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Report No. 29-SE

SENEGAL

APPRAISAL REPORT OF THE

SENEGAL RIVER POLDERS PROJECT

November 29, 1972

CURRENCY EQUIVALENT

Currency Unit	=	CFAF Franc
1 US$	=	CFAF 255.79
100 CFAF		US$0.39

WEIGHTS AND MEASURES

1 Ha	=	2.47 acres
1 Km	=	0.62 mile
1 Ton	=	2,204 pounds

ABBREVIATIONS

BNDS	-	Banque Nationale de Developpement au Senegal
FAC	-	Fonds d'Aide et de Cooperation
IRAT	-	Institut de Recherches Agronomiques Tropicales
IGN	-	Institut Geographque National
MDR	-	Ministere du Developpement Rural
OMVS	-	Organisation de Mise en Valeur du Fleuve Senegal
ONCAD		Office National de Cooperation et D'assistance pour le Developpement
PWD	-	Public Works Department
SAED	-	Societe D'amenagement et D'exploitation des Terres du Delta
SATEC	-	Societe d'Aide Technique et de Cooperation
SCET	-	Societe Centrale pour L'equippement du Territoire
SOCAS	-	Societe de Conserves Alimentaires au Senegal
SDRS	-	Societe pour le Developpement Rizicole du Senegal

CONVERSION RATIOS

Paddy to milled Rice = 65%

FISCAL YEAR

October 1 - - September 30

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SUMMARY AND CONCLUSIONS

i. The cost of food imports is rising steadily in Senegal despite 70% of the working population being employed in the rural sector. The principal food import is rice, and imports of this commodity in 1971 cost US$22 million and accounted for 10% of all imports. It is Government policy to stimulate domestic rice production, both rainfed rice in the south and irrigated rice where this is possible. The Senegal River offers substantial scope for irrigation and it is estimated that a potential 50,000 ha could be irrigated with its waters. Irrigated development is given high priority by Government, although the area now irrigated is very small. A cycle of poor growing seasons due to drought has reinforced this policy but, due to lack of skills and the high cost of irrigation works, expansion of the area under irrigation will be slow.

ii. The project would improve and expand irrigation in the Delta and lower Valley of the Senegal River, and produce rice and other crops for import substitution. The project consists of improving water control for a single rice crop in two existing polder areas, and developing a new polder with full water control permitting double-cropping of rice and a range of crops including other cereals, tomatoes, potatoes and onions. The project would result in a net increase of 3,000 ha of cultivated land, and provide a better livelihood for some 1,700 farm families comprising about 10,000 people in all. The project would include strengthening extension services and other support services for participating farmers; establishing a training center and an applied research center in the project area; and procuring farm machinery. The project is based on experience gained from rice development schemes in the Senegal Delta financed jointly by the French Fonds d'Aide et de Cooperation (FAC) and Government, and studies and research carried out by UNDP/FAO since 1965. The project would be the fourth Bank Group operation in the agricultural sector in Senegal, and the second aimed at increasing Senegal's rice production. Two of the three ongoing projects are proceeding satisfactorily. The third has experienced problems but these have been largely overcome.

iii. The project would be carried out by Societe d'Amenagement et d' Exploitation des Terres du Delta (SAED), an autonomous agency responsible to the Ministry of Rural Development. SAED is charged with development of the Delta area, through constructing and maintaining water control works, and providing extension, land cultivation, credit and marketing services, and rice processing facilities. In carrying out its technical and agricultural program SAED has been assisted since 1967 by Societe d'Aide Technique et de Cooperation (SATEC) and Societe Centrale pour l'Equipement du Territoire (SCET-International). SAED supervises some 9,500 ha of irrigated land and has developed and operates several pumping stations, and a rice mill with a capacity of 19,000 tons paddy per annum.

iv. Project costs are estimated at US$7.4 million, with a foreign exchange component of US$3.0 million. About 80% of total costs would be for irrigation development and 10% for extension services. An IDA credit of US$4.5 million is proposed which would finance about 60% of project costs. Government would contribute the remaining project costs, US$2.9 million, from budget allocations. Farmers would pay fees for using project developed land which would permit Government to recover, over the 35-year life of the project, all operation and maintenance costs plus project investment costs.

v. Contracts for major irrigation and drainage works (about US$5.0 million) and the procurement of farm machinery and water pumping and land preparation equipment (about US$0.9 million) would be let through international competitive bidding following the Bank guidelines. Vehicles, furniture, training and research equipment (about US$100,000) would be procured under local competitive bidding. Buildings and houses (costing about US$250,000) would be built by local contractors after competitive bidding.

vi. The project would generate import savings of about US$1.2 million a year at maturity, mainly from replacing imports of rice and tomato paste. The economic rate of return from investment in the project is estimated at 14%; 17 and 19% for the existing polders to be improved under the project, and 14% for the new polder.

vii. Per capita incomes of the some 10,000 people comprising participating farm families are expected to increase to CFAF 20,000 for those farmers in existing polders, and to CFAF 30,000 for those who would take up land in the new polder. Studies indicate a current average income of about CFAF 8,000 for rural people in the project area; this is about one-third of the national rural average which is estimated at about CFAF 25,000; consequently the project would benefit a particularly poor segment of the population.

viii. The project is suitable for an IDA credit of US$4.5 million to the Republic of Senegal.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

I. INTRODUCTION

1.01 In 1971 Senegal asked IDA to help finance further irrigation development in the Delta of the Senegal River. Senegal's rice imports are increasing steadily, and to save foreign exchange Government is giving high priority to domestic production of rice and other import substitution crops. Since 1965, it has been demonstrated that rice and a range of other crops can be grown successfully on a commercial scale in the Delta under irrigation. The proposed project would comprise improvement of water control on 2,100 ha within two existing irrigated areas; development of a new irrigated area of 2,700 ha for double-cropping; provision of extension services to farmers in the three areas; and establishment of training and applied research centers. Principal project crops would be rice and tomatoes; subsidiary crops would include potatoes, onions, vegetables and cereals. The project was identified by a FAO/IBRD Cooperative Program (CP) mission in June 1969, and subsequently prepared by French consultants, Societe Centrale pour l' Equipement du Territoire (SCET - International), with the assistance of CP and the Bank's Permanent Mission in West Africa (PMWA). This report is based on the findings of an appraisal mission during March/April 1972, composed of Messrs. K. H. S. Haasjes and J. Tillier (Bank), and F. L. Hotes (Consultant). The mission was assisted in Senegal by Mr. M. Palein of PMWA.

1.02 The project would be the fourth Bank Group agricultural operation in Senegal. In 1969, a US$6.0 million IDA credit and a US$3.5 million Bank loan were approved to help finance a groundnut and millet improvement program. Initially this project suffered numerous problems but remedial measures taken by Government in 1971 solved many of these. Some organizational problems are outstanding but it is expected that these will be resolved by the end of 1972. In 1971, IDA credits of US$1.25 million for a small settlement project (Terres Neuves Project) and of US$3.7 million for the development of rainfed rice in the south (Casamance Rice Project) were approved. Both projects have made promising starts.

II. BACKGROUND

General

2.01 Senegal has a land area of 197,000 km^2 and a population of about 4.1 million, estimated to be increasing by about 2.2% annually. Population increase ranges up to 6% in the larger towns reflecting internal migration. Population density ranges from 130 per km^2 in parts of the "groundnut basin" in the west, to zero in some areas of the east.

2.02 Topography is flat, and vegetation ranges from heavy forest in the south to desert in the north with a corresponding annual rainfall range of 1,500 to 300 mm. Wet and dry seasons are very pronounced, and droughts, which tend to occur in a cyclical pattern, are frequent and more severe in the north. Soils are mostly light and about 15% of total land area is cultivated.

2.03 In 1971 GDP was estimated at US$937 million or about US$234 (CFAF 60,000) per capita at the then prevailing exchange rates. With manufacturing and construction contributing about 13% of GDP, Senegal has a relatively advanced industrial sector compared to other West African countries. Unfortunately, further industrialization is restricted by limited local markets and relatively high costs. Mining although growing rapidly is still insignificant; oil prospecting is being carried out. Development of Senegal's economic potential depends basically on the rural sector, agriculture, livestock, fisheries, and forestry.

Agricultural Sector

2.04 Agriculture plays the central role in Senegal's economic life. About 70 percent of the labor force is engaged in rural activities and, although this sector accounts for only 30 to 35 percent of GDP (at factor costs), its leverage on the economy is considerable through its impact on exports and the size of the domestic demand for locally-produced goods and services. The sector is not well developed and within it incomes are low, averaging about CFAF 25,000 per capita in 1971. The sector, and the economy, as a whole, is overly dependent on groundnuts, the principal cash crop; thus, in 1971 when all exports were valued at CFAF 40.7 billion the value of groundnut produce exports was CFAF 12.4 billion or 30%. This strong dependence on groundnuts makes Senegal's foreign exchange earnings most susceptible to unforseeable climatic and world market price fluctuations. The principal food crops are millet and sorghum, the only rainfed cereals that can be grown satisfactorily over most of the country which is typified by generally poor climatic and soil conditions. Government's strategy for developing the sector consists principally of increasing productivity in the heavily populated "groundnut basin"; opening up the undeveloped but better watered east and southeast for settlement; diversifying production both for export and import substitution - while scope for the former is not large several opportunities exist for import substitution and among these most important is rice- and making a modest start in irrigation. In time an irrigated sector must develop in Senegal to meet its needs of agricultural commodities that cannot be grown under Senegal's erratic rainfall conditions. A prerequisite for the development of an irrigation sector is the development of experience and skills; the development of these would be one of the objectives of the proposed project.

Rice Production and Consumption

2.05 Rice is the most popular food grain after millet, but the gap between domestic production and demand is high and filled by imports. Annual production is 62,000 tons of milled rice. Rice imports in 1971 amounted to 208,000 tons (US$22 million) and accounted for 10% of total imports. Rice consumption is estimated to increase from 260,000 tons in 1971

to about 350,000 tons by 1978. Local production cannot be increased rapidly enough to meet this demand and Government aims at stabilizing imports at about 175,000 tons annually and growing the balance domestically. Part of the required domestic production will come from ongoing projects which are expected to increase national production to 150,000 tons by 1978; the remainder can come only from new projects.

2.06 About 80% of Senegal's rice is grown in the Casamance region of southern Senegal, primarily under rainfed conditions. Most of the balance is grown under irrigation in the Delta. Although Casamance is the major producer, it remains a net importer of rice. Several projects have been initiated in Casamance to increase production and include schemes financed by FED, the Republic of China and the Netherlands as well as the IDA project referred to in para 1.03.

Other Imported Food Items

2.07 Other substitutable food imports include tomato paste, of which about 8,000 tons valued at US$2.5 million are imported annually; potatoes, 10,000 tons valued at US$0.98 million; and onions, 7,000 tons valued at US$0.9 million.

Institutions

2.08 While Government activity in the agricultural sector is extensive, results are very variable. Responsibility for sector development rests with the Ministry of Rural Development (MDR), but numerous semi-autonomous government agencies have been created to sponsor the production of specific crops or to provide support services for agriculture in specific areas. MDR control over these agencies is tenuous; many are poorly organized and their operations expensive. The indifferent performance of many of the agencies, coupled with ill-planned Government price policies, has eroded farmer confidence in many Government programs.

2.09 Of five agencies working with rice only two of importance work in the Senegal Delta and one of these, Societe pour le Developpement Rizicole du Senegal (SDRS), is being wound up. From 1945 until 1971 SDRS managed the 5,000 ha Richard Toll polder in the Delta and produced rice on an estate basis; the estate is being converted to sugar production and the production of some 8,000 tons of rice annually will be lost. The second agency, Societe d'Amenagement et d'Exploitation des Terres du Delta (SAED) is efficient and since 1965 has developed some 10,000 ha of irrigated land for smallholder rice production in the Delta.

2.10 Research on rice and other crops is carried out by Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres (IRAT), a French research institute, whose operations in Senegal are financed jointly by Senegal and France. IRAT's main station is at Bambey in the "groundnut basin"; rice research is carried out at its Richard Toll substation, and work on other cereals, pastures and legumes is carried out in the Senegal Valley.

III. THE PROJECT AREA

General

3.01 The project would be carried out in the Delta and lower Valley of the Senegal River. These areas are described in some detail in Annex 1. Extending to some 1,200 km^2, the area is triangular; its base is the 125 km of highway between the regional capital, Saint-Louis, and the Dagana polder to be constructed under the project; its apex is the Debi polder which would be improved under the project; and its western and eastern sides the great loop of the main stream of the Senegal River. The Lampsar polder also to be improved under the project is about 20 km east of Saint-Louis, see map 3984.

Topography

3.02 Topography is characterized by the Senegal's many branches, some active and others extinct. Over time the branches have developed broad banks or levees which are slightly higher than the surrounding land. Typically, the Delta's topography is composed of the raised river banks, and the depressions (cuvettes) in between. The area's villages are located on the levees which are also used for rainfed cropping. The cuvettes are flooded by the Senegal in the wet season and are used for rice production where their soils are not saline. Over the last decade Government has regulated the flooding of about 10,000 ha of cuvettes by constructing water control structures. This is in addition to the 5,000 ha at Richard Toll which were developed in the late 1940's. Generally this work has been simple empoldering through constructing dikes with flow regulators. The exception is Richard Toll which is developed for year-round irrigation. Roads built on the dike crests provide the Delta's secondary road network.

Climate and Soils

3.03 The Delta has a single rainy season, July through September. Annual rainfall averages 310 mm. Temperatures are highest March through July with an average maximum in May of 40°C. Lowest temperatures occur in January with an average minimum of 14°C. Cuvette soils have a high clay content and are extremely hard when dry. The levee soils have lower clay contents and, while easier to work, are prone to erosion. In the Delta proper many of the cuvette soils are too saline for use.

Population and Land Tenure

3.04 Population is about 110,000 people of whom about 80,000 live in Saint-Louis. About 30,000 rural people live in 30 principal villages where many combine fishing and farming. There is no firm data on rural incomes but it would appear that they are considerably lower than the national rural average and amount to about CFAF 8,000 per capita or only one-third of the national rural average. Ethnically these people are mixed and comprise five major tribal groups. The rural family averages about 6 persons of whom 3.5

are active workers. There is no shortage of land and no system of individual land ownership. Farmers are granted the right of usufruct by the village authorities. Agencies such as SAED can take over land in the public interest without compensation (zone pionniere). The three sub-project areas have been so classified.

Communications

3.05 Communications are good. Saint-Louis is connected to Dakar, the capital, by about 250 km of modern paved highway and by railroad. From Saint-Louis another excellent paved highway extends eastward to Matam, 400 km inland on the Senegal River, and serves the important centers of Lampsar, Ross-Bethio and Richard Toll in the Delta, and Dagana in the Valley. From this highway secondary all-weather roads, most on dike crests, serve all populated points within the Delta including Debi. Maintenance of the paved highways is carried out by the Public Works Department (PWD) and is good. Secondary roads and dikes are maintained by Societe d'Amenagement et d'Exploitation du Delta (SAED) with its own funds and those which it receives from PWD for maintenance of the main Senegal River dike, see para 3.08.

3.06 There is an airport at Saint-Louis, and during the flood season river transport carries freight and passengers as far upstream as Podor, 260 km inland, but such traffic is minor. Saint-Louis is connected to Dakar, Ross-Bethio, Richard Toll and Dagana by telephone, and SAED has its own radio-telephone network, which services its mobile units throughout the Delta.

Farming Systems

3.07 Traditional. Traditional agriculture is governed by the rainy and river flood seasons which begin in June-July. At that time rainfed crops such as millet, maize, vegetables and cowpeas are planted on the river banks. Later as the flood recedes the same crops are planted lower down the banks and their growth is sustained by moisture retained by the soil. In those cuvettes which are not saline some rice is grown; floating varieties are mainly used and consequently yields are low and variable.

3.08 Improved. The Delta's agricultural potential can be developed only through investment in flood control, irrigation and drainage. After construction of the first phase of the Richard Toll polder, little further development occurred until the construction in 1964/65 of an 84-km dike along the south bank of the main stream of the Senegal River to protect some 120,000 ha of land from flooding, see map 3984. SAED was established to develop land within this dike and to date has developed 9,200 ha in nine separate polders, ranging from 400 to 3,100 ha in size, in which small farmers produce one crop of rice a year. Until 1969 the polders operated on the simple principle that as the Senegal flood rose in July/August water was allowed into the polders, and as the flood fell, water was drained out. No provision is made for land levelling within the polders or for internal water control; consequently depths of flooding and rice yields are extremely variable. A further problem is that the duration of the flood at levels permitting gravity irrigation is relatively short and if floods are delayed or ended early, as is the case to some extent

in about 50% of the seasons, yields are seriously reduced. In 1969 SAED installed three pumping stations to allow pre-irrigation on some 8,750 ha of its polders in advance of the flood crest. Through permitting earlier cultivation of the land and the more timely sowing of rice significant yield improvements have occurred. For example, in the dry year of 1968 a complete crop failure occurred while in 1970, another dry year, production exceeded 10,000 tons of paddy.

3.09 For the future SAED plans polder development in three phases. Phase 1 is empoldering and supplemental pump irrigation; the stage now reached on 8,600 ha. Phase 2 is such bunding and water control as is required to limit maximum rice submergence to between 20 and 50 cm; the Lampsar and Debi polders would be improved to this second stage under the project. Phase 3 is the introduction of full water control within the polder by the construction of internal drainage and irrigation networks. The Dagana polder would be constructed to this standard.

3.10 A feature of the Senegal is that the Atlantic influences river levels more than 260 km inland, and river salinity for more than 200 km. At Dagana salinity is not a serious problem, and double cropping will be possible, see para 4.02. Downstream, however, the period of excessive salinity increases rapidly and double cropping at Debi and Lampsar is impractical except through constructing a major barrage downstream of these polders. The feasibility of such a barrage is under study, as are other projects designed to develop the potential of the Senegal River, see Annex 1.

3.11 On existing SAED schemes farmers are allocated 1 to 2.4 ha each which they plant with rice. Farmers are drawn from nearby villages and the polder land is in addition to their traditional farming operations. In SAED's South Kassak polder a farmers' cooperative grows tomatoes for canning.

3.12 SAED provides support services to its rice farmers, including extension, credit, supplies of fertilizer and seed, transport, machinery hire, processing and marketing. Also, and in collaboration with Societe de Conserves Alimentaires au Senegal (SOCAS), a private company growing (150 ha) and canning tomatoes, SAED provides similar services to tomato growers. Services provided by the machinery-hire pool generally are limited to land preparation and threshing. Farmers are organized in cooperatives or small mutual guarantee groups of 10-15 farmers, the latter have proved more successful than the larger cooperatives.

3.13 Seed, fertilizer and other inputs and services are supplied to farmers by SAED and repayments are deducted from the proceeds of sales of rice and tomatoes to SAED and SOCAS to which participating farmers must sell their crops. These advances are for less than six months duration, and repayments include a 15% provision for SAED overheads.

International Water Agreement:Organisation pour la Mise en Valeur du Fleuve Senegal

3.14 The Senegal River is international, 1,800 km in length, and originates at the headwaters of its tributary, the Bafing, in the high rainfall area of the Massif du Foota Djalon in northern Guinea. The Senegal River proper begins at Bafoulabe in Mali, thereafter it flows through Mali. From its departure from Mali upstream of Bakel in Senegal, the River marks the international frontier between Senegal and Mauritania throughout practically all of the remainder of its route. In 1972 Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS) was established with Mali, Mauritania and Senegal as members. The objective of OMVS is to study and plan the most efficient use of the Senegal for power generation, navigation and irrigation. The institution of any major works affecting the river requires the mutual agreement of the three members. Such agreement has been obtained.

IV. THE PROJECT

Description

4.01 The project would be carried out in the four years 1973-1976 and would be managed by Societe d'Amenagement et d'Exploitation des Terres du Delta (SAED) (see Chapter VI). Three subprojects would be the principal components of the project and would result in a net increase in irrigated land of about 3,050 ha and the improvement of another 1,780 ha. The subprojects would be:

(a) constructing a new irrigation scheme at Dagana permitting the year-round cultivation of 2,730 ha;

(b) improving water control in the Debi cuvette and increasing the area irrigated from 260 ha to 1,025 ha; and

(c) improving water control in the seven cuvettes forming the Lampsar subproject and increasing the area irrigated from 880 ha to 1,080 ha.

Complementary project activities would be:

(d) strengthening SAED with staff, facilities and equipment both to carry out the project and to provide support for farmers who would use land developed under the project;

(e) constructing, equipping and staffing a training center at Dagana for SAED staff and for farmers;

(f) carrying out, through collaboration with IRAT, a program of applied research to support agricultural operations at Dagana; and

(g) expanding the SAED farm machinery pool to permit the provision of land preparation services to farmers using land developed under the project.

Detailed Features

4.02 Dagana. This subproject alone would be developed for year-round cropping and provide for full water control. The Dagana site extends to a gross area of 5,000 ha within a large bend of the Senegal River from which it is separated by a relatively high river bank. The southern boundary is the low plateau carrying the main highway from Saint-Louis to Dagana. Some 600 ha are now cropped, and under the project about 3,500 ha would be developed to give a net irrigable area of 2,700 ha, 70% of which would be double-cropped; about 1,400 ha with rice and 1,300 ha with other crops. Major works would include construction of about 19 km of perimeter dike, installation of separate irrigation and drainage systems, construction of three low lift pumping stations, a reservoir for storing either irrigation or drainage water to reduce pumping capacity, and necessary land clearing and preparation. Further details are at Annex 2. Costs per irrigable ha are estimated at CFAF 311,000 (US$1,215) free of identifiable taxes. This cost is on the high side and is accounted for principally by first, a lack of competition between civil works contractors in Senegal which has resulted in the high unit costs which have been employed in appraisal; and second, employment of a substantial degree of automation for hydraulic equipment to compensate for the lack of experience on the part of both farmers and SAED employees in irrigation water management. In short, the high costs reflect the absence of a significant irrigation sector in Senegal; it is hoped, however, that international competitive bidding will reduce these high costs to some extent.

4.03 Debi. This cuvette is protected against flooding by the Senegal perimeter dike. Surface area is about 1,500 ha, and currently a single crop of rice is grown on about 260 ha. Yields are low due to lack of means of controlling submergence depths within reasonable limits. Irrigation water is both supplied and drained off by gravity through a dual function structure in the perimeter dike. Proposed project works would control submergence depths on 1,025 ha to within a range of 20 cm-50 cm, and permit cultivation of a single high yielding rice crop each year. Major works would include the construction of dikes, dual purpose irrigation and drainage canals, a pumping station, and ancillary hydraulic structures. Annex 3 contains details of the existing situation at Debi and of proposed project works. The capital costs of improvement and development works over the 1,025 ha are estimated at an average of CFAF 74,000 (US$290)/ha free of identifiable taxes.

4.04 Lampsar. This subproject would encompass seven small cuvettes totalling 2,000 ha in extent. About 800 ha are now cropped with rice, but for the same reasons as at Debi, yields are low. Proposed project works would result in a single water level for each cuvette during the period of rice submersion which, taking into account ground levels, would give a range in submersion levels of 20 cm-55 cm. Major works would include dikes to protect protect each cuvette against uncontrolled flooding, a system of unlined canals to serve as supply and drainage conduits, and ancillary hydraulic structures.

No new pumping station would be required as the Lampsar polders would be supplied by the existing pumps on the Senegal at Ronq. Annex 4 contains further details of the subproject. Costs free of identifiable taxes per ha improved are estimated at CFAF 71,000 (US$280). Costs of development at Debi and Lampsar are significantly below those expected at Dagana, and the economic rates of return from investment in them are higher than from investment in Dagana (see para 8.01). Unfortunately Debi and Lampsar are the only two remaining cuvettes that can be improved at a relatively low cost. Future development will have to be of polders of the Dagana type.

4.05 Strengthening SAED. To carry out the project and support project farmers, SAED would increase its staff. This is discussed in Chapter VI. In brief, an increase in establishment of 4 professional, 9 technical, and 92 field staff would be required. To help accommodate this staff 48 houses and an office would be built at Dagana, 8 houses at Lampsar, and 5 houses and a warehouse at Debi. Thirteen vehicles and 62 motorcycles would be purchased for staff transportation.

4.06 Dagana Training Center. SAED would continue to train its newly-recruited field agents in irrigated rice production at its Savoigne polder farm. Training in the production of other crops would be provided at a new center at Dagana that would be established under the project and which would give courses of four-week duration (see Annex 5). The center also would give courses and demonstration for farmers, and include an ox-training unit. The center would be under the general supervision of a training specialist expected to be provided to SAED under the French Government's 1972-77 technical assistance program. During negotiations assurances were obtained from Government that the center would be under the supervision of a suitably qualified training specialist.

4.07 Research. SAED would contract IRAT to carry out a program of applied research mainly on nonrice crops (see Annex 6). The program would be for a minimum of four years and its objectives would be to provide technical support for Dagana farmers including the development of new and more productive methods and the introduction of new crops and varieties. Ongoing IRAT rice work would continue at Richard Toll. During negotiations assurances were obtained that the contract between SAED and IRAT would be satisfactory to IDA, and that the research program would be reviewed annually with IDA. IRAT staff would be provided with working and living accommodation at the training center, see para 4.06.

4.08 Expansion of Machinery Hire Pool. As described in para 3.03 cuvette soils are difficult to work when dry. Donkeys are the principal mode of animal traction in the project area, but since they are not suitable for heavy cultivations the use of ox drawn equipment would be sponsored under the project. Despite this, some powered machinery would still be required to carry out the deep plowing cuvette soils require every three to four years and which is impossible with oxen, and in addition to provide an insurance that farmers at Dagana would be able to carry out sufficiently timely operations to permit double cropping. The principal items to be procured would be 16 60-hp farm tractors. Annex 7 contains lists of SAED's existing farm equipment and of equipment to be procured under the project.

Technical Aspects

4.09 Water Supply, Demand and Quality. The project would derive its entire water supply from the Senegal River, by gravity during high water and by pumping during low water. Reliable flow measurements are available for several stations along the river; at Dagana for example 56 years. As described in Annex 8, the Senegal has a single flood each year, and in its lower reaches follows a regular annual flow pattern. Between June 24 and July 6 flows usually begin to increase in response to the start of the rains in its headwaters area; increase gradually and peak 3 to 3-1/2 months later. The flood declines more slowly in accordance with well-established stream hydrology patterns and reaches minimum stages in May or June.

4.11 As flows decrease in the Delta, saline water from the Atlantic moves slowly upstream and by early March salinity levels at Debi and Lampsar are as much as six times the maximum limit for irrigation. These high levels remain until flows again increase in June/July. At Debi and Lampsar pre-irrigation by pumping would start with the beginning of the flood in June and pumping would be discontinued once flood levels permitted gravity irrigation. Since only one rice crop of about 150 days' duration would be grown on these two polders, salinity would not be a problem. At Dagana, where double cropping would be practised, quality of irrigation water would be more than satisfactory July through April. 3Salinity begins in June, with the water becoming unsuitable for irrigation some time during that month but for a maximum duration of 30 days. However, two of the pumping stations constructed to serve Dagana, Gae and Bokhol, would be upstream of Dagana, and records show that at these locations even in dry years water is suitable for irrigation in June and would be adequate for project demands. In the event of an exceptionally dry year excessive salinity could occur at Gae or, as an even more remote possibility, at Bokhol. Fortunately, the date of occurrence of excessive salinity can be predicted, in advance as early as January with considerable accuracy once the Senegal has clearly established its recession pattern for the dry season. If excessive salinity is indicated, planting of the rainy season crop would be delayed. This would be only for a few days and farming operations for the remainder of the year would not be disrupted unduly. Existing SAED salinity measurements are satisfactory and would be continued. Annex 8 contains further details on water supply and requirements.

4.11 Water availability for the three sub-projects is more than adequate. With the project, the area of wet season irrigated rice in the Delta will increase to 16,300 ha requiring the maximum diversion of 65 m^3/sec. This compares with an average July discharge of 417 m^3/sec and a lowest recorded discharge of 70 m^3/sec.

4.12 While no serious problem in providing water for two cropping seasons at Dagana is foreseen, any upstream developments using significant amounts of river water during low stages could upset the delicate saline-fresh water interface balance that occurs annually. In addition to the agreements obtained and described in para 3.14 during negotiations assurances were obtained that Government would inform IDA of any new irrigation development above Dagana and agree with IDA on the necessary limitation on quantities of water to be pumped from the river upstream of Dagana.

4.13 Irrigation Systems. Flood irrigation would be employed at Debi and Lampsar; no special technical or social problems are foreseen. For rice areas in all three subprojects the system would be designed for 24 hours of operation per day. For "other crop" areas at Dagana night irrigation is considered impractical given the lack of farmer experience and the system would be designed for daylight operation. The large capacity field delivery system thus required is one reason for the relatively high investment cost per hectare. Each of Dagana's three sectors would have its own pumping station, which would lift irrigation water to both high (other crop) and low (rice) service areas within the sector. The Dagana B Station would pump on a 24-hour basis and function solely for irrigation. Water pumped at night would be stored in a regulating channel for release during the day. Station A would handle drainage from both Sectors A and B which would have a common drainage system; and Sector C would be largely independent.

Engineering Design and Construction Schedule

4.14 While detailed designs have not been completed for any of the three subprojects, preliminary designs are in substantial detail, of high quality, and adequate for appraisal. Tender documents for all major works are scheduled to be completed by SCET-International by end December 1972. Construction would start in 1973 at Debi and Dagana (Sector A) and be completed in early 1974 with first project crops grown in that year. Work at Lampsar would start in 1974 and the first crop grown in 1975. All project works would be completed by January 1976; a detailed construction schedule is at Annex 9, Table 3.

4.15 For rice areas at Dagana a satisfactory rotational schedule of pre-irrigation has been designed. At Debi and Lampsar different polder arrangements and flooding depths would require different preirrigation rates and an expensive system of pre-irrigation is proposed. Assurances were obtained during negotiations that SAED would cause the consultants to review the various possible preirrigation procedures to determine if any cost savings would accrue through adoption of modified preirrigation schedules.

4.16 Of some concern is the potential impact of the Lampsar subproject on the city of Saint-Louis water supply; the Lampsar serves as the principal source of water for that city. To drain the seven cuvettes comprising the subproject, the level of the Lampsar would have to be lowered to +0.50 IGN each year at the end of the irrigation season in December. The Lampsar would then be filled again by pumping at Ronq. SCET is undertaking a FAC-financed study, to be completed by June 1973, on the future water requirements of Saint-Louis and the most feasible means of meeting these. The study would clarify the amount of Lampsar valley storage needed in the future, and whether or not the Lampsar irrigation subproject would have any adverse effect on the city water supply. Assurances were obtained during negotiations that Government would not permit construction of the Lampsar sub-project should it adversely affect the city water supply.

4.17 Parts of the main Saint-Louis/Rosso highway embankment between Ndiol and Ross Bethio, where it forms the eastern boundary of Cuvettes 3a, 3b, and 4, will have water ponded against them when the Lampsar water levels are raised to +1.75 IGN. This may weaken the highway subgrade unless a small protective barrier dike or embankment is placed on the river side of the highway. CFAF 1 million have been included in project costs for this purpose. During negotiations assurances were obtained that the PWD had no objection to the implementation of the Lampsar subproject.

Environment and Health

4.18 The ecology would be little changed by the project. No known species of wildlife would be endangered. Farming systems practised would involve the excessive use of neither pesticides nor other chemicals likely to have a deleterious effect on human health. Except for malaria the area is relatively free of the more serious tropical diseases. SAED distributes malaria prophylactics to its farmers, and the Ministry of Health operates three health centers and twenty-one dispensaries in the project area. These provide treatment and advice on disease prevention. Despite twenty-five years of irrigated cultivation at Richard Toll bilharzia is unknown, and there is no evidence that the project would cause a change in this situation. Assurances were obtained during negotiations, however, that SAED would cooperate with the Ministry of Health in ensuring that regular checks would be made to enable the early detection of the disease and of its vector in the event that they became present. Waterborne diseases such as amebiasis and cholera occur but are controllable; and the situation should be improved through a French technical assistance program which will equip most project area villages with wells. In the light of the generally satisfactory situation no special health arrangements are proposed under the project.

V. COST ESTIMATES AND FINANCING

5.01 Project costs during the development period 1973-76 are estimated at CFAF 1.9 billion (US$7.4 million), of which the foreign exchange component is about CFAF 0.75 billion (US$2.9 million) or 40%. Detailed cost estimates are at Annex 9 and are summarized in the following table:

Summary of Project Cost Estimate 1973-76

	CFAF Million			US $ '000			
	Local	Foreign	Total	Local	Foreign	Total	% Foreign Exchange
Irrigation Works							
Land clearing	61.2	28.7	89.9	239	112	351	32
Earth works	486.9	220.6	707.5	1.904	862	1.766	32
Civil works	148.4	55.9	204.3	580	219	799	27
	696.5	305.2	1.001.7	2.723	1.193	3.916	30.4
Building Construction							
Staff housing	16.2	9.8	26.0	63	38	101	37.5
Offices and stores	19.7	11.9	31.6	77	47	124	37.5
	35.9	21.7	57.6	140	85	225	37.5
Equipment							
Pumping station and hydraulic gates	13.5	121.7	135.2	53	476	529	90
Tractors & accessories	6.6	59.6	66.2	26	233	259	90
Research & training equipment	1.3	2.4	3.7	5	10	15	65
Vehicles	8.0	5.5	13.5	31	22	53	43
	29.4	189.2	218.6	115	741	856	86.5
Engineering Services	32.1	82.5	114.6	126	322	448	72
Management and Other Costs							
Cost							
Salaries	61.3	14.7	76.0	240	57	297	19
Vehicles & maintenance	12.1	4.5	16.6	47	18	65	27
Training & research	44.6	6.7	51.3	174	26	200	13
Compensation to Dagana farmers	3.6	--	3.6	14	--	14	--
	121.6	25.9	147.5	475	101	576	17.5
TOTAL	915.5	624.5	1,540.0	3,579	2,442	6,021	40.5
Physical contingencies	104.5	45.8	150.3	409	179	588	30.4
Price contingencies	128.6	84.3	212.9	503	329	832	39.6
TOTAL PROJECT COST	1,148.6	754.6	1,903.2	4,491	2,950	7,441	39.6

5.02 Cost estimates for irrigation works, buildings and equipment are based on recent contract prices for similar work and suppliers' quotations. Personnel costs are based on those incurred by SAED. A physical contingency of 15% has been applied to irrigation works and a price contingency of 6% per annum compounded to all project costs. Costs include CFAF 3.6 million for the purchase of sorghum for distribution in 1973 to compensate farmers at Dagana as 480 ha now cropped with sorghum each year would be taken over by the project and there would be no production from this area in 1973. Project costs do not include import duties on equipment imported directly for the project such as pumping station equipment, hydraulic gates, tractors, and implements. Government has indicated that these would be duty free, and during negotiations this was confirmed. Project costs include all other taxes such as, value added tax and taxes on fuel oil which are estimated to account for 24% of costs.

5.03 Financing. It is proposed that an IDA credit of US$4.5 million (CFAF 1.15 billion) be made to cover the estimated foreign exchange costs of the project, and 35% (US$1.55 million) of local costs. The IDA credit would represent about 60% of total project costs or 80% of project costs less taxes. Government would finance the remaining 40% of project costs, US$2.94 million (CFAF 752 million). However, due to the tax component of project costs. Government's net contribution would be about US$1.1 million. The project financing plan is summarized in the following table:

FINANCING PLAN
(Million)

	IDA			Government			Total		
	CFAF	US$	%	CFAF	US$	%	CFAF	US$	%
- Engineering Services	114.6	0.45	100				114.6	0.45	100
- Imported Machinery	181.3	0.70	90	20.1	0.09	10	201.4	0.79	100
- Irrigation Works	600.1	2.35	60	401.6	1.57	40	1.001.7	3.92	100
- Building Construction	34.5	0.14	60	23.1	0.09	40	57.6	0.23	100
- Salaries				76.0	0.30	100	76.0	0.30	100
- Compensation to Dagana Farmers				3.6	0.01	100	3.6	0.01	100
- Vehicles, Research equipment and other costs	51.4	0.20	60	33.7	0.12	40	85.1	0.32	100
- Contingencies	169.1	0.66	48	194.1	0.76	52	363.2	1.42	100
	1.151.0	4.50	60	752.2	2.94	40	1.903.2	7.44	100

The IDA credit and Government's own contribution to project costs would be passed on to SAED; US$3.1 million (CFAF 800 million) as a grant, and US$4.3 million (CFAF 1.100 million) as a credit bearing interest of 1% for a term of 35 years including a grace period of 5 years in which interest would be capitalized. The credit would cover the costs of irrigation works and infrastructure. These lending terms are dictated by the project cash flow at Annex 10. Signature of a financing agreement between Government and SAED satisfactory to IDA would be a condition of credit effectiveness.

5.04 SAED has run into financial difficulties with its ongoing projects due to delays in obtaining funds from Government, see para 6.02. This situation has occurred also with Bank financed agricultural projects in Senegal. To help prevent such problems in future, assurances would be obtained from Government that SAED would open a project Bank account with Banque National de Developpement du Senegal (BNDS) into which Government would deposit three months in advance the funds required for the project on the basis of an annual budget prepared by SAED and approved by MDR and IDA.

5.05 Procurement and Contracts. International competitive bidding in accordance with Guