, a net transfer is taking place from agriculture to the rest of the economy.

Senegal's annual food grain imports are approximately 150,000-200,000 tons of rice, 80,000-110,000 tons of wheat and some 50,000 tons of other cereals, including sorghum and millet. Dependence on the world market absorbs 15-20 percent of total export earnings. A main reason for this dependence is that a main concern of public authorities for the past century has been to develop groundnut production (to support Government's recurrent and investment budgets), and, as a result, farmers have had little initiative to produce millet for sale. In recent years, progressive urbanization has led to increased dependence on imported grain. To reduce its dependence on imports, Senegal is attempting to increase production of grains such as millet, the main foodcrop; wheat, as a possible dry season irrigated crop along the Senegal River; and rice, major production of which will depend on irrigation schemes along the Senegal River.

The agricultural potential of Senegal is severely limited by sparse rainfall, which occurs in a short period of the year, and by relatively poor soils. In the Seneval River Valley, rainfall is marginal for cropping, averaging some 400 mm, and soils over much of the area are sandy. However, heavy, bottomland soils and coarsers soils of the flood plain (Hollalde soils) are used for flood-recesssion cropping. Since rainfall is by and large unpredictable, the efficient use of water resources is the first means of ensuring production in a given year. Irrigation projects are, therefore, given high priority by the Government of Senegal. Irrigation can shelter part of Senegal's agricultural production from the vageries of rainfall, and advance two Government objectives: (1) increase farmer's income; (2) increase the assured domestic production of cereals.

When one considers irrigation schemes in Senegal, the focus of attention is on the Senegal River. No major investments in developing Senegal's other two major rivers, the Gambia and the Casamance, are expected in the foreseeable future. The Senegal River is the second largest river in West Africa. It is over 1,800 kilometers long, drains a watershed of about 290,000 square kilometers and produces an average annual flow of over 20 billion cubic meters. The river basin occupies over 14 percent of the area of Senegal, almost 13 percent of Mali and Guinea, and about 7 percent of Mauritania. While 825 kilometers, or about 45 percent of its length forms the border between Senegal and Mauritania, almost 55 percent or 155,000 square kilometers, of the drainage area is in Mali and about 50 percent of the streamflow originates in Guinea.

Geographically, the basin is divided into three regions. The lower 200 kilometers from the ocean to Dagana comprises the Delta. It is a completely flat area with seawater intruding up the full length of the river reach at low river flows. The next 600 kilometers from Dagana to Bakel in the Valley is an alluvial plain, 10 to 20 kilometers wide, surrounded by semi-desert. The upper 1,000 kilometers constitute the Upper Basin. This area of mountains and hills provides almost all of the flow of the river.

In 1971, the three riparian nations of the Senegal River: Mali, Mauritania and Senegal, formed a cooperative organization to plan and carry out the coordinated development of the Senegal River Basin under an agreed plan. This is the "Organization pour la Mise en Valeur du Fleuve Senegal" (OMVS), in which all three nations actively participate. Under the OMVS charter, these three nations have agreed to the priorities which will govern their planning. These are: (1) to assure the stability of the population now living in the basin by using the river's resources to improve their livelihood: (2) to insure that the ecology of the basin will not be adversely affected by projects therein; and (3) to develop the basin as a surplus food-producing region.

Under OMVS auspices, various studies and projects have been, and are, underway to realize the river basin's fullest potential as an integrated river system. The principal mainstream components of this system will be two dams operating in concert: one low-level dam in the river Delta to arrest saltwater intrusion during the low water season, and one storage dam on the principal tributary of the river in Mali to assure sufficient flow for irrigation and navigation on a year-round basis.

While these mainstream components are geing developed, various food production schemes are being initiated to prepare the population of the Senegal River Basin for their eventual partipication in irrigated farming in lieu of their traditional post-flood recession cropping on the

river basin. In accordance with the OMVS charter, agricultural projects totally within the boundaries of any of the riparian members are to be negotiated on a bilateral basis between that riparian and the prospective donor. To provide capital to accelerate the development of these production schemes, the European Development Fund (FED) and the World Bank (IBRD) are providing financing for the development of irrigated perimeters adjacent to the mainstream, and, in 1975, the United States was asked to join in this effort.

Both the lower and upper portions of the Senegal side of the River Basin historically have been largely excluded from pre-independence colonial and post-independence natural development schemes. Prior to the severe Sahelian drought, most of the agricultural development efforts in the Senegal River Basin were concentrated in the Delta in sizeable, highly mechanized shcemes where assurance of water and proximity to markets and transport systems minimized risks. Now emphasis is being placed on structuring irrigated land production schemes into smaller plots so that all inputs can be provided through the traditional family unit working its own land. This family unit, of some 8 to 10 persons, are to also be the prime beneficiary of the land's development and use.

In the Spring of 1975, the Africa Bureau Executive Committee for Project Review held a series of meetings on a PRP for the "Development of Irrigated Perimeters in the Senegal River Basin." Potential donors to the OMVS and the GOS had been asked to look at possible projects outside the sparsely populated Delta and to consider irrigated perimeters in the lower and upper reaches of the river basin. The projects undertaken by the FAC, FED and the IBRD are in the lower basin. In continuing the progression of projects from the lower to the upper region of the basin where population centers are located, AID had been asked to give particular attention to possible irrigated perimeters at Matam (7250 net hectares) and

Saldi Walda (3500 hectares), both in the Upper River Basin. These, along with possible alternative sites (Lampear - 2500 ha and Debi - 1500 ha) in the lower basin were investigated and discussed. The PRP concentrated on, and recommended proceeding with a project at Matam.

After the series of meetings, the ECPR agreed to proceeding with the necessary technical, engineering, economic and social analyses for Matam to provide a basis to determine economic and technical feasibility. The field studies were completed in June 1975 and the consultant's final report is due in October 1976. However, in order for the project review process to be accelerated, the consultants have given AID full access to their findings and analyses on which that report will be based.

B. Detailed Description

1. Basic Framework

The project to which the proposed AID grant and loan will contribute is located adjacent to and west of the town of Matam approximately 220 airline miles (407 km) from the city of St. Louis at the mouth of the river. The total project, once completed, will consist of the construction of a flood, surface and sprinkler irrigation system for 8,590 gross hectares (7,290) net hectares of land. The area is situated in the plain of the river where elevations vary from 13 to 18 meters above the local datum. In the past, large portions of the project area have been subjected to annual inundations by the Seneval River which, at flood stage, have reached an elevation of 16.5 meters. By contrast, in some years during the dry season, the flow of the river drops to only a few cubic meters per second. Indications are that the river at Matam has gone completely dry on one or more occasions during the 72 year period of record.

The principal features of the total project includes the construction of 45.1 kilometers of flood protection dikes, six pumping and drainage stations, main canals, secondary canals, 113 wells, drainage systems, land leveling and service roads. These facilities will eventually serve 7,290 net hectares of irrigated land. The AID-financed portion will develop 3,875 net hectares of irrigated land with ancillary infrastructure in proportion.

2. Project Description

The consulting engineers who conducted the feasibility study for the project have recommended a four-phased development of the entire Matam perimeter. Phase I totals 2,175 net hectares; Phase II 1,940 net hectares; Phase III 1,700; and Phase IV 1,475 net hectares. The AID-financed portion will address Phases I and III which are con-

tiguous plots of land. These two phases total 3,875 net hectares of irrigated land.

Phases I and III are the furthest removed from the River, Along with Phase II, they are primarily located in the Fonde (light) soils which are primarily brush lands and traditionally not used for rainfed or irrigated agriculture. The initial development of these soils was chosen for the first phases of this project in order to minimize the initial impact on traditional agricultural practices. It is the Hollalde (heavy) soils which are the most valuable to the practitioners of the centuries-old flood-recession agriculture. The development of Phases I and II will convert some 900 hectares of the traditional flood recession agriculture to controlled irrigation, leaving approximately 1,290 hectares in the center of perimeter for continuation of flood recession practices.

The project will develop a training farm in the first phase of implementation to introduce the different systems of irrigation to the beneficiary population. This farm will be approximately 100 hectares and operate with surface and sprinkler irrigation systems. Villages which will be participating in the project are expected to choose and assign farmers to the training farm to become familiarized with irrigation methods, and they, in turn, will be expected to establish and convey these methods within their own villages.

At the same time that the training farm is being established, technical assistance will be provided to the project. Twelve man-years of technical assistance is provided for: (1) an agricultural generalist, experienced in irrigation, for three years; (2) an irrigation engineer for three years; (3) an equipment mechanic for three years; and (4) an agriculture extension specialist, also for three years.

These technicians will work alongside GOS counterparts to prepare them for project management by the end of the contracted periods of time. The TA group and the counterparts will be responsible for establishing and managing the training farm, and then extending methods perfected onto the actual perimeter development. It is therefore critical that competent personnel be recruited early in order to have them established and the farm operational by the July 1977 planting season.

The project will construct 16.6 kilometers of protective dike ranging from less than one meter to 5.5 meters in height. Along the outer edge of the dike, a drainage canal will also be constructed. This canal is expected to be filled during the high water season and will provide supplemental water for flood irrigation.

Two pumping stations will be installed by the project. They will be used for both drainage and, during the highwater season, for irrigation. One pumping station will be installed on Phase I and will pump into (and out of during the highwater season) the drainage canal to be constructed alongside the protective dike. The second pumping station will be installed on Phase III and will utilize the Marigot adjacent to this phase for drainage and supplemental water during the highwater season.

Groundwater will be the source for the irrigation waters and will entail the drilling and construction of wells. It is estimated that a well can provide sufficient water to irrigate 25 hectares of flood irrigation, 60 hectares of surface and up to 70 hectares of sprinkler irrigation. To develop the 3875 hectares of irrigated land in the AID-financed project, 81 wells will need to be drilled and constructed. The first three wells will be put on the training farm to permit its early development.

These wells will be the focal points around which the project will be organized. Each well will have a farmers' group (or water users association) which will have responsibility for the well and its water use. These farmer/water users will all be of the same village or village quarter in order to minimize the potential for conflict. They will observe well maintenance and call for assistance when needed, see that fees are collected and provide the framework upon which water use is regulated.

Water distribution systems will be developed for each method of irrigation. Sprinkler irrigation will require wells, p8mps, pump engines, pipes and sprinkler valves. This system will be developed to provide irrigation for 740 net hectares of irrigated land. Surface irrigation will require wells, pumps, pump engines and distribution canals. Two-thousand three-hundred seventy (2,370) net hectares of irrigated land will be served by this system. The remaining 765 net hectares of flood irrigation land will be served by a similar water distribution system as that for surface. Namely, it will require wells, pumps, pump engines and distribution canals.

The project will be developed for double-cropping. The first growing season will be between June and November, and will require less groundwater utilization as this period of time encompasses both the rainy season and the high water season. The second growing season is between January and May, and encompasses the cool weather in January and February and the hottest time of the year, in April and May. Groundwater needs will be considerably higher during this second period.

The Hollalde soils will be developed for flood irrigation and used primarily for rice culture. The rice can be grown either from direct seeding or transplanting from pepinieres. Either way, the first growing season will be from mid-July to mid-November and the Hollalde soils will be planted 100 percent in rice. The second growing season

will be from December to April. During this second season, 20 percent of the Hollalde soils will be planted in sorghum and 80 percent in rice. These sorghum plantings will be rotated on different lands so that every five years the soil will be broken up by the sorghum plants.

In the Fonde soils, crops which can use either sprinkler or surface irrigation will be grown. These are wheat, corn, sorghum, niebe (cowpeas) and some vegetables. The vegetables to be grown will be for local consumption and constitute only five percent of the crops planted during both growing seasons.

Corn and sorghum will be grown during the first growing season. Corn will represent 50 percent of the crop and sorghum 45 percent. The corn will be planted in June for harvest by the end of September and sorghum in July for harvest by the end of October. During the second growing season wheat (60%) and niebe (35%) will constitute the cropping pattern. The wheat can be planted in December and harvested by the end of March. Niebe will be planted in mid-January and harvested by mid-April.

Double-cropping is another new element being introduced to the agricultural practices of the people in the region. Investigations show that the people are amenable to accepting innovations and change in their agricultural practices. However, these same investigations show that they are not as amenable if it means adding hardships in an already harsh existence. Double cropping will do this without an added element to ease the burden.

There are two bottlenecks during the year between the growing seasons. One occurs in November/December and the other in May/June. These inter-season time periods are when the crops have been harvested and require preparation for marketing and/or storage. This is also the time frame when the land must be prepared for the next crop. In order to assure that these time constraints will be manageable by the farmers and to increase their willingness to accept double cropping,

a degree of mechanization will be introduced by the project. This mechanization is minimal in that it will only assist the farmers in land preparation and planting, and in harvested crop preparation for marketing and storage.

First off, the project will provide tractors for plowing, harrowing and planting. This mechanization is especially needed in the heavy hard-to-work Hollalde soils which are to be developed for rice culture. Secondly, it has been shown that in order to provide the requisite incentives to the farmers, in terms of income after subsistence needs are met, 2.0 hectares of cultivation are needed. In the absence of some degree of mechanization, it is estimated that a maximum of 1.5 hectares of land could be cultivated by hand.

The second element of mechanization to be introduced will be multipurpose threshers which are tractor driven. With the anticipated increase in yields it would not be possible for the farmers to do the threshing by hand and at the same time prepare their land for the next planting.

Time studies conducted by the consultants for the feasibility study on the project show that one set of equipment per well is needed. This means one thresher and one tractor with the requisite implements. With farmer groupings organized around each well, we again have a natural organization on which to build the concept of an equipment cooperative. Two such equipment cooperatives are being initiated on a pilot basis on other perimeters in the basin, so there will be some experience on which to pattern these in Matam by the time they are organized.

3. Logical Framework

Goal

The primary goal to which the project is addressed is the increase in production of agricultural products in the Fleuve Region of Senegal. Meeting the primary goal will contribute to the sector goal of decreasing Senegal's dependence on food imports and becoming self-sufficient in cereals food production.

These goals can be met only if the resources of the Senegal River Basin are developed and the constraints of water availability are reduced to a minimum. This means that it is therefore necessary to develop irrigated agriculture. The Government of Senegal places a high priority on this development which is the primary contributing factor in the lack of economic development in the riverain region. Removing the constraints of water availability should result in a very positive increase in economic activity.

Purpose

The purpose of the project is to establish irrigated agriculture in the Matam Department of the Fleuve Region of Senegal, and demonstrate the feasibility of irrigation utilizing groundwater. The construction of the project is scheduled to be completed by mid-1982, by which time five years experience will have been gained on the training farm and four years will have elapsed from the time water was first delivered to a completed portion of the perimeter. The other sections will have had 1 - 3 years of water delivery and the final section will just be preparing to commence its irrigation.

A secondary purpose is to introduce changes in agricultural practices. That is, prepare people of the riverain region for controlled irrigation in agriculture, in the use of agricultural inputs (e.g., fertilizer), and to introduce and prove the feasibility of double cropping.

By doing this, the project will meet its final purpose of producing enough food grains to provide for subsistence and incentives to risk a change in agricultural practices.

Evaluations are scheduled for each year of the project life. At the end of 1979, a mid-term evaluation will measure progress of the project toward meeting the project purposes and assess the need for change. A major evaluation is scheduled for 1982, the year when the project purposes should be attained, to determine whether and if project conditions have been met. The target conditions for the time of this evaluation include:

1. A perimeter of 3,875 hectares constructed and operating with flood, surface and sprinkler irrigation systems;

2. Sufficient groundwater being provided from the wells constructed;

3. 1935 area farm families accepting change and working the irrigated lands;

4. Average per hectare yields if food crops sufficient to provide subsistence, incentives, cover operation- and maintenance costs and make some contribution to the recovery of capital costs.

Outputs

The outputs of the project include the establishment of a training farm to introduce irrigated agriculture to the farmers of the area, construction of irrigation systems and hydrogeological studies.

The specific outputs for the project are as follows:

1. Training farm of 100 hectares including necessary infrastructure (3 wells, distribution canals for surface irrigation and pipes for sprinkler irrigation).

2. Construction of 81 wells with construction to coincide with the development of land.

3. 3,875 hectares of land prepared for irrigation (surface drainage, access roads and consolidation into uniform farms).

4. Two (2) pumping stations constructed for drainage and irrigation during highwater season.

5. Construction of water distribution systems including distribution canals for flood and surface irrigation and pipe installed for sprinkler irrigation.

6. Construction of 16.6 kilometers of protective dikes.

7. Extent and characteristics of the aquifers under Matam through hydrogeological studies.

Inputs

1. $3.1 million grant financing for technical assistance ($1.5 million), the training farm ($1.0 million) and the hydrogeologic studies ($0.6 million).

2. $22.0 million of loan financing for foreign exchange costs of irrigation equipment ($4.11million); flood dikes ($3.00 million) other construction ($3.94 million); wells ($1.25 million); engineering services ($2.30 million); local currency costs ($3.4 million), plus inflation and contingencies.

3. Land ($1.0 million equivalent).

4. Local currency construction costs ($4.6 million equivalent).

5. Counterpart personnel. $0.1 million equivalent).

6. Farm equipment ($2.6 million).

Purposes to Goal Assumptions

In order that the stated project purpose contribute to the goals of increased agricultural production, decreasing Senegal's dependence on imported food products, and having the country self-sufficient in cereals food production, a major assumption must be made: the project, once established, will continue to operate as a successful economic enterprise and similar projects will be developed which can do the same. More specifically, the following assumptions must be made:

1. Farmers will be willing to take risks inherent in making necessary changes in agricultural practices.

2. SAED will have the capabilities to take on expanded programs.

3. Sufficient groundwater and surface water will be available at reasonable cost.

4. That assistance and agricultural imports will be available to farmers who take risks to make changes.

Outputs to Purpose Assumptions

In order that the stated project outputs result in the project purpose being met, the following assumptions must be used:

1. That the interventions and proposed changes in agricultural practices will not only be successfully accepted by farmers, but that they will also provide improved subsistence and incentives for these farmers.

2. Timely construction of the project will take place and SAED's ability to develop an operational and management capability which will keep pace with projected project implementation and development.

3. That experienced technical assistance personnel willing to live and work at Matam can be recruited and placed in a timely manner.

4. That SAED and other GOS counterpart personnel are available.

Inputs to Outputs Assumptions

In order that the stated project inputs will result in the project outputs, the following assumptions must be made:

1. That traditional land tenure and the "Law of National Domain" can work compatibly. In other words, that the villages of the beneficiaries will be willing to consolidate the land into uniform farm plots.

2. That funds and other inputs to be allocated by AID and the GOS will be provided in a timely manner.

3. That SAED will be able to make full use of engineering and technical assistance consultants' services in carrying out the project.

BEST AVAILABLE

Part 3. Project Analyses

A. Technical Analysis and Environmental Assessment

1. Irrigated Agriculture

a. Irrigation Methods

Irrigation distribution systems may be classified into two basic types: (1) open systems and (2) closed systems. An open system has water conveyed from its source to a field byway of open, non-pressurized free-flowing canals. A closed system, on the other hand, has water conveyed from its source to a field through closed conduits under pressure. Open systems depend on gravity for flow (hence sometimes also called gravity systems) and must be designed to closely follow the topography of the land. Closed systems utilize pressure for flow and can be designed in the more regular and convenient manner, with little regard for topography. The Matam Irrigated Perimeters will use both open and closed systems.

The ultimate application of water to a crop may be by any one of several methods for either the open or closed distribution systems. Most common methods for application used with open systems are "border", "furrow" and "corrugation." Closed systems may employ these same methods as well as drip and sprinkler methods.

The Hollaldé soils in the Matam Perimeters are to have flooded rice as the main crop. These soils will be irrigated from an open distribution system using level borders (also called basins) to apply water to the crop. By this method, an area of any convenient size, commonly 10 to 40 meters square, is enclosed within a "border" or "bund" about 30 cm. high, which permits the impoundment of water to a depth of up to 20 cm. while the rice is growing. It is important that the inside of each border or

basin be level in all directions to permit uniform flooding. This is the only system where this is required. For other gravity methods, land is leveled to a uniform gradient in the direction water is to flow across the field.

The Fondé soils will have only non-flooded crops grown. These will be partially irrigated from an open distribution system and partially from a closed distribution system. With the open system, water will be applied to crops through one of the surface methods, i.e., graded border, furrow or corrugation. The closed system will apply water to crops through sprinklers.

The project will have irrigation waters applied by the various methods as follows:

	Phase I	Phase III	Total
Flood irrigation on Hollalde soils producing mostly rice.	285	480	765 ha.
Surface irrigation on Fonde soils producing crops other than rice.	1620	750	2370 ha.
Sprinkler irrigation on Fonde soils producing crops other than rice.	270	470	740 ha.
Total	2,175	1,700	3,875 ha

The amount of land to be placed under basin irrigation for rice production is limited to the amount of slowly permeable soils available for its cultivation. Expansion of rice cultivation to other more permeable soils would be impractical due to the additional amounts of water required to keep the paddies inundated.

The amount of land to be placed under surface irrigation compared with the amount to be placed under sprinkler irrigation is more flexible and is based on several considerations. While surface irrigation is the most common and has in the past been considered the least costly and easiest to manage, its relationship to sprinkler irrigation vis-a-vis these factors has changed considerably.

The difference in cost between the surface and sprinkler methods of irrigation has been considerably narrowed in recent years. This is especially true where land leveling costs are anything more than minimal. With sprinklers, land-leveling is minimal, and fields can be laid out in a regular pattern without the difficulties and added expense of irregular layouts resulting from the necessity of fitting fields and canal alignments to the topography.

There is also the sometimes held opinion that sprinkler irrigation systems are too technical and mechanical for people who have not had prior experience in the operation and maintenance of such systems. While there is some truth in this, the difficulties though different, are no greater than with other systems. The irrigator utilizing the sprinkler method will have difficulty maintaining pipes, valves and sprinkler heads. On the other hand, the surface irrigator will have difficulty cleaning ditches, repairing structures and maintaining land-levels so that he can get water from one end of the field to the other.

In some ways, sprinkler irrigation is easier to understand and operate than surface systems. With surface systems, both streamflow and time must be measured to determine when enough water has been applied to crops. With sprinklers, the flow is constant, and only time needs to be measured. Thus, once the system is operating, all the irrigator needs to learn is to open and close valves, move pipe and keep time. Besides this, sprinklers simulate rain and every farmer has a feeling for rain and its effect on soil and crops. In short, sprinkler irrigation is as practical as surface methods and is therefore in the Matam Project on land that would require extensive leveling for surface irrigation.

Drip irrigation was not considered advisable for use at this time. Water application by this method is continuous and more or less invisible. Because of this, management of drip irrigation requires a high degree of "self-discipline" and sophistication which can only come from a thorough understanding of water movement within the soil profile and confidence in how the system works and that water is actually getting to the plants. Without this, the inexperienced irrigator will succomb to the temptation to open, or even remove, emitters to increase the flow of water to more visible and appreciable quantities. Water filters are required to prevent clogging of emitters which introduces added problems of operation and maintenance. In addition, plastic tubing utilized in drip irrigation is easily damaged in fields and is subject to possible theft and vandalism.

b. Crop Selection

The general scarcity of water and the uncertainties as to its availabilities, which presently limits the types of crops grown in the Matam region, will be largely overcome through the use of irrigation. The proposed project will provide full control of the amounts and times of application of water in the areas served, which will considerably expand the range of crops which can be grown, given the soils and climate of the

region. Nevertheless, in the early stages of the project, only a few crops will be cultivated. These will be crops with which the local farmers are either familiar or which can be readily introduced. They will include rice, sorghum, corn (maize), wheat, cowpeas (niebé) and vegetables. Reasons for this crop selection include the need for basic food grains, the present state of agricultural knowledge and animal husbandry, and the problem of providing technical assistance to farmers.

Only a few farmers associated with the experimental irrigation plots of SAED and the OMVS have had any experience with irrigation, and these few have not yet gained proficiency. To be successful with irrigation, farmers accustomed to flood recession and rainfall agriculture will have to make basic changes in their methods of cultivation and in the intensity of their efforts devoted to crops. Extension services to help farmers master these changes will be admittedly minimal relative to the magnitude of the task. This fact was important in the selection of crops and the project is designed to minimize the extent of the changes that will be necessary.

Sorghum is presently the staple crop cultivated in areas subject to flooding. Where residual floodwaters provide sufficient moisture, corn and vegetables are also grown. Cowpeas are familiar as both a rainfed crop on the dieri lands and as a flood recession crop. Some of the techniques already in use can be applied when these crops are cultivated under irrigation.

Rice is included as the major crop to be grown in flooded paddies on the less permeable soils. Although very few people in the Matam area have, as yet, had experience growing rice, it is in great demand, and there is much interest on the part of farmers in growing this crop. Experiments at Matam, and in other parts of the Senegal River Basin have shown that farmers can achieve results with rice that warrant its inclusion as a major crop.

Although Senegal imports large quantities of wheat, and the consumption of bread is increasing, wheat is presently almost unknown as a crop in the Matam area. However, systematic trials at Guédé have demonstrated that satisfactory yields can be obtained under irrigation. Therefore, wheat is included in the selected crops and also to provide suitable rotations with sorghum and corn on the lighter soils. Once farmers are assured that there is a market for wheat, it is expected that it will be accepted as a major crop.

Upland rice is a possible alternative to wheat in rotation with corn or sorghum on the lighter soils, and would have the advantage of being already desired by farmers. Upland rice is currently grown to some extent in Senegal as a rainfed crop. The yield per hectare is low and irrigation would increase this, though still considerably below that obtained under flooded cultivation However, since no systematic trials have been carried out on irrigated upland rice, it is not included in the crop selection, but should be considered after trials have been conducted.

Similarly, dry beans, lentils and perhaps other pulses may be considered as probable substitutes for cowpeas as farmers gain experience in irrigated farming and develop a desire for more variety in their diets. At present prices, such a change would also increase farm income.

Irrigated crops grown expressly for forage are not included owing to uncertainties concerning the productive use of such crops in the early stages of development. There is presently no established pattern of animal husbandry, involving the use of cultivated feeds. The occasional chopping of tree branches to facilitate grazing on the leaves is the only food supply activity now practical.

c. Soils

For purposes of simplification, two types of soils are identified in the project perimeter: 1) Hollalde, heavy textured clay soils, and 2) Fondé, medium light textured soils.

All the soils in the area of the proposed irrigated perimeter are flood plain alluvial soils with texture ranging from heavy to medium light. Three types of soils have been classified in the area. First is the Hollalde which are heavy alluvial soils with 51 to 60 percent clay. This soil has a low permeability and is well suited to the cultivation of rice. A second soil in the area is identified as the "False" Hollalde. This is a medium heavy textured alluvial soil of 45 to 50 percent clay and is also suited to the cultivation of rice. For purposes of the proposed project, these two types of soil have been included under the one classification of Hollalde and will be developed for rice cultivation. Combined, they equal approximately 60 percent of the grass hectarage of the perimeter area.

Furthest removed from the river, yet still within the alluvial flood plain are the Fonde soils. These are medium light soils with 30 to 44 percent clay and are well aerated and permeable. These soils are irrigable for wheat, corn, cowpeas, beans, tomatoes and vegetables. They amount to about 40 percent of the gross hectarage of the perimeter.

Beyond the flood plain and not within the perimeters of the proposed project, are the Diéri Soils which are cultivated in rainfed millet. These are the sandy soils of the Sahel.

The soils in the project area are all deep and heavily enough textured so that one finds no problems with excessive sand or wind erosion. Salinity and alkalinity will pose no problem and there is no water table under these soils which would require drainage. The low areas of the Hollalde soils flood each year and are the areas of flood recession agriculture.

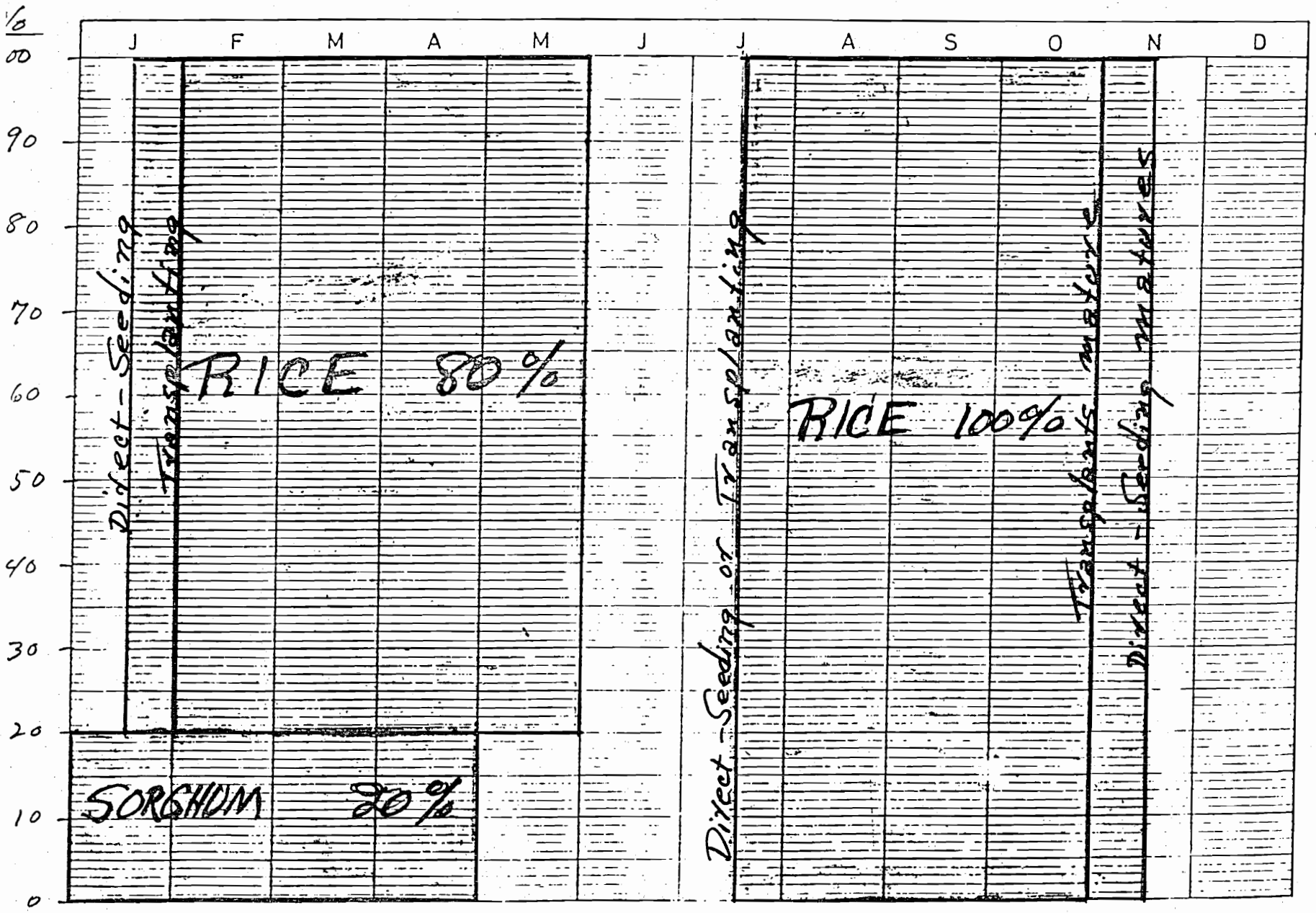
d. Cropping Patterns

The soil characteristics described above have determined the cropping pattern for the project. The heavy textured, slowly permeable Hollaldé soils are best suited for growing rice, and the lighter textured Fondé soils are too permeable for growing flooded rice, but are well suited for growing other crops of the region. The "False" Hollaldé soils, having characteristics of both the other soils can be used for either Hollaldé or Fondé soils cropping patterns, but will be primarily used for Hollaldé cropping patterns in the 3,875 net hectares to be developed under the proposed project. Figures ____and ___illustrate the two cropping patterns developed, the percentage of land occupied by each crop and the season in which it is grown.

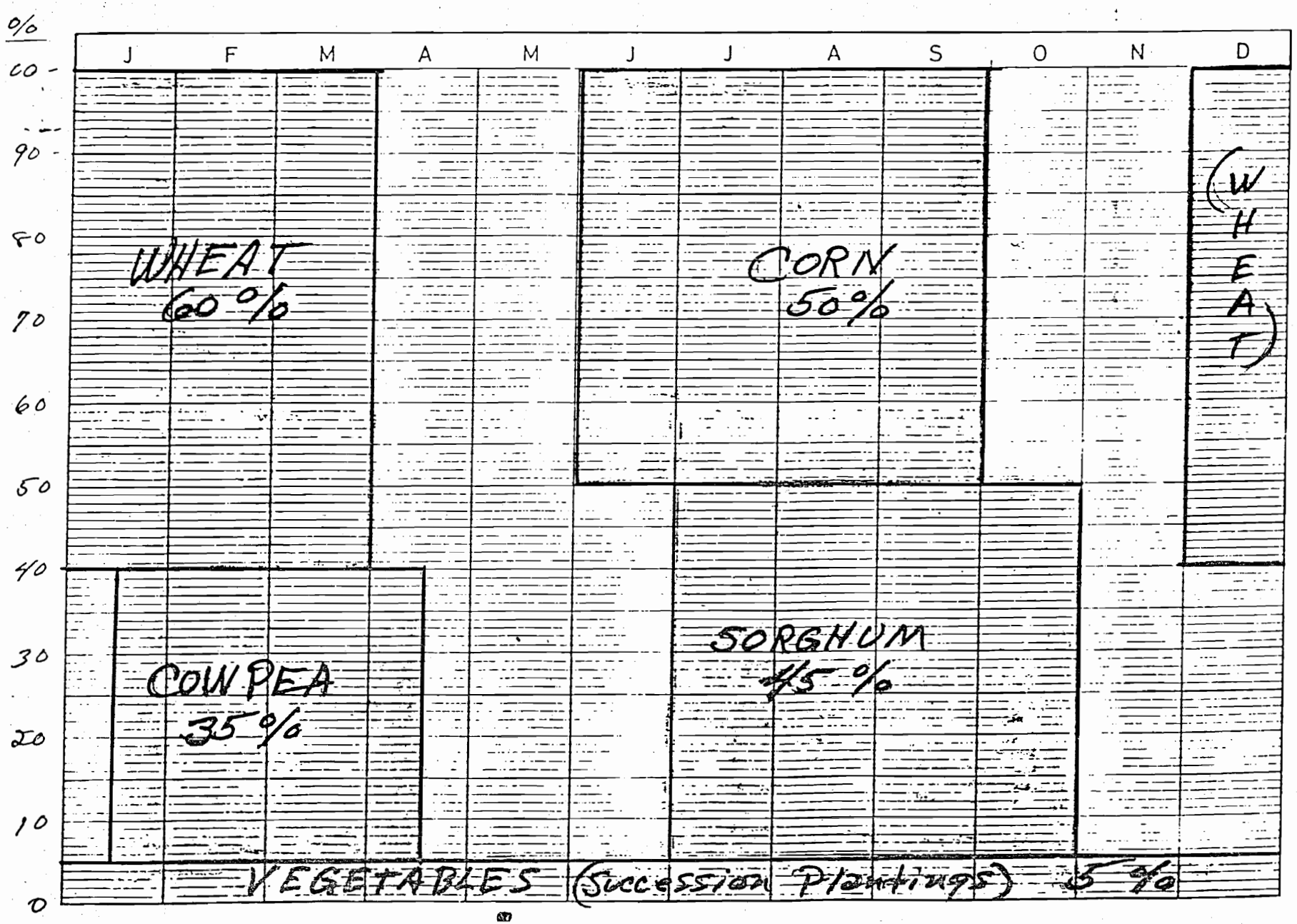
The possibility was seriously considered of growing on the Hollaldé soils rice in the Summer months (July - December) only, with non-flooded crops in the Winter months (January - May). This would make it possible to make the most effective use of available moisture, especially summer rainfall, and to minimize monthly peak use rates of water at the same time. However, several factors mitigated against this possibility, in favor of continuous rice cultivation. First of all, extra time is required after the rice crop has been harvested for drying out and preparing a seedbed in such heavy soils following flooded rice. For wheat, this would have to be done by December 15, the latest recommended seeding date. For rice it can wait another month or more. Furthermore, if a farmer fails in his attempt to prepare a "dry" seedbed, he can, when growing rice, resort to under-water seedbed preparation and hand-broadcasting soaked seed. With other crops, the only alternative is to lose the crops.

PROJECTED CROPPING PATTERN

Hallalde Soils - Matam



PROJECTED CROPPING PATTERN
FONDE SOILS - MATAM



For the above reasons, it is felt that farmers in the Matam area will be more inclined to grow rice continuously rather than alternating with other crops. The cropping pattern projected for the Hollaldé soils nevertheless includes one winter season sorghum crop every five years to provide opportunity for sub-soiling and periodic drying out of the soil. This is considered helpful in controlling aquatic weeds and anaerobic pathogens. To this extent, the Hollalde cropping pattern may be considered a five-year rotation of 9 crops rice and 1 crop sorghum.

The Fondé cropping pattern provides more possibilities for varying crop rotations - several simple one-rotations may be grown as follows:

- - corn - wheat
- - corn - cowpeas
- - sorghum - wheat
- - sorghum - cowpeas

Two, three, or four-year rotations could also be found by combining 2, 3, or 4 of the one-year rotations outlined above. However, it is expected that the most typical rotations will be a two-year rotation such as follows:

1st year = corn (summer) - Wheat (winter)

2nd year = sorghum (summer) - Cowpeas (winter)

Agronomically, these are acceptable rotations which could eventually be improved by inclusion of deep-rooted legume forage and manure crops.

2. Hydrologic Analysis and Design

a. Water Supply

The available sources of water for the Matam Project area include rainfall, the Senegal River and groundwater from drilled wells on the project.

Rainfall in the area averages approximately 500 millimeters per year. The occurrence of rain is concentrated in the three months period of July, August and September -- the rainy season. There is a high variability from the average with some years being less than half the average annual rainfall figures.

The Senegal River at Matam has an average annual flow rate of approximately 764 cubic meters per second. As with rainfall, one finds an extreme variance from the average. As regularly as the river floods, it also regularly has essentially zero flow for a period of one to three months. Furthermore, the occurrence of low to zero river flow coincides with the period of low to zero rainfall. There is no reservoir water storage on the river and will not be until the Manatali Dam and/or others are built. In the absence of this reservoir storage, it is therefore necessary to obtain the major part of the project's irrigation water from the third source, groundwater.

Underlying the project area are two sandy aquifers -- an upper aquifer 13 meters below the surface and approximately 50 meters in depth, and a lower aquifer 100 meters below the surface, separated from the upper aquifer by an impermeable clay layer of 30 meters, and of yet undetermined depth. In order to estimate the water supply available from these two aquifers for the project, two test wells were drilled and pumping tests performed during the months of April, May and June 1976. The analysis of test results from the wells indicate that it is feasible to pump approximately 55.5 million cubic meters of

water per year from those two aquifers. This will provide sufficient water for Phases I and III of the Matam Perimeters which are to receive financing from the proposed project. This water will be pumped from a field of 81 wells, each designed for a flow capacity of 800 gallons per minute (50 liters/second). The well field design provides for half the wells in the upper aquifer and half in the lower aquifer. This is to prevent unreasonable drawdown on either aquifer since it has not yet been determined whether or not there is a connection between the two. The available information indicates that there is not.

The project plans and cost estimates include provision for additional groundwater exploration and development in the project area. These further tests will determine the specific recharge characteristics of the aquifers and define the precise interrelationships between the two aquifers and between the aquifers and river flows. Analysis by engineering consultants and an independent groundwater expert indicate a feasible project water supply for the proposed Matam Irrigated Perimeters project. The additional tests will help to determine the extent to which further development of the aquifers can occur without reducing normal river flows. This is an important determination as it affects the degree to which groundwater can be developed without eventually adversely affecting other water users.

The quality of both the groundwater supply and of the surface water have been tested and found to be of satisfactory or better quality for irrigation. Further details on the surface water and the groundwater supplies are contained in Annexes III A and III B, which are excerpted from the draft report on the Feasibility of the Matam Irrigated Perimeters project.

The water supply for the project will be drawn from the three sources described above. Surface water will be used to supplement the well pumped water during the high flow and flood stages of the river. This conjunctive use of the water sources will help to limit well drawdowns so that pumping lifts do not become excessive. This water will be drawn from a drainage canal along the outer edge of the dike during high water, and for the marigot adjacent to the project at the same time.

b. Water Requirements

The feasibility study for the Matam project details the estimated water requirements for the project by cropping pattern and season. These estimates are based on climatological records, water percolation rates for project soils and on experience with sprinkler, surface and flood irrigation systems. In millimeters of depth, the annual requirement for the Hollaldé soils is 3.522 millimeters. For the Fondé soils, the requirement is 1.255 millimeters. Table _____ shows the requirements by crop and by month.

c. Flooding and Drainage

The feasibility study includes frequency-duration-stage curves for the Senegal River at Matam based on observations of about 70 years. These records indicate a maximum flood level of 16.47 meters (IGN datum) in 1906. The project area to be financed by the A.I.D. loan will be protected from river flooding by a levee designed to withstand a 50-year flood plus an added safety margin of one meter. This additional meter in height should make the protective dike practically effective for the centenary flood.

The project area contains only about twenty per cent of annual flood lands (approximately 900 gross hectares). These annual floods follow the patterns of the marigots in the project area -- flooding lands between the river bank and the higher areas of the fonde soils (see map). Drainage is out through these same marigots.

Designs for internal project drainage are based on analysis of rainfall intensities and drainage area characteristics. The drainage system will be designed to serve a dual function. The two pumping stations to be included on the perimeter will provide rainy season project drainage and supplemental surface water pumping when needed. One should also expect to see, under project conditions, improved drainage through the soils as water is pumped from wells.

MATAM

SUMMARY of IRRIGATION REQUIREMENTS

(mm of depth)

CROPS	% of Area	Weighted Farm Delivery Requirements												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Hollalde Soils														
Direct-Seeded														
Rice: Summer	100							104	485	475	456	171		1691
Winter	80	110	453	421	386	251								1621
Sorghum	20	35	44	66	65									210
Total	200	145	497	487	451	251		104	485	475	456	171		3522
Fonde Soils														
Corn, Summer	50						69	57	73	58				257
Sorghum, "	45							21	37	65	105			228
Wheat, Winter	60	111	147	91									75	424
Cowpea, "	35	18	64	111	63									256
Vegetables, Summer	5						7	2	1	1	7	10		28
" , Winter	5	9	9	11	11	13							9	62
	200	138	220	213	74	13	76	80	111	124	112	10	84	1255
TOTAL														

7/30/76 M.E.

6/16/76 M.E.

3. Final Design and Construction

A. Design

A preliminary design of the Matam Perimeters will be available with the final report of the consulting engineers for the feasibility study. The final design will specifically show the location of each well, from which aquifer it will draw water, well access roads and the type of irrigation to be located on each plot of land. Present considerations of these elements are shown on the map attached as Annex I. Also shown on the map are the locations of the flood protection dikes to be constructed and the drainage/irrigation pumping stations.

As previously noted, each well will have a delivery capacity of 800 gpm (50 liters/second). They will have a steel casing treated to withstand corrosion, stainless steel screws and a gravel pack. Water will be pumped by a deep-well turbine pump driven by a diesel motor. An illustration of a typical well is attached as Annex ___. The depth of each well will be determined by which aquifer it is to draw water. This depth can range from 75 meters for the upper aquifer to 200 meters for the lower aquifer.

The criteria and method to be used in the irrigation and drainage systems designs have been determined after evaluation of both the agronomic and engineering considerations of the advantages and disadvantages associated with different types of irrigation systems. Included in these evaluations were the desires of the Government of Senegal to increase rice production, the assistance of the people in the Matam area of different crops, the topography of the land the results of tests and surveys carried out as part of the feasibility study.

The project is designed to provide for 735 hectares of flood irrigation, 2460 hectares of surface irrigation and 680 hectares of sprinkler irrigation. Flood irrigation will amount to approximately 20 percent of the total irrigated land and will be primarily in rice culture. Rice is, first

of all, a readily accepted and desired crop of the people in the Matam area. It is also the main crop on which the GOS has placed a primary emphasis for increased cultivation. The lands to be placed under rice cultivation are the heavy Hollalde soils which are well suited for flood irrigation.

The lighter Fonde soils previously discussed will have both surface and sprinkler irrigation. Surface irrigation has already been introduced to the area through FAO/SAED pilot projects. Some experience has been gained in the use of furrow irrigation for the growing of corn, sorghum and cowpeas, which are all crops which the people are familiar with and use as part of their regular diet. Surface irrigation will cover approximately 63 percent of the irrigated lands.

Sprinkler irrigation will be a new technology introduced to the Senegal River Basin. From an engineering and economic standpoint, it is the most appropriate system of irrigation to use in the Fonde soils of the Matam area. Sprinkler irrigation systems are most appropriate for distributing irrigated water on these lands for the following reasons:

(1) The sprinkler system is inherently more efficient in use of water than surface irrigation because of the control on water application rate and evenness. The water made available for irrigation use is valuable because of its relative scarcity and the high costs associated with its collection and delivery to the irrigated area.

(2) The required distribution by pipeline results in lesser conveyance, operational and evaporative losses than with surface irrigation, while minimizing possibilities for unauthorized use.

(3) Minimal land preparation, such as land leveling, is required for sprinkler irrigation, which additionally can be applied on sloping or rolling ground on which surface irrigation would be impractical.

(4) The requirements for surface and subsurface drainage facilities are much lessened. Also, in water-short areas, the greater efficiency in water use increases the land area that can be irrigated.

(5) The buried pipeline systems associated with sprinkler irrigation require little maintenance and have few surface structures to interfere with farming operations. This is in sharp contrast to the relatively large land surfaces required for, and the impediment to farm operation and general access caused by the canals, ditches and drains of surface irrigation.

(6) Sprinkler irrigation systems are more easily controlled and more efficiently operated because of the closed water systems and their valving. Water is available at the farm turnout on a demand basis without extensive adjustment or balancing of the system.

Because it is a new technology to Senegal however, sprinkler irrigation will be applied to only 17 percent of the total lands to be irrigated under the project. The type of sprinkler equipment to be introduced by the project will be "Hand-move" equipment. This equipment consists of the following: a lateral coupler with valve opener at the riser, standard-wall aluminum piping with quick-coupling joints, sprinkler riser and sprinkler head at each pipe coupling, and an end-plug with flush valve. The hand-move equipment is disassembled and moved two or three times daily during the peak irrigation delivery periods. A simple pipe length, complete with riser, sprinkler head and coupling will be moved by hand between successive irrigation positions. This type of equipment is labor intensive, relatively simple and appropriate for this project.

The final design of the project will include protective dike where necessary. This dike will have a maximum height of 5.5 meters (approximately 17 ft. 10 in.) and be designed to minimally withstand the 50-year flood. It will be an earth-filled compacted dike. Because of its height, it will be necessary to construct the dike utilizing heavy equipment.

The two pumping stations included in the project will be designed to serve two purposes. The first purpose is for drainage. Water will be drained off the irrigated lands into irrigation channels and moved towards the protective dikes and the pumping stations. The water will then be pumped over the dike and into a drainage canal on the outer edge of the dike (in the case of one pumping station) or into the marigot. The second purpose of the pumping stations will be to pump supplemental water for irrigation during the high water season. At this time of year, the low-lying Hollalde soils will be flooded and water will be plentiful in the marigot and the drainage canal. The pumps will be able to be reversed and water pumped to provide additional water for surface and flood irrigation.

Construction

The project is designed for phased development and construction over the life of the project (i.e. 5 years). The first phase is the development of the training farm. This will involve the clearing and preparation of 100 hectares of land for irrigation, the drilling of 2 or 3 wells to provide water, drainage structures and other facilities.

The construction of the perimeter's civil works is to take place over a 42 month period. This schedule is necessary to permit SAED to phase its own inputs (i.e. final land preparation and assistance to farmers for irrigated agriculture). This construction could take place over a 30 month period bur following this schedule would put the irrigation system in long before SAED and the farmers were ready to make use of it. Construction will be by contract, let through international bidding. Construction monitoring/supervision will be by the A&E firm which does the final design.

4. Environmental Impact

Any development project can be expected to have an impact on the environment of the area being developed. This section considers the impact of the proposed irrigated agricultural development project on vegetative and wildlife resources and on public health.

Vegetation

One of the preliminary stages in development of the Matam Perimeter will involve land clearing and earth moving. A total of 4,520 hectares will be cleared in Phases I and III. Even though it is often described with the word "scrub", which has an uneconomic conotation, vegetation is an important resource in the Sahel. Considerable vegetation will be cleared in the development area of the Matam Perimeter.

The rapid decline of wood supplies is recognized as a major problem facing the nation of Senegal. Although the demands on the wood supply for use as fuel and construction material are heavy, the decline in supply cannot be blamed on this irritrievable use alone. The effect of overgrazing and especially the herdsmen's practices of cutting out-of-reach branches for browse, severely limits the capability of the plants to mature, or even remain productive in a water-short region where natural soil nutrient supplies are scarce. The problem of scarcity of wood can be expected to increase throughout Senegal whether or not the proposed project, and others similar to it. are developed althought it is now cheaper in the Matam area to cook with locally available bottled gas than purchase wood or charcoal, the large capital outlay (about 1800 CFA), for the stove and first bottle of gas, makes rapid and universal change to this method doubtful, particularly for those who have traditionally gotten their fuel from the land. Eventually, substitute fuel sources will be used widely, if annual incomesincrease to permit purchase of the substitutes. The proposed project can be expected to raise incomes of those associated with the irrigation project. This would make the transition to gas fuel less difficult for them. Removal of vegetation in the area to be prepared for irrigation is to

be done in such a manner that cleared wood will be available for use by local people.

Much of the area is now cultivated each year and foraging herds of cattle, sheep and goats utilize the area after harvesting. There is little reason to believe that conversion of this area to irrigated agriculture will have a damaging effect on the surrounding lands by encouraging an increased level of utilization since the entire area already has substantial man-induced changes. Natural vegetation is characterized by a wide variety of plants growing adjacent to each other, which exploit all levels of the soil. Light requirements are met by the plants growing to different sizes in different strata above the ground. This natural condition has been altered by partial and in some areas complete clearing for the current subsistence level agriculture. The project will, in a sense, complete the clearing process and substitute intensive agricultural practices. Thus, traditional methods of agriculture will be foreclosed in the area to be developed. Although these methods have been often considered wasteful and inefficient, they eveolved over many years, made effective use of the limiting resource, water, and produced the desired results, subsistence harvests. Such results can be substantially improved by modern techniques, but supplemental water, fertilizers and pesticides will be required to achieve the desired greater harvests, and the people will have to adapt to a more intensive method of agriculture.

Wildlife

Implementation of the project is not expected to have a deleterious impact on the limited wildlife in the perimeter. Wild animals which now use the perimeter area will be displaced, but their numbers are small and there is similar habitat adjacent to the project area which can absorb the displaced animals. There are no known species of wildlife which will be endangered.

Long-term operational effects of the project are expected to have little effect on the ecology of the region, though pest control will have to be instituted. Methods to control grasshoppers will be necessary to prevent the type of damage that occurred in the Senegal Valley in 1973. Baiting rather than spraying would be the method of choice to minimize impact on non-target organisms. Methods to control predation by rates will be required and again, baiting would be the method of choice.

Baiting could result in poisoning of non-target organisms such as birds, but if vegetation is eliminated along the edges of the developed lands, the lack of cover and the human activity in the fields may keep valuable species, such as bush foul away from baits. Since crop damage from birds can be expected, large-scale spraying of bird concentrations with toxic chemicals may be found necessary. It can be expected that non-target organisms will be killed in bird eradication programs. Proper planning to destroy the birds on their roosts, however, can minimize the effects on non-target organisms.

Water Quality

The possible impacts associated with irrigated agriculture must be addressed. The first of these concerns, the use of hand dug wells in the area as the water source for villages and the possible water table drawdown in neighboring village wells due to drilled well pumping for irrigation. Water needs of the immediate project to be developed may not have any effect on water levels in village wells. However, as full development on the entire perimeter takes place, and during years when the annual Senegal River flood (and consequent recharging of groundwater aquifers) is below normal, pumping will most likely affect water levels in wells. To avoid disrupting village water supply, the project will include piping water from the irrigation wells to neighboring villages, and drilling additional wells specifically for water supply in or near major settlements. Piped water from

cased wells is expected to also benefit public health in the villages by providing a more sanitary water supply. Water quality analysis has shown extraordinarily high levels of nitrate in water supplies. High levels of nitrate is evidence that human or other animal pollution has entered the source (i.e., hand dug wells).

A second adverse impact could result if the proposed project substantially affects surface or groundwater quality. However, certain features of the land and of the prospective project design minimize the potential for adverse effects. The design of the surface drainage system will be such that during the rainy season surface drainage from the developed area, both excess water from surface irrigation and stormwater runoff, and runoff from land lying at higher elevation will be carried off in ditches to catchment basins. The ponded water in the basins will be pumped as necessary onto undeveloped land adjacant to the fringing dike. If the need to pump drain water occurs when the Senegal River flood waters have reached the dike, the drain water will mingle with the flood and be carried off. Alternatively, if drain water pumping is needed wieh floodwaters have not reached the dike, or have reached, the drainwater will spread out, or pond, as the ground contour permits. Eventually, the drainwater will evaporate or seep into the ground. The volume of drainwater is not expected to be great enough to result in flow to the marigot. During the dry season, drainwater return flow is expected only from surface irrigated plots. Drainwater will be ponded and used to supplement groundwater pumped for irrigation of rice. With proper management of water application, no discharge of drainwater outside of the diked area is anticipated during the dry season.

Fertilizer and pesticides will be used to maximize crop yields and minimize crop damage. Depending on the types of fertilizers and pesticides used, small amounts of these materials may end up in drainwater or percolate into the soil. The amounts of fertilizers and pesticides which may be translocated with the water is indeterminate because there are many factors which can influence concentrations in the water and transport,

e.g., application rate, timing of application, type of material applied.

The management goal of the agricultural effort will be to apply only that amount of fertilizer and water which can be used by the crops (fixed in the root zone) and only enough pesticide to control the target organisms. The types of fertilizers expected to be used (urea, ammonium sulfate and superphosphate) provide nutrients in readily available form. No green manures, which contain both readily available and slow release forms of nutrients, will be used. Consequently a high percentage of the applied fertilizer will be fixed in the root zone and not translocated.

Depending on the types of plant diseases or pests which must be controlled, a wide variety of pesticides may be used. Some, such as the organophosphate types, have short persistence times (a few days to a few weeks). Others, such as the organo-chlorine types, may persist for months. The more persistent types could eventually be found in drainwater.

No measurable effect of residual fertilizers or pesticides on receiving water is expected if drainwater is carried off and diluted by the Senegal River flood. Nevertheless, water containing residual fertilizers as pesticides may eventually percolate into the groundwater table. When and iff this occurs, the magnitude of any effect would depend on a number of factors:

- percolation rates;
- concentration of fertilizers and pesticides in water;
- concentration of other ionic and non-ionic substances in water;
- exchange capacity of soils;
- absorptive capacity of soils;
- rate of aquifer recharge.

The overall effect is not expected to be great. To determine whether or not agricultural practices are affecting groundwater quality, a water quality monitoring program could be started with the onset of the irrigated agricultural development. Routine sampling of well water can provide a data base from which changes in water quality with time can be followed.

Public Health

Development of the Matam irrigation project must also take into account the possible effects on public health. In general, the climate of Senegal provides a favorable environment for the spread and maintenance of parasitic diseases in humans and domestic animals. In particular, environmental change associated with a project that enhances the extension or creation of parasitic habitat can have an effect on public health.

In evaluating possible effects, Schistosomiasis and malaria must be considered since they are the two diseases representing major health hazards. Schistosomiasis (Bilharzia) is caused by two species of small worms living in the capillaries of the bladder or bowel. Eggs of worms are passed into water via urine or feces, where they hatch and produce larva that invade an intermediate host: snails of the family Bulinus. The larval forms multiply in the snails, emerge and enter the water from which they penetrate the skin of persons wading or swimming in the contaminated water. Worms develop in the infected person's liver and migrate into small veins around the intestine or bladder. Eggs are produced which work their way into the bowel or bladder from which they are passed to complete the vicious life cycle.

Schistosomiasis is reported to be present in the Matam area, and measures to control the spread of the disease must be considered as the agricultural project develops. Control methods should include those aimed at controlling the intermediate host (snails) and at prevention of introduction of worm eggs to the water. Since snails require fresh water, rich in organic material, a measure of control can be achieved by keeping canals free of vegetation, and preventing canal leakage and overflow. In addition, treatment of water, where it enters the fields, with appropriate molluscides could be used as a direct control measure. Snail control will probably not be required on those lands subject to sprinkler irrigation because these lands are not likely to contain enough moisture to permit establishment of snail colonies. Flood rice lands will probaly require repeated application of

molluscides while on other surface irrigated croplands, snail control could be achieved with periodic application of molluscides and elimination of vegetations in ditches and furrows.

Malaria is the most common infectious disease of man in the tropics and it is present throughout Senegal with an infection rate of 56 percent in the Fleuve Region. The principle vector is the Anopheles sp. mosquito. Mosquito breeding occurs during the July to September rainy season which corresponds to the flood period of the Senegal River. It is questionable whether or not the proposed project will provide a greater breeding area for malaria vectors when the amount of irrigated land is considered in comparison to the amount of land flooded by the river. Even though the irrigated land will represent a potential mosquito breeding area in the dry season, there is sufficient doubt significant numbers of Anopheles could survive in the dry heat, as to all but dismiss the potential threat. Control methods are to be aimed at preventing mosquito habitat from forming by carefully controlling canal leakage. Nevertheless, treatment of possible breeding areas with insecticide to kill larvae may be necessary.

Many other diseases prevalent in Africa are of some, but not undue concern. The design and intended operational features (e.g. minimization of drainwater) of this project militate against aggrevation of health problems. Onchocerciasis is not expected to be a problem, even though it is highly endemic in eastern Senegal and in Mali. The vector (Simulium) requires well-oxygenated, fast-flowing water for breeding, and this condition is not present in the Matam area. Similarly, the human form of Trypanosomiasis is not a serious problem in the middle Senegal River Valley, possibly because the region is too hog and lacks dense groves of trees which are needed to harbor its vector, the teetse fly. Public and animal health surveillance during project development and operation, coupled with the provision of better water supplies to villages from project wells, and aided by the likelihood of increased nutrition as a result of greater agrilcultural production, should result in a net health benefit.

Other Considerations

Many tracks, used by the local people to get to and from Matam, and by herdsmen who drive their animals to and from watering areas near the river and marigots, cross the area to be developed. In an attempt to minimize the possible conflict between herders and farmers that blocking of the tracks might generate, five laterite surfaced access roads through the agricultural development will be provided. In addition, three pathways along dike crests will be provided. It may be necessary to consider fencing fields and canals adjacent to the roads to prevent damage by animals. Otherwise, the task of keeping animals out of the fields and canals will probably fall on the children who are normally used to scare birds from the fields.

Conclusions

The impact of a development project on the area under development is, to a greater or lesser degree, dependent upon the type of project, its design and intended operation. The discussion above dealt primarily with the impact of the proposed project on vegetative and wildlife resources and on public health. As shown in the discussion, there are no major concerns over any adverse impact of the project on the environment. There is, nevertheless, the possibility that some effect on groundwater quality will result from residual insecticides and pesticides. This is to be monitored, noted and, if necessary, corrective measures taken.

B. Financial Analysis and Plan

1. Financial Viability - Effect on Project Participants

Tables ____ through ____ are budgets showing estimated farm expenses and farm revenues associated with the production of various crops under irrigated cultivation. All budgets are for one crop cycle, i.e., from land preparation to harvest, and all are expressed in terms of one hectare of land. Obviously, expenses and yields per hectare will vary in the project depending on land quality, skills of labor and management, and other factors. The budget estimates are intended to represent average results at a level of technology and farming skill that could be obtained in the Matam area.

The prices of the various inputs and outputs shown in the budgets are expressed in terms of their 1976 values. It is assumed that future changes in these prices will maintain approximately the current relative price structure, so that budgets will represent adequately the operating results that can be expected during the life of the irrigated projects in relation to the general level of prices then prevailing.

a. Labor and Management

With the exception of machinery operators, all labor and management is assumed to be supplied by the farm family. The cost to the family for supplying their labor to an irrigated farm is the amount of output they could have produced working on non-irrigated land in the absence of the irrigation project. Based on estimates of the labor required for traditional cultivation of dieri and oualo land (the alluvial flood plain) and the time at which times at which tasks must be performed, it appears that the average family of three workers can cultivate three to four hectares, depending on the timing of rain and floods. Estimates of the number of families concrened in the project area and observations of the preparation

of that area in flood recession agriculture suggests that an average family will have about one hectare cultivated in the oualo. Therefore, for purposes of this analysis, it is assumed that the typical family presently cultivates one hectare in the oualo and two hectares in the dieri.

The average yield of millet in the dieri is about 350 kg per hectare, with 1000 kg of stalks for fodder (stover). Valuing the grain at 30 FCFA per kilogram, the average annual value produced in the dieri is about 15,000 FCFA per hectare. Similar calculations for the oualo, where the average yield is about 500 kilograms of sorghum and 2000 kilograms of stone, give an annual value produced of 24,000 FCFA per hectare. The typical family with two hectares of dieri and one hectare of oualo under cultivation therefore has an annual income of about 54,000 FCFA from its labor without using any purchased inputs. Since this income must be given up to devote time to irrigation, it is considered an opportunity cost of irrigated farming. Assuming a typical family plot under irrigation to be 2 hectares double cropped, this amounts to 13,500 FCFA per hectare of irrigated crop, which is entered as a family labor cost per hectare in the production budgets for irrigated crops.

b. Machinery and Equipment

The costs of machine work are estimated on a hourly basis to permit appropriate changes to each crop depending on the hours of work per hectare that will be required. The hourly costs of tractors and tractor-drawn equipment were estimated using procedures and cost factors developed by the American Society of Agricultural Engineers and applying them to current prices of machinery and fuel in Senegal. The procedure allows for depreciation of the machine

of the machine over its useful life, interest on the undepreciated value, repairs, fuel and lubricants and insurance. The latter is taken to represent the risks of damage, even though machinery may not be formally insured at Matam. Fuel consumption varies with the load on a tractor and was calculated for each operation. The hourly wage for the driver at the current SAED scale was increased 20 percent to allow for the t spent in servicing the tractor and other time that the driver is not actually performing operations in the field. Ten percent of the direct costs are added as an allowance for the administrative costs of supplying machinery services to individual small farms.

It is assumed that each family will have its own donkey and cart and its own hand tools, while back-pack sprayers will be shared by two or more families. Costs were first calculated on the total animal cost of using each item and the allocated pro-rata to the hectares of crops cultivated by a family. The per hectare costs have been based on a typical plan of two hectares, double cropped making a cost of farm hectare of crops per family.

c. Seeds

For the various crops proposed for the project, the varieties best suited to the area have not yet been established. Seed costs will vary with the variety and the extent to which seed can be saved from the harvest for subsequent use instead of purchasing fresh seed each year. SAED charges to growers in the Nianga Project (near Podor) in 1975/76 were 70 FCFA per kilogram for rice and 100 FCFA per kilogram for corn. These prices are used in the crop budgets. The rice and corn prices are also used as estimates for wheat and sorghum respectively. Seed for cowpeas is estimated at twice the price of the harvested crop, or 56 FCFA per kilogram.

d. Fertilizers

It is the practice of the Senegalese Government to provide fertilizers throughout the country at less than the cost to the government in order to encourage the use of these materials. It is assumed that this practice will continue. Prices to farmers have been increased for the 1976/77 season, with a reduction in the element of subsidy involved, and these prices are used in the crop budgets.

e. Pesticides, Herbicides and Rodenticides

Senegal River Valley projects have shown a wide variation in the per hectare use of these products from year to year, depending on the problems encountered during the growing season and on the availability of chemicals and of equipment for applying them. In generalized crop budgets proposed by SAED, lump sum estimates of 20,000 FCFA for rice and 70,000 FCFA for tomatoes were shown. Lump sum estimates also are used in the present analysis without attempting to specify individual chemicals and amounts used. These estimates are for rice, 22,000 FCFA/hectares, for cowpeas 10,000 FCFA/hectares, and for other grains 2,000 FCFA/hectare.

g. Land and Buildings

Buildings are not required on the small family farms planned for the project. Such shelters as may be needed in the fields can be built of local materials requiring no cash outlay. The charge for family labor discussed earlier includes the joint product of that labor and land cultivated without irrigation, and no further charge for the use of the land is required.

g. Transportation

With the small family farms envisaged in this project and the small size of the irrigation area served by a well it is expected that a large part of the movement of inputs to the fields and of products from the fields will be accomplished by hand carrying, donkey-

back and donkey-carts. The estimated annual costs of a donkey and cart have been prorated on a per hectare basis to the cropsthat could be grown by a family. Harvested crops will be brought to a central location in each well service area for threshing, and families will carry away grain for their own use. However, transport will be needed to move surplus crops to collection points for sale, and to bring to each service area such inputs as seed and fertilizer. For this purpose, tractor-drawn trailers can be used, the hourly cost of which has been estimated in connection with other mechanical equipment. A charge for the estimated use of these trailers is included in the crop budgets.

h. Irrigation Water

Although farmers will pay for water supplied by the project, the scale of charges has not yet been determined and the crop budgets do not include payment for water. The farm income before water charges represents the total amount earned by the family as a result of irrigation, before water charges. The ability to pay for water depends on the level of income considered necessary for the farm family. This is estimated and summarized in Table _____.

Prices for Production

With the exception of wheat and fresh vegetables, there is a minimum price guaranteed by the government at which each of the crops envisaged for production in the project can be sold. Relative prices charged significantly over the period encompassing the 1973/74 to 1975/76 growing seasons. This is a reflection of encouragement to increase domestic production in a time of high prices for imports. There is no basis on which to determine whether the

1975/76 price relationships represent a long term equilibrium for Senegal. However, comparison with the 1985 world prices of grains reveals that the price relationships are about the same. Paddy is perhaps still somewhat undervalued in Senegal, but the 1975/76 prices are a reasonable indication of probable producer prices, and they are used in the crop budgets.

CROP PRICES GUARANTEED TO FARMERS -- 1973/74 - 1975/76

(FCFA per kilo, at collection points)

Crop	1973/74	1974/75	1975/76
Paddy	25.00	41.50	41.50
Millet & Sorghum	25.90	30.00	30.00
Corn	25.00	35.00	35.00
Cowpeas	25.00	30.00	28.00
Potatoes	---	55.00	60.00

Since there are no official prices for wheat and for crop residues that can be used for animal feed, it is assumed that these products would have an average market value equivalent to their economic value to the nation. For wheat, this is estimated to be 45.00 FCFA per kilogram, and for crop residues (stover) 4.50 FCFA per kilogram.

No attempt was made to develop production budgets for a variety of vegetables, which are scarce for most of the year at Matam and command high prices in local markets. Since vegetables require intensive work and careful control of insects, disease and predators, farmers can be expected to desire a higher return per

hectare than they can get from more easily cultivated crops. For present purposes, the net income from vegetables is assumed to be twice the average obtained from sorghum, corn and wheat, i.e., 284,000 FCFA per hectare at full yield. This is practically the same as the farm income projected by SAED in a crop planning budget for tomatoes in the Matam experimental irrigation plot in the 1975/76 season. Purchased inputs are seasonal to equal 52 percent of net income. This means purchased inputs of 148,000 FCFA and a gross market value for vegetables of 432,000 FCFA per hectare.

Effect on Project Participants

The family farm will be the production unit of the project. The farm family will supply most of the labor needed to grow and harvest the crops. That is, the size of the farm is adapted to the labor that the family can be expected to supply.

The net income available for the farm family is a function of the size of the farm unit, of the crop yield per hectare and the production expense per hectare. Over a considerable range, net income per hectare can be increased by increasing farm inputs for such things as fertilizer, pesticides, weeding and preparation of seed beds. Net income can also be increased by reducing production expenses through substitution of family labor for hired machinery. However, this substitution is limited by the marginal income that the family considers necessary to make additional labor input worthwhile. At some point the family will cease to work harder for additional income. If irrigated farming is to be attractive, the reward for labor at the margin must compare favorably with the potential for leisure and for earnings elsewhere.

Owing to the limited capabilities of families working with manual cultivation to contribute to payment of irrigation project costs, the manual approach is considered too impractical for the Matam project. Full mechanization and animal traction have been rejected because of unjustified and exorbitant costs, and a lack of interest and trained animals and drivers respectively. A partially mechanized farming system best meets the needs of double cropping under irrigation and is the basis for the design of this project. Farmers at Matam are aware of its use in other projects and expressed the opinion to the feasibility study consultants that mechanical assistance would be needed to prepare the land for planting.

The size of the family farm unit necessarily represents a compromise between ability to pay for project costs and the social objective of spreading project benefits to a large number of families. The results expected with farms of 1.5, 2.0 and 2.5 hectares are shown in Table _____. It is believed that two hectares per family will permit a reasonable achievement of both objectives. This allows for 2,100 kilograms of cereals for family subsistence, which is estimated as the level necessary. It also allows additional income in cash, livestock feed or food crops equivalent to about 100,000 FCFA to 150,000 FCFA per family as further incentive to undertake the year-round work discipline required for double cropping under irrigation. Finally, it also allows for substantial payments toward the costs of the irrigation project, operation and maintenance and water charges as shown by the last two lines of Table _____. In other words, there is a very strong, positive effect on the farm families who are to participate in the project.

Table _____

Projected Crop Budget for Irrigated Rice

(Hollalde Soils - FCFA per Hectare)

Costs of Production

		Man Days	Machine	
(a)	Cultural Operations:	Family Labor	Hours	Cost
	Plow *		3.5	7980
	Disc, 2 times		2.0	4800
	Level (2 times, each 4 crops)		0.7	1519
	Irrig. & Drainage Maintenance	7		
	Haul Seed & Fertilizer		0.5	1135
	Plant		1.0	2950
	Fertilize, 2 times	1		
	Irrigate	4		
	Weed (3 times)**	12		
	Bird watch	(30)		
	Pest Control	5		
	Harvest	21		
	Thresh	4	2.7	14742
	Haul		2.0	4540
	Subtotal	54	12.4	37,666
(b)	Other Purchased Inputs:			
	Seed (100 kg @ 70 F CFA /kg			7000
	Fertilizers (140 kg @ 67.5 FCFA/kg. Avg.			9040
	Insecticides, Herbicides, Rodenticides			22000
	Donkey & Cart			4418
	Back-pack Sprayer			9[illegible]4
	Hand Tools			1960
	Subtotal			45362
	Total Purchased Inputs			83028
(c)	Other Costs:			
	Opportunity Cost of Family Labor			13500
	Total Cost to Farm Family			96528

*Plowing Omitted for Winter Crop

**During daylight hours for 30 calendar days; not included in total

TABLE _____

RICE - Summer

INCOME

Paddy	4000 Kg @	41.50 FCFA		166,000
Straw	3000 Kg @	4.50 FCFA		13,500
Gross Income				179,500
Less Total Purchased Inputs (rounded)				83,030
Total Net Family Income, Before Water Charges				96,470
Less Opportunity Cost of Family Labor				13,500
Net Family Income Attributable to Irrigation, Before Water Charges				82970

Average Applied Irrigation Water	16,910	cubic meters
Net Family Income Attributable to Irrigation per Cubic Meter of Applied Water	4.91	

RICE - Winter
(plowing not required)

INCOME

Paddy	4000	Kg @	41.50	FCFA	166,000
Straw	3000	Kg @	4.50	FCFA	13,500

Gross Income	179,500
Less Total Purchased Inputs (rounded)	75,050
Total Net Family Income, Before Water Charges	104,450
Less Opportunity Cost of Family Labor	13,500
Net Family Income Attributable to Irrigation, Before Water Charges	90,950

Average Applied Irrigation Water	20,260	cubic meters
Net Family Income Attributable to Irrigation per Cubic Meter of Applied Water	4.50	

Table _____

Projected Crop Budget for Irrigated Grain Sorghum
(Hollalde Soils - FCFA per hectare)

Costs of Production

		Man Days	Machine	
(a)	Cultural Operations:	Family Labor	Hours	Cost
	Subsoil		4.0	9520
	Plow		3.5	7980
	Disc		1.0	2400
	Harrow (2 times)		1.0	1790
	List		1.0	2180
	Irrigation & Drainage Maintenance	4		
	Haul seed and fertilizer		0.5	1135
	Plant fertilizer	5		
	Irrigate	9		
	Cultivate (4 times)	13		
	Bird watch*	(20)		
	Rodent and Bird Baiting	1		
	Harvest	19		
	Thresh	4	2.7	14742
	Haul		2.0	4540
	Subtotal	55	15.7	44287
(b)	Other Purchased Inputs:			
	Feed (12 kg. @ 100 FCFA/kg.)			1200
	Fertilizers (170 kg @ 66 FCFA/Kg Avg.)			11210
	Insecticides, Herbicides, Rodenticides			2000
	Donkey & Cart			4418
	Back-pack Sprayer			---
	Hand-Tools			1960
		Subtotal		20,788
		Total Purchased Inputs		65,075
(c)	Other Costs			
	Opportunity Cost of Family Labor			13,500
	Total Cost to Farm Family			78,575

*During daylight hours for 20 calendar days; not included in total.

TABLE _____

SORGHUM-(Hollaldé)

INCOME

Sorghum grain	4,000 Kg @	30	FCFA	120,000
Stover	10,000 Kg @	4.50	FCFA	45,000
Gross Income				165,000
Less Total Purchased Inputs (rounded)				65,080
Total Net Family Income, Before Water Charges				99,920
Less Opportunity Cost of Family Labor				13,500
Net Family Income Attributable to Irrigation, Before Water Charges				86420

Average Applied Irrigation Water	10,500	cubic meters
Net Family Income Attributable to Irrigation per Cubic Meter of Applied Water	8.23	

Table _____

Projected Crop Budget for Irrigated Grain Sorghum
(Fonde Soils - FCFA per hectare)

Costs of Production

		Man Days	Machine	
(a)	Cultural Operations	Family Labor	Hours	Cost
	Plow		2.5	5100
	Disc		1.0	2400
	Harrow (2 times)		1.0	1790
	List		1.0	2180
	Haul seed & fertilizer		0.5	1135
	Plant & fertilize	5		
	Irrigation & drainage maintenance	4		
	Irrigate	4		
	Cultivate (4 times)	13		
	Bird watch *	(20)		
	Rodent & bird baiting	1		
	Harvest	19		
	Thresh	4	2.7	14,742
	Haul		2.0	4,540
	Subtotal	50	10.7	31,887
(b)	Other Purchased Inputs:			
	Seed (12 kg. @ 100 FCFA/kg.)			1200
	Fertilizers (170 Kg @ 66 FCFA/Kg. Avg.)			11,210
	Insecticides, Herbicides, Rodenticides			2,000
	Donkey & Cart			4,418
	Back-pack sprayer			----
	Hand Tools			1,960
	Subtotal			20,788
	Total Purchased Inputs			52,675
(c)	Other Costs:			
	Opportunity cost of family labor			13,500
	Total Cost to Farm Family			66,175

*During Daylight hours for 20 calendar days; not included in total.

TABLE _____

SORGHUM - (Fondé)

INCOME

Sorghum grain	4,000 Kg @	30	FCFA	120,000
Stover	10,000 Kg @	4.50	FCFA	45,000

Gross Income	165,000
Less Total Purchased Inputs (rounded)	52,680
Total Net Family Income, Before Water Charges	112,320
Less Opportunity Cost of Family Labor	13,500
Net Family Income Attributable to Irrigation, Before Water Charges	98,820

Average Applied Irrigation Water	5,070 cubic meters
Net Family Income Attributable to Irrigation per Cubic Meter of Applied Water	19.49

Table _____

Projected Crop Budget for Irrigated Corn

(FCFA per hectare)

Costs of Production

		Man Days	Machine	
a)	Cultural Operations:	Family labor	Hours	Cost
	Plow		2.5	5100
	Disc		1.0	2400
	Harrow (2 times)		1.0	1790
	List		1.0	2180
	Haul seeds & fertilizer		0.5	1135
	Plant fertilize	5		
	Irrigation & drainage Maintenance	4		
	Irrigate	7		
	Cultivate (4 times)	13		
	Rodent & bird baiting	1		
	Harvest & Shell	37		
	Haul		2.0	4540
	Subtotal	67	8.0	17,145
(b)	Other Purchased Inputs:			
	Seed (24 Kg @ 100 FCFA/Kg.)			2400
	Fertilizers (190 Kg. @ 63.6FCFA/Kg. Avg.)			12090
	Insecticides, Herbides, Rodenticides			2000
	Donkey & Cart			4418
	Backpack Sprayer			---
	Hand Tools			1960
	Subtotal			22,868
	Total Purchased Inputs			40,013
(c)	Other Costs:			
	Opportunity Cost of Family Labor			13,500
	Total Cost to Farm Family			53,513

TABLE ____

CORN

INCOME

Corn grain	5,000	Kg @	35	FCFA	175,000
Stover	10,000	Kg @	4.50	FCFA	45,000

Gross Income	220,000
Less Total Purchased Inputs (rounded)	40,010
Total Net Family Income, Before Water Charges	179,990
Less Opportunity Cost of Family Labor	13.500
Net Family Income Attributable to Irrigation, Before Water Charges	166,490

Average Applied Irrigation Water	5011	cubic meters
Net Family Income Attributable to Irrigation per Cubic Meter of Applied Water	33,22	

Table _____

Projected Crop Budget for Irrigated Wheat

(FCFA per hectare)

Costs of Production

		Man Days	Machine	
(a)	Cultural Operations:	Family Labor	Hours	Cost
	Plow		2.5	5100
	Disc		1.0	2400
	Harrow (2 times)		1.0	1790
	Land plane (2 times each 2 years)		1.0	2170
	Haul seed & fertilizer		0.5	1135
	Plant		1.0	2935
	Fertilizer	1		
	Irrigation & drainage maintenance	4		
	Irrigate	6		
	Bird watch*	(20)		
	Rodent and Bird baiting	1		
	Harvest	21		
	Thresh	4	2.7	14742
	Haul		2.0	4540
	Subtotal	37	11.7	34827
(b)	Other Purchased Inputs:			
	Seed (100 kg @ 70 FCFA/Kg.)			7000
	Fertilizers (140 Kg @ 16.9 FCFA/Kg.)			9360
	Insecticides, Herbicides, Rodenticides			2000
	Donkey & Cart			4418
	Back-pack Sprayer			---
	Hand Tools			1960
	Subtotal			24,738
	Total Purchased Inputs			59,565
(c)	Other Costs:			
	Opportunity Cost of Family Labor			13,500
	Total Cost to Farm Family			73,065

*During daylight hours for 30 calendar days; not included in total.

TABLE _____

Wheat

INCOME

Grain	4,000	Kg @	45	FCFA	180,000
Straw	3,000	Kg @	4.50	FCFA	13 500

Gross Income	193,500
Less Total Purchased Inputs (rounded)	59,570
Total Net Family Income, Before Water Charges	133,930
Less Opportunity Cost of Family Labor	13,500
Net Family Income Attributable to Irrigation, Before Water Charges	120,430

Average Applied Irrigation Water	7,070	cubic meters
Net Family Income Attributable to Irrigation per Cubic Meter of Applied Water	17.03	

TABLE _____

Cowpeas

INCOME

Cowpeas grain	2,000 Kg @	28	FCFA	56,000
Stover	3,500 Kg @	4.50	FCFA	15,750

Gross Income	71,750
Less Total Purchased Inputs (rounded)	45,540
Total Net Family Income, Before Water Charges	26,210
Less Opportunity Cost of Family Labor	13 500
Net Family Income Attributable to Irrigation, Before Water Charges	12,710

Average Applied Irrigation Water	7,300	cubic meters
Net Family Income Attributable to Irrigation per Cubic Meter of Applied Water	1.74	

Table _____

Projected Crop Budget for Irrigated Cowpeas (grain)
(CFCA per hectare)
Costs of Production

		Man Days	Machine	
(a)	Cultural Operations	Family Labor	Hours	Cost
	Disc (2 times)		2.0	4800
	Harrow (2 times)		1.0	1790
	List		1.0	2180
	Haul seed and fertilizer		0.5	1135
	Plant & fertilize	9		
	Irrigation & drainage maintenance	4		
	Irrigate	6		
	Cultivate (3 times)	13		
	Insect and disease control	4		
	Harvest	21		
	Thresh	1	2.0	10920
	Haul		1.0	2270
	Subtotal	59	7.5	23,095
(b)	Other Purchased Inputs:			
	Seed (25 Kg @ 56 FCFA/Kg)			1400
	Fertilizer (70 Kg @ 53 FCFA/Kg Avg.)			3720
	Insecticides, Herbicides, Rodenticides			10,000
	Donkey & Cart			4,418
	Backpack Sprayer			944
	Hand Tools			1,960
	Subtotal			22,442
	Total Purchased Inputs			45,537
(c)	Other Costs:			
	Opportunity Cost of Family Labor			13,500
	Total Cost to Farm Family			59,037

Table _____

Ability to Pay for Irrigation Water

Partially Mechanized Farm - at Full Development

(FCFA)

Hollalde Soils

Farm Size (hectares)	1.5	2.0	2.5
Gross Market Value Produced	534,150	712,200	890,250
Production Costs Directly Proportional to Farm Size	214,990	286.650	358,310
Production Costs Related to Farm Unit	25,490	25,490	25,490
Value of Cereals for Family Subsistence	98,000	98,000	98,000
Farm Income Before Water Charges	195,670	302,060	408,450
(Farm Income from Stover)	(49,950)	(66,600)	(83,250)
(Farm Income from Grains and Vegs.)	(145,720)	(235,460)	(325,200)
Amount Available to Pay for Water After Farm Family Net Income Incentive of:			
100,000	95,670	202,060	308,450
150,000	45,060	152,060	258,450

Table _____

Ability to Pay for Irrigation Water

Partially Mechanized Farm - at Full Development

(FCFA)

Fonde Soils

Farm Size (hectares)	1.5	2.0	2.5
Gross Market Value Produced	552,990	737,330	921,660
Production Costs Directly Proportioned to Farm Size	146,150	194,860	243,580
Production Costs Related to Farm Unit	25,490	25,490	25,490
Value of Cereals for Family Subsistence	98,000	98,000	98,000
Farm Income before Water Charges	283,350	418,980	554,590
(Farm Income from Stover)	(81,340)	(108,450)	(135,570)
Amount Available to Pay for Water After Farm Family Net Income Incentive of:			
100,000	183,350	318,980	454,590
150,000	133,350	268,980	404,590

2. Financial Plan/Budget Tables

Total estimated costs for the Matam irrigated perimeter project are $33,400,000. This figure includes both the grant element and the loan element, plus factors for inflation and contingencies. The capital costs for developing the project have been based on the assumption that construction would be by an American Contractor with an American A & E firm doing the design and construction supervision. The estimated cost(before inflation and contingencies) of the physical development of the perimeter is $18.7 million including both foreign exchange and local currency costs. An inflation factor of 18 percent has been used or a total of $3.36 million; contingencies have been calculated at 12 percent on $2.24 million, for total of $5.6 million inflation and contingencies. Physical development including inflation and contingencies is then $24.3 million. Approximately 71 percent of the inflation and contingency figures are applied to foreign exchange. The total project costs are detailed in Table _____, "Summary Cost Estimate and Financial Plan."

Including the grant element and inflation and contingencies, the AID contribution will be $20.45 million dollars for foreign exchange costs and $4.65 million for local currency costs, or a total of $25.1 million. The Government of Senegal is expected to contribute $1.415 million in foreign exchange (primarily for farm equipment) and $6.885 equivalent for local currency costs. This latter figure includes a $1,000,000 re-evaluation on the 4,520 gross hectares of the project area. This figure is 10% for 10 years.

Though difficult to assign and somewhat arbitrary, Table _____ projects have the design team assign the investment to project outputs. As can be seen, the bulk of project inputs go for the development of the irrigation system(s)(output #2). The second largest contribution is to

increase the yields of the major crops to be grown. These are somewhat arbitrary in that the contribution going towards the construction of the irrigation system(s) cannot be divorced from that going towards increased yields. As well, the assignment of the Technical Assistance to the training farm and to increase yields is arbitrary. The training farm is to prepare farmers for irrigated agriculture which will provide a means for increasing crop yields.

TABLE _____

SUMMARY COST ESTIMATE AND FINANCIAL PLAN

(US$ 000)

Source =	AID		HOST COUNTRY		TOTAL
	FX	LC	FX	LC	
Use					
Flood Dikes	3,000	1,200		360	4,560
Pumping Plants	800	100		420	1,320
Irrigation Canals, Drainage & Roads	570			560	1,130
Sprinkler Equipment & Materials	1,350			70	1,420
Pumps, Engines & Drivers	1,960			60	2,020
Wells	1,250			500	1,750
Land Clearing & Leveling	2,920	1,700		560	5,180
Farm Facilities and Structures	450	400		470	1,320
Farm Equipment			1230	1,030	2,260
Land				1,000	1,000
Engineering	2,300				2,300
Hydro. Studies	100	500			600
Technical Assistance	1,555				1,555
Training Farm		390			390
Equipment and Supplies	195	360			555
Personnel				100	100
Inflation Factor	2,400		185	1,115	3,700
Contingencies	1,600			640	2,240
Total	20,450	4,650	1,415	6,885	33,400

SUMMARY COST ESTIMATE AND FINANCIAL PLAN

(US$ 000)

Source =	AID		HOST COUNTRY		TOTAL
	FX	LC	FX	LC	
Use					
Flood Dikes	3,000	1,200		360	4,560
Pumping Plants	800	100		420	1,320
Irrigation Canals, Drainage & Roads	570			560	1,130
Sprinkler Equipment & Materials	1,350			70	1,420
Pumps, Engines & Drivers	1,960			60	2,020
Wells	1,250			500	1,750
Land Clearing & Leveling	2,920	1,700		560	5,180
Farm Facilities and Structures	450	400		470	1,320
Farm Equipment			1230	1,030	2,260
Land				1,000	1,000
Engineering	2,300				2,300
Hydro. Studies	100	500			600
Technical Assistance	1,555				1,555
Training Farm		390			390
Equipment and Supplies	195	360			555
Personnel				100	100
Inflation Factor	2,400		185	1,115	3,700
Contingencies	1,600			640	2,240
Total	20,450	4,650	1,415	6,885	33,400

Table _____

Costing of Project Inputs/Outputs

($000)

Project Inputs	Project Outputs				Total
	#1	#4	#3	#4	
AID Appropriated					
1. TA & Training Farm	1825	---	---	675	2,500
2. Constr., Equipment, Mtl's.	---	15,140	---	4,500	19,700
3. Engineering	---	2,300	---	---	2,300
4. Hydro. Studies	---	---	600	---	600
Host Country					
1. Land	221	779	---	---	1,000
2. Personnel	25	---	---	75	100
3. Farm Equipt.	---	---	---	2,600	2,600
4. Constr. & Mat'ls.	---	3,970		630	4,600
Total	2,071	22,189	600	8,340	33,400

C. Social Analysis

1. Social and Ethnic Groups and Structures

The ethnic breakdown of the Fleuve Region of Senegal is estimated to be 54% Toucouleur, 16.5% Maure, 14% Peul, 10.5% Oulof, 4% Sarakole, 0.5% Bambara and .5% others. In contrast, the ethnic composition of the project (Matam) area is calculated to be 82.5% Toucouleur (including Fulbe), 10% Oulof, 1.5% Sarakole, 2.0% Maure, 1.5% Bambara and 2.5% others. From this breakdown, one can easily see the predominance of the Toucouleur in the region.

These ethnic divisions - - or horizontal diversity - - are accompanied by a vertical division of the population according to a hierarchical social structure that, in its general form, is shared by all groups. This vertical division is as follows:

1. Freeman (Rimbe), consisting of the Torobe (former Toucouleur ruling group or "nobles"), most of whom are agriculturalists, herders, or marabouts (religious leaders), the Tiado, or "warriors" who are mainly cultivators, the Thioubalo, or "fishermen" who engage in both fishing and farming.
2. The Artisans (Nyenbe) made up of many specialized castes such as the Baylo or blacksmiths, the Sakkeebee or leather workers and the Awlube, or griots; and
3. The Captives (Maccube), descendants of former prisoners of war and slaves.

The representative percentages of these groups in the general population are as follows:

Freeman:	Torobe - 45%
	Tiedo - 10%
	Thioubalo - 16%
Artisans:	Various castes - 7.5%
Captives:	Maccube - 21%

The proposed project area is bounded by Matam, Ouro Sogui and Boyenadji.. It includes villages which, while not lying immediately adjacent to its boundaries, have among their population people presently cultivating within the demarcated tract. By name, these villages are as follows:

Doulomadji Dambe	Ouro Sogui
Bokisaboudou	Thiankono Hiray
Nahalji	Ogo
Nourorbe	Galeyabe
Sinthioubal (Sinthioubara)	Hamarabe
Thioubalel	Matam
Mogo	Diamel
Boyenadji Rounde (Boyenadji)	Tiguere Yene
BoyenadjiSinthiou	Tiguere Soubalbe
Thiambe	Navel

These project villages represent mixed populations composed of farmers, artisans and captives. Villages differ, however, in the nature of the predominating group of Freemen. In larger communities (e.g., Matam or Sinthiou Bara), these distinctions exert their influence on the "quartier" (ward or district) level.

Basically, villages tend to conform to one of four possibilities:

1. Ethnically, heterogeneous clusters such as Matam and Ouro Sogui, representing all groups; (b) Douloumadji Dembe; Torobe, Thiedo and Fulbe.
2. Torobe dominated communities such as Boyenadji Rounde, Thiambe and Galeyabe.
3. Thioubalel (fishing) villages such as Thioubalel, Diammel, Navel and Tiguere Soubalel.
4. Fulbe (Peul) settlements such as Bokisaboudou, one "quartier" of Sinthioubara, Hamarabe and Tiguere Yene.

Present day Senegalese law does not recognize the social status divisions such as captive or slave. However, for project purposes, an awareness of them is necessary for at least two reasons. First of all, tradition and social status play an important role in the daily interaction of the population. When any attempt is made to create a new relation between parties, a high possibility of conflict exists. Past attempts at the development of projects have shown that caste differences have proven directly responsible for the failure of different groups to work successfully together. There is a real danger in attempting to organize single work units above the village level where caste differences are most clearly defined. While caste differences also exist within the village, everyone is already a member of the same functioning unit, and thereby have established ties that exert a calming influence on possible sources of discord. Organizing groups at this level to make competitive efforts in the development process will lessen this problem while at the same time increase the probable efficiency of each unit.

The second important reason for recognizing social and ethnic distinctions is the extent to which they are reflective of the economic situation and occupation of the individual concerned. For example, while not all Subalbe are fishermen, most fishermen are Subalbe. Likewise, it is the Artisan castes which actually do that sort of work. And, while all groups cultivate, the freemen (including fisherman) are better off so far as possessing decent oualo land (Hollaldé Soils), while the Maccube (captives) have the least. A delicate awareness of this fact is necessary for project design and implementation.

2. Secular and Religious Power and Influence

Since independence, the indisputed political power in the region has been vested in the representatives of governmental power: the Prefect, Chef d'Arrondisement, Responsable Politique and Chef de Village. On the village level, each family is led by its older male member (the "Galle Mawdo") who acts as its representative in village meetings at which decisions are made in association with the Chef de Village.

Alongside the secular authority, there exists those figures of religious authority. The religious devotion of the populace of the area cannot be overemphasized. It has been a traditional breeding ground of numerous expansive movements of Islam into other points of West Africa. Most people are members of the Tidjanis sect, but owe their allegiance to different marabouts both within their villages and throughout the region. It is necessary that the support of these religious leaders be solicited in the introduction of any proposed technological change. As highly respected members of the community, it is a simple fact that their words and opinions are sure to be carefully weighed. Furthermore, in terms of hard economic reality, a large percentage of surplus village funds is expended in the fulfillment of various religious activities especially the construction and improvement of village mosques.

3. The Religious Calendar and Work Productivity

The holidays celebrated by the people of the region, as Moslems, are those of the Islamic religion: Tabaski, when a ram is sacrificed by each family head in memory of Abraham substituting a lamb for his son in sacrifice; Korite, which celebrates the ending of the fasting month of Ramadan; Molukes, the birthday of the prophet Mohammed; and Haran, the night during which one's fate through the coming year is decided. Both Korite and Tabaski are official three day festivals of which the first day is the only one on which no work is ever done.

Of greater significance to questions of production is the fasting month of Ramadan during which one can neither eat, drink or even swallow his saliva from sunrise to sunset. This strenuous prohibition unquestionably takes its toll on the efficiency of any labor performed during this period of time. However, since it is calculated on a lunar calendar (approximately 33 lunar years for 34 Gregorian calendar years), it has a constantly changing moment of occurrence vis-a-vis the year's work schedule. Its effects and the advisable compensating actions must be calculated on a year by year basis.

4. The Land

Probably more than any other single factor, it is the land and its topography which has shaped the lifestyle and livelihood of the region.

The "Dieri" is the high inland grounds above the flood plain which is used for traditional rainfall millet agriculture. It has been estimated that approximately 75 percent of the population cultivates Dieri land, of which 45 percent also work the Oualo, while 30 percent work the Dieri only. The average Dieri holding is estimated at 1.26 hectares with a potential yield of anywhere from 350 to 1000 kilos per hectare, depending on the rain (although often only once out of every two years). Though the Dieri does play a significant role in the economy of the area, because it is seen as an infinite resource, available to any who want and are willing to travel to it and clear it, it has not played a particularly significant role in the social and political life of the region.

The same is true for the "Falo" and "Fondé" lands. The Falo (singular "Palle") are those areas along the banks of the river that are planted as the water level descends, with such crops as corn, potatoes, beans and tomatoes. The Fondé are those high areas that are watered only during years of very high flooding, at which time sorghum is planted. Both of these areas, because of the limited nature of their output, are relegated to secondary importance in terms of total agricultural production.

It is the "Oualo" (or "Walo") between the Falo and the Fondé and Dieri, that represents the most valuable and coveted land resources. Oualo refers to all the lands flooded when the river spills into banks during the rainy season. Since the land undulates, one finds basins of water called "collade" (singular: "collengal"), the soils of which are called "hollaldé". A differentiation is made between the "low hollaldé", which floods every year, the "mid-hollaldé", which floods during years of average river height, and the "high hollaldé", which is covered only at times of strong flood waters.

5. Land Tenure and Usufruct

Being a valuable but limited resource, it is around the Oualo lands, and especially the low Hollaldé (which can be depended on even in years of little rainfall, when the Dieri crop fails), that a complex traditional system of ownership and use evolved.

Prior to the colonial period, power over the land was divided between secular and religious authorities. These religious authorities were often recipients of the "Assakal", the 10% Moslem religious tithe that a man is supposed to give each year to the poor and needy. At other times, the Assakal was given to the Galle Mawdo, the head of the extended family, by each male who farmed family land. The Galle Mawdo would keep a part for himself and redistribute the rest for family purposes as he saw fit. Today the Assakal is a totally voluntary act and no longer of great import as regards the question of land tenure and use.

Land not belonging directly to the religious community was controlled by secular landlords referred to as "Djom Leydi's " (Djom"- proprietor; "Leydi" - earth). Having gained control through various means (original settler conquest or gift in return for services to the ruling authority), the Djom Leydi was free to cultivate it himself, or confide its use to another. He might give it to a family slave in return for his allgiance and a number of days' work a week on other family land, or loan it ("loubal") to an artisan in return for specific services rendered. Otherwise he could make one of several business arrangements with a third party, the land could be permanently sold to another for him and his heirs (pandougal"), or given for an indefinite period of time in return for an annual rent (("n'ouldi") paid before each season, plus symbolic payment ("tiotigu") given the heir, upon the death of the Djom Leydi, as acknowledgement of the heir's ultimate right over the land.

Several more temporary transfers of usufruct also existed. The "thiogu" was a lease of the land, usually for less than six years. On the higher hollalde, which does not flood every year, an arrangement was made whereby the lessee actually paid for a certain number of adequate floods, regardless of the number of intervening years ("joelande"). Finally, for those for whom even such payment was beyond their means, there existed either the "remetagiie", whereby in exchange for clearing overgrown land, free use of it was obtained or, most common of all the "remption", a form of simple share-cropping, in which the Djom Leydi received a fixed percentage of the total yield, depending on the productivity of the land parcel.

During colonial times, the French tribunals and codification of customary law actually served to reinforce this system. However, four years after independence a drastic change occurred with the passage of the "Law of National Domain." It is stated within that law that "those people personally occupying and exploiting the lands of the National Domain at the effective date of the present law will continue to so occupy and exploit them." The intent of the law was, and is, to create only a right of usufruct in the land. Thus, the Decree of Application states, "The conferring (of the land) is personally to the individual or group in question. It cannot be made the object of any transaction.

It is decreed for an indeterminate duration. It confers to the benefitting party a right of usage of the land in question."

In practice, the full intent of the law has never taken place. Rather, what happened with its promulgation was that the holdings of the ancient Djom Leydi were suddenly reduced to the fields actually cultivated by them or members of their families. At the same time, a new, greatly expanded number of small scale landholders -- now generally referred to as "Djom N'Gessa" (proprietors of the field) -- were created consisting of those persons who were actually working the land at the moment of the law's decree. Today, the older obligations such as the Nioldi and Tiotigo have virtually disappeared. Nor are the new, small scale Djom N'Gessa willing to create any new, long term arrangements with third parties for fear that these will later be used as the basis for a new claim on the land. Those Djom N'Gessa not cultivating the land themselves therefore either hire paid laborers to do so, or make only short term contracts for its use by a third party.

For project purposes, the traditional tenure system, despite its supposed demise with the passage of the "Loi sur le Domaine Nationale", exercises a present day influence which cannot be lightly dismissed. The traditional system has both engendered and reflected certain important attitudes towards land that continue to be held today. The idea that land is personal property and the individual has the right to obtain and exercise clearly definable rights to its use is strongly held. If a project design is imposed, wherein the land must be worked collectively, its produce divided equally and its actual use (i.e. crop) decided by another party, the feeling is that in reality the land belongs to the project and not the people. The people are therefore, considered project workers who should be salaried and not required to invest their own money into operational costs.

The question of who shall pay the initial costs and yearly operational expenses is an area of particular sensitivity, and great misunderstanding. Under the traditional system, a man using land not his own is most commonly paid only in relation to its successful use. Such an arrangement is not so much a question of custom as it is of reality. Most people, especially those who are

not landowners, do not possess large financial reserves that permit them to take a risk. This is especially true of one that may not pay off for several years. Concomitantly, labor is seen as an alternate form of investment.

These factors have had their due infleunce on the proposed project. It is the intent that the training farm will be used to not only introduce and prepare farmers for the new technology, but also to establish that what a farm family produces is for its use, i.e., subsistence and payment of inputs and costs. Cooperation, not collectivity, is the emphasis and a key to establishing this will be village participation on the training farm. This will bring the farmers into the planning and decision making, at the beginning.

The Agricultural Process

The basic unit of production is the nuclear married family -- husband, wife and unmarried children. Even if the unit lives in a larger family compound called the "galle", it largely operates apart, eating around its own hearth called the "foyre", and it is this name that is used to denote this primary functional group. Each foyre farms its land apart with minimal cooperation between members of the larger group. This is true whether or not the foyre cultivates land owned or rented by itself, or land technically belonging to the extended family, but temporarily given to a particular member for his use ("lowre").

The galle, through its elder the "galle mawdo", usually presents itself as a single entity vis-a-vis the outside world. Though this indicates that project participation might best be made through the galle, it is not ignored that little agricultural cooperation exists, even between married brothers, above the level of the foyré. In calculating farm budgets, numbers of workers, subsistence needs and ability to pay for inputs and costs, it is the standard of the foyre and not the galle that has been used. This is how the galle itself will allot whatever land it is given.

An idealized yearly agricultural calendar for the basic production unit would be as follows:

1. Dieri soils are planted during the month of June at the beginning of the rainy season. Weeding and hoeing of the crop takes place during August and September. The crop is guarded against pests during October and November while the crop is maturing. Harvest takes place during the latter half of November.

2. The Fondé soils are planted at the height of the floods near the the end of September or beginning of October. Weeding takes place during the latter part of October and November with guarding against pests in December and January. Harvest takes place in February.

3. As the flood waters of the River recede in mid-October and November, the Oualo soils are planted. Weeding is done from the end of November through mid-January. Guarding of crops against pests is through February, March and into April with harvest in April.

4. The calendar for the Falo soils has considerable variation depending on the crop and the level of the River. It can range anywhere between the end of September and mid-May.

It is the rains for the Dieri soils and the flood recession for the Oualo soils that determines the precise moment of planting. For the Oualo this can be as early as late August or as late as the end of October.

May through June is the only period of the year normally free of agricultural work. It is not, however, a time of complete leisure. There is, rather, a moment of almost frenzied activity in building and repairing houses, roofs, walls and fencing, all in anticipation of the coming rains. During all other months at least some member of the family is occupied in some work related to the crop.

ESTIMATED YEARLY AGRICULTURAL CALENDAR—MATAM

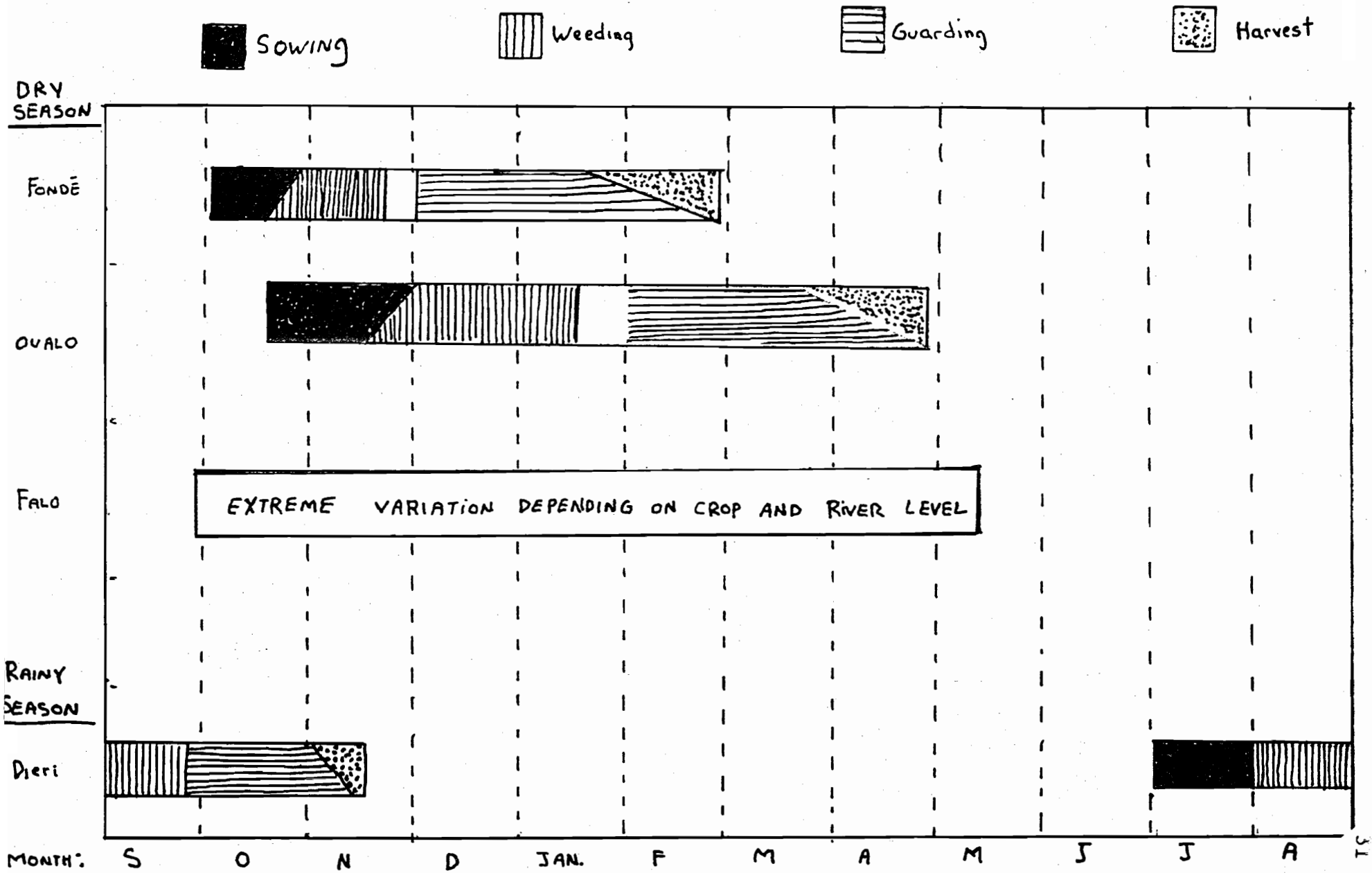


PLATE II

The technology used for farming both the Oualo and Dieri is fairly simple. Most people continue to use tools of local fabrication: a hand hoe ("jalo" or "daba"), a hole punching stick ("luugal"), a small and large axe ("jambaie" and "saccade"), a large hoe ("gendanku"), a knife ("labi"), and a sickle ("woofdu").

Work usually begins on the Oualo 15-20 days after the water has receded and the land is firm enough to walk on. The land is cleared of debris and plants and sorghum sowed. The process usually employs four people who walk in procession, one breaking the soil, one making a hole, a third dropping in the seed, and the fourth covering it with dirt. The area is then guarded for about two weeks to prevent birds and rats eating the seeds. Weeding then begins, virtually all done by men as it is generally considered the most physically demanding work. When the plants are sufficiently developed, the monotonous task of guarding against rats, birds and other pests begins. This is a task in which everyone participates. Finally the crop is harvested and transported to the village where it is stored on the stalk heads and not threshed until it is used for food.

The process for the Dieri involves a slight variation of technique and labor application. After clearing the land, it is usually planted by two people -- one breaking the soil and the other dropping the seed and covering it. There is little guarding of the seeds, but once the millet is 2 to 3 inches high, a more intense weeding occurs. This effect is carried out to cover the entire area at least twice and sometimes three times. This is then followed by weeks of guarding and finally the harvest, as for the Oualo.

With both the Oualo and Dieri, the process of weeding seems to be the most difficult and limiting factor as to the size of the productive land unit. An attempt is often made to obtain paid labor to help with the task. On Oualo land, the size of the year's flood and its pattern over a period of successive years is an important factor in the difficulty of the task. Not only the quantity, but the quality of weeds changes directly with the availability of water. Land that

has been adequately watered for 2-3 years in succession gives rise to weeds more difficult to pull than those that appear after several years of inadequate watering. The result is that the low hollalde soils are generally more difficult to cultivate than high hollalde soils. If given a choice, in years of high flood, people will desert the low areas for the higher ones.

Besides the constriction weeding exerts on both Oualo and Dieri farming, a second bottleneck exists due to the overlapping of the two as the sowing of the Oualo coincides with the harvesting of the Dieri. Ironically, this conflict is greatest in years of plentiful rain, since this is when the Dieri yields the most. At the same time, the largest percentage of usable Oualo is flooded. In good years, hectare for hectare, the Dieri is more productive and labor is diverted from Oualo land production to that of the Dieri harvest. Another important factor that then presents itself is the cold dry season wind that arrives in December and January. Sorghum on the Oualo must be sufficiently high by this time to prevent its destruction. Thus, even if adequately watered Oualo exists after a prolonged harvest on the Dieri, it may be too late, for all intents and purposes, to use it.

All of the above mentioned factors unite to produce a somewhat unexpected result -- namely that in any given year, and especially in years of plentiful rainfall, a good percentage of the Oualo, the scarcest and most coveted of land resources, is not put into total production. It is also indicative of the fact that while most of the year is devoted to some agricultural pursuit, it is during the months of August through December that available manpower is working at its peak, while from late January there is significant slack in the work schedule.

The consequences of the above outlined schedule on the proposed introduction of irrigated double cropping will depend on the operational phase of the project itself. As long as the project lands are not capable, for any reason, of supplying the full needs of those working them, a simultaneous attempt will be made to continue traditional practices to assure adequate subsistence.

Should the double cropping scheme prove, early on, sufficiently productive to justify a full time investment of labor by the cultivator, one can expect a corresponding drop in the production of millet from the Dieri due to a shortage of available manpower.

The Importance of Labor Migration

If agriculture is the economic root of the region, migratory labor provides it with its fruits. For the period July 1974 through June 1975, the Matam post office received approximately $2.7 million in postal money orders. Forty percent of this was from "regime exterior" -- France (approximately 32%), Congo and Gabon; thirty-one percent from "regime interior" -- Senegal, Niger, Dahomey, Upper Volta and Ivory Coast; and twenty-nine percent from "regime capteao" -- Mali and Mauritania. The general consensus of people is that an amount at least equal to that which arrives through the mail is presumably brought back by returning workers or their representatives. The general use of this money falls into three categories: 1) gifts to third parties, 2) investment in houses, averaging CFA 1-1.5 million each; 3) investment in cattle (average price CFA 40-60,000 per grown steer of 5-8 years).

The general orientation of outside observers is to look upon this phenomenon adversely, since it results in a depletion of the available labor force. This is especially true of those between the vigorous ages of 15-35. There is no doubt that this will have a negative effect on the ability of local communities to organize sufficient labor for difficult manual tasks, and is one important factor arguing for the incorporation of some mechanization into the project.

Basically, there are both economic and social reasons for this continual relocation. While many migrants have difficulty finding work, those who succeed are capable of earning between CFA 15,000 and CFA 30,000 in-country, and up to CFA 80,000-100,000 a month in France. Those are sums far in excess of that obtainable through agriculture in the immediate area -- even presuming the

adequate availability of land. The rigid social system and traditional culture further exascerbate the process by inducing the departure of many individuals who find themselves in disgrace, normally low in social status or who, as the result of some personal conflict, no longer feel secure staying in the region.

Recent tightening of regulations for emmigrating will probably have some small effect on the number of future migrants out of the area. Realistically, however, it seems dubious to rely on any great lessening of the process in the immediate future. Those leaving for social reasons are largely beyond the reach of subtle economic incentives, and those leaving for financial motives are lured by the prospects of gain substantially greater than any available for agricultural pursuits. What must be attempted is to demonstrate to the population the value of diverting some of the surplus funds from migratory labor, that are now expended on non-productive projects into investments in modern technologies to help compensate for existing defficiencies in human labor, and help resolve foreseeable task bottlenecks in the proposed double cropping irrigation scheme.

8. The Role of Women

Among the Toucouleur wholive in the Matam area, it is the nuclear family - the "foyré" - composed of husband, wife and children that constitutes the basic unit of agricultural production. As shown in Tables ____, _____ and _____, the largest portion of agricultural work is performed by adult males. This work is concentrated in those tasks requiring strenuous physical labor -- clearing, weeding and fencing. Women and children make most of their contribution by doing the simpler, more monotonous tasks such as guarding, and at times when more than one person is needed, such as seeding. It is estimated that an adult female will work nearly 91 days per year in farming and a female child 37.5 days. The smaller percentage of time women devote to agriculture is, however, more than offset by the household chores of cooking, fetching water, doing the laundry and caring for children. In all, the family must be viewed as a closely knit unit, all of whose members are mutually dependent and according to ability, mutually responsible for contributing to the general welfare.

In the traditional, very orthodox Moslem society of the Toucouleur, women have little or no direct role in the conduct of community affairs. The society as a whole has traditionally excluded them from such a role as well as the fact that a woman is traditionally subservient to her husband. Though one of the most consistent elements of traditional life is an endless pressure favoring a continuous distribution of wealth among all parties, it is the male head of household who, nevertheless, determines the disposition of gain from family land. Many women may supplement their income through market activities, by either selling products gathered or grown by themselves (e.g., vegetables and spices), or sharing in revenue obtained by their sale of goods originating from primarily male activities (e.g., fishing).

Though restricted by a traditional Moslem society, women can be owners in their own right, either through purchase or inheritance, of both animals and land. In fact, present instances actually exist of women possessing land, share-cropped for them by male cultivators.

It cannot, and will not, be claimed that the proposed project will have a measurable impact on the traditional role that women play in the orthodox Moslem society of the Toucouleur. The project does not address their fundamental subservient condition. There is, however, a question of whether or not the modernization of the traditional means of production will deprive them of the role they now possess in agriculture. This could occur with the introduction of irrigated agriculture.

It can be assumed that to the extent mechanization is introduced, it will be in the performance of difficult labor normally in the male domain. However, project planning calls for: 1) mechanization, limited only to the accomplishments of those tasks beyond the capacity of the local populace, and 2) that land be distributed to, and worked by, the single family unit. Under such circumstances, little disruption of already existing family interdependence could be expected, and concomitantly, the continual input of labor by all family members would be preserved.

What remains, however, is the problem of whether the proposed double cropping system will place new excessively increased demands on all parties. The predictable labor bottlenecks in the agricultural calendar have been examined and the need for the introduction of some means of mechanization indicated. Unfortunately, the ability of women to assume additional responsibilities is limited by the demands of household duties on their time. If there is an increased demand on women by the project, either due to an intensification of already assumed obligations, or the creation of new responsibilities, there will have to be an accompanying reduction in the time devoted to non-agricultural pursuits. The increased use of machine-

husked rice, instead of millet, is one factor that can have such a result and is a major reason it is favored by the female population. Project plans to include improvement of village water supplies will also provide another lessening of daily female labor.

One question, which only the future can answer, is whether substantial augmentation of family income will be distributed proportionally to the increased inputs of all parties, or whether it will be appropriated by the male household heads. No doubt practices will vary between families and will be beyond the control of the project itself. However, since the enthusiasm and cooperation of women will no doubt be closely tied to the benefits derived, it is not outside the realm of project concerns. To insure the creation of at least one positive gain for females, the proposed cropping pattern for the project reserves five percent of irrigated lands for the growing spices and vegetables. Women grow and harvest these crops for use in family cooking and to sell in the market. The cropping pattern will assure a ready supply for both auto-consumption and market sales. There is also a fairly extensive commerce in all food-stuffs within the local community which consumes a significant amount of any surplus that is produced. It is the woman who conducts the local commerce and her economic activity and benefits will be increased by the additional availabilities of crop surpluses produced by the project.

The influence of women on any advocated innovation cannot be discounted. This applies especially to any new crops introduced. Difficulties in the preparation and cooking of newly introduced food-stuff can result in rejection by females that the male household head is powerless to overcome. Project implementation will, therefore, make careful acknowledgement and consideration of any difficulties they encounter.

DIVISION OF OUALO WORK ACCORDING TO TASK AND TYPE OF WORKER
(DAYS WORKED PER HECTARE)

Type of Worker	Seeding	Clearing & Weeding	Guarding	Harvest	Transport of Harvest	Fencing	Total
Adult males (15 yrs+)	5.8	14.8	15.9	2.3	0.5	0.3	39.9
Adult females (15 yrs+)	3.2	-	13.0	0.9	0.7	-	17.8
Total Adults	9.0	14.8	28.9	3.2	1.2	0.3	57.4
Children male	1.4	5.6	10.3	0.5	-	-	17.8
Children female	0.7	-	8.6	1.0	-	-	10.3
Total Children	2.1	5.6	18.9	1.5	-	-	28.1
Total Workdays	11.1	20.1	47.8	4.7	1.2	0.3	85.5

PLATE III

DIVISION OF DIERI WORK ACCORDING TO TASK AND TYPE OF WORKER
(DAYS WORKED PER HECTARE)

Type of Worker	Seeding	Clearing & Weeding	Guarding	Harvest & Transport	Fencing	Total
Adult males (15 yrs+)	2.9	25.3	8.5	5.3	0.5	42.5
Adult females (15 yrs+)	1.0	2.3	6.7	6.3	-	16.3
Total Adults	3.9	27.6	15.2	11.6	0.5	58.8
Children male	0.3	4.3	4.1	0.8	-	9.5
Children female	0.1	-	0.9	1.1	-	2.1
Total Children	0.4	4.3	5.0	1.9	-	11.6
Total Workdays	4.3	31.9	20.2	13.5	0.5	70.4

PLATE IV

AVERAGE ESTIMATE NUMBER OF TOTAL AGRICULTURAL WORKDAYS PER YEAR ACCORDING TO TYPE OF FIELD AND WORKER

Type of Worker	Oualo	Dieri	Total
Adult male (15 yrs+)	127.7	87.1	214.8
Adult female (15 yrs+)	57.3	33.4	90.7
Children male	57.3	19.5	76.8
Children female	33.2	4.3	37.5

Based on average estimated area of land worker per family per year; 3.2 hectares, Oualo; 2.05 hectares Dieri.

PLATE V

Part 4. Implementation Arrangements

A. Analysis of the Recipient's and AID's Administrative Arrangements

1. S.A.E.D. and Project Management

For development of irrigation projects using the water of the Senegal River throughout the Region du Fleuve, the GOS Ministry of Rural Development created an automonous branch entitled La Societe pour l'Amenagement et l'Exploitation des Terres du Delta (S.A.E.D.). Established with its headquarters in St. Louis to concentrate initially on the delta area of the river, its mandate has now been expanded to include all lands on the flood plain of the Senegalese side of the river. Accordingly, it has moved up from the delta into the lower basin with the realization of the IBRD-financed irrigated perimeter at Dagana and the F.E.D. financed perimeter at Nianga. S.A.E.D. has also extablished pilot farms at the perimeters of Matam and Bakel.

S.A.E.D. has a highly competent professional staff which to date has undertaken the planning, development and operation of some 11,000 hectares of land. From an economic and managerial standpoint its accomplishments have been impressive. However, its experience has been somewhat limited to the large polder-type projects developed on the sparsely settled lands of the delta region. Here the heavier clay soils have required a rather high degree of mechanization, and the organization and operation of these large perimeters have been largely dictated by engineering and economic factors. The nature of management and crop patterns on these tracks has largely precluded the farmers working on them from participating in organizational and operational decisions. SAED will be responsible for the development of the Matam Perimeter, and recognizing that this

undertaking will be in the population center of the upper valley, it also recognizes that its strategy to date must be revised radically.

The GOS has undertaken extensive studies of the staff requirements and projected role of SAED with a view to restructuring and decentralizing this organization. The most comprehensive of these studies has just been completed, and should serve as the basis for multidonor assistance in this task. The IBRD, FAC and USAID are now reviewing this latest study, and plan to jointly implement its recommendations. ADO/DAKAR has earmarked $4,000,000 for this undertaking beginning in FY '78. An AID/IBRD appraisal team will undertake the design of SAED's immediate and long-term training requirements in October 1976. The reorganization of SAED and initiation of these training programs for its personnel will preceed the development of the first 500 hectares at Matam.

S.A.E.D. has maintained offices and an equipment depot at Matam ever since undertaking the development of some 80 hectares of pilot farms adjacent to the river and the Diammel marigot. These facilities will be relocated on the pilot farm and expanded as the perimeter develops. The equipment depot in particular will be developed to service and maintain all pumps and mechanized equipment, keeping a prescribed number of pumps in reserve at all times for immediate installation should there be any failures at a critical time during irrigation of crops. Establishment of this equipment depot will be through a joint-funded technical assistance contract which will provide for the training of all required counterpart personnel.

The nature of this irrigated perimeter at Matam makes for a totally different type of management than SAED has exercised in the past. The developed portion of this perimeter is to be subdivided

into plots around individual pumped wells according to soil classification and irrigation system. These plots will range from 25 ha. to 68 ha., with individual farm families on each working 2 ha. holdings. These families will operate and maintain their wells, pumps, tractors and threshers by cooperative groupings on each plot serviced by a single well. Each of these cooperative groups of from 12 to 34 families will make the basic decisions regarding its parcel of land. Each cooperative group will be responsible for its selection of crops, and for the sowing, cultivation, irrigation and harvesting of same.

The pumped well irrigation at Matam, with relatively small sub-perimeters operating on a basin-flood, surface, and sprinkler irrigation systems independent of one another, allows for a much greater degree of automony to be vested in farmer cooperatives. This is in contrast to the large polder projects characteristic of this river development to date, where large pumps, working with primary and secondary irrigation canals for the whole perimeter, required that most operations be done in unison under central direction. Also at Matam, there will be a much higher proportion of lighter soils relative to total development, which with the different irrigation systems employed, permit a much wider selection of staple cash crops by individual farmers. The mechanization required to work the proposed 2 ha. family holdings is essentially a function of time constraints between the harvesting of the summer crops in November and the preparation of land for planting in December. Each of the 45 > 60 hp wheel tractors and the attachments will be operated and maintained by the cooperative groups of farmers (1 tractor per 37 ha of hollaldé soil and 1 tractor per 60 ha of fondé soil).

The foregoing patterning of what is essentially a conglomerate of small, individually irrigated perimeters, each being run by its own farmer cooperative, dictates that a wholly new system of project operation be devised with managerial and operational responsibilities being shared between SAED and representatives of these cooperative groups. The nature of this perimeter's operation and the variety of scope it will provide also bodes for a much greater degree of automony being vested in those responsible at the project site. Authority to be delegated would include all decisions regarding crops, equipment, logistics and marketing which have heretofore been dispersed among several GOS organizations, e.g., SAED, ONCAD, SODEVA.

All of these factors can be taken into account in the reorganization of SAED now being considered. While Matam at this time presents a radically new design in irrigated perimeters on the Senegal River, it is probably a forerunner of the type of irrigation system which can be extended throughout the valley and upper basin regions of this river. SAED's operations in these portions of the Region du Fleuve will have to be tailored accordingly to take into account the hydrological, agronomic and sociological factors which distinguish introduction of modern irrigation techniques here from those in the delta.

Project Design Summary
Logical Framework

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: To enable Senegal to become self-sufficient in cereals food production through: 1. developing the resources of the Senegal River Basin. 2. reducing to a minimum the constraints of water availability on the economic development of the riverain region.	**Measures of Goal Achievement:** 1. The production of staple food crops obviates the need for imports or is in excess of needs. 2. All program projects are in place. 3. All projects in the Fleuve Region are having a favorable economic return.	1. Food crop production statistics in the Senegal River Basin. 2. GOS statistics on food imports. 3. SAED, USAID, other GOS and donor reports.	**Assumptions for Achieving Goal Targets:** 1. Donors continue to be willing to contribute to the development of the Senetal River Basin. 2. Sufficient ground water and surface water will be available at reasonable cost. 3. SAED has capabilities to manage expanded project development.
Project Purpose: 1. Develop one section of the potential irrigated agricultural lands through the establishment of a perimeter consisting of sprinkler, surface and flood irrigation systems. 2. Demonstrate the feasibility of groundwater irrigation. 3. Introduce changes in agricultural production practices. 4. Produce enough food grains for project beneficiaries' subsistence and to provide an incentive for risking a change in farming methods.	**End of Project Status:** 1. A perimeter of 3,875 hectares constructed and operating with flood, surface and sprinkler irrigation systems. 2. Wells drilled and constructed to provide water. 3. Area farm families accepting changes and working the irrigated lands. 4. Average per hectare yields of food crops sufficient to provide subsistence and necessary incentives.	1. End of project evaluation. 2. Statistics from hydrogeological studies/surveys. 3. Surveys on farmer acceptance of irrigation practices. 4. Statistical surveys on food production and marketing.	**Assumptions for Achieving Purposes:** 1. Farmers willing to risk making necessary changes in agricultural practices. 2. Interventions proposed will in fact be able to provide subsistence and incentives. 3. Needed agricultural inputs will be available to farmers on a timely basis at reasonable cost.
Outputs 1. Training farm established (ha.) 2. Irrigation system installed: a--wells constructed (no.) and operating b--land prepared for irrigated agriculture (ha.) c--pumping stations installed and operating (no.) d--water distribution system for 3,875 hectares in place (% completed) and operating e--dike construction (% completed) 3. Hydrogeologic studies (% completed) 4. Increased per hectare yields of crops.	**Magnitude of Outputs** FY 77 / FY 78 / FY 79 / FY 80 / FY 81 / FY 82 1. 100 / - / - / - / - / - 2. a. 3 / 6 / 24 / 52 / 81 / - b. - / 100 / 850 / 1850 / 2,850 / - c. - / 1 / 1 / 1 / - / - d. - / / / / / - e. - / 25 / 75 / - / - / - 3. 100 / - / - / - / - / - 4. Wheat 4 mt/ha Rice 4 m5/ha Corn 5 mt/ha Cowpeas 2 mt/ha Sorghum 4 m5/ha	1. SAED and/or contractors' progress reports. 2. Physical inspection (USAID).	**Assumptions for achieving outputs:** 1. Timely construction and effective SAED/contractor performance. 2. Timely delivery of inputs. 3. Experienced TA personnel and qualified counterparts available.
Inputs: **USAID Contribution:** $25.1 million 1. Technical assistance and Training Farm($2.5 mill) 2. Construction, equipment and materials ($19.7 mill) 3. Engineering, design and construction supervision ($2.3 million) 4. Hydrogeological studies ($0.6 million) **GOS Contribution:** $8.3 million 1. Land ($1.0 million) 2. Personnel ($100,000) 3. Farm Equipment ($2.6 million) 4. Construction, equipment and materials ($4.6 mill) **Total Project Cost:** $33.4 million	**Implementation Target: ($000)** FY 77 / FY 78 / FY 79 / FY 80 / FY 81 / FY 82 USAID 1. $1700 / 400 / 400 / - / - / - 2. 330 / 520 / 11,830 / 2,900 / 3,120 / 3,875 3. 900 / 350 / 350 / 350 / 350 / - 4. 600 / - / - / - / - / - GOS 1. $1000 / - / - / - / - / - 2. 10 / 20 / 20 / 20 / 20 / 10 3. - / 190 / 490 / 580 / 670 / 670 4. 122 / 609 / 1,549 / 1220 / 550 / 550 Totals 4,662 / 2089 / 14,639 / 6,070 / 4,710 / 1,230	1. GOS budgets and reports. 2. USAID reports. 3. On-site inspections (USAID).	**Assumptions for providing inputs:** 1. GOS and AID timely allocation of funds. 2. The traditional land tenure system and the "Law of National Domain" can be made to work compatibly.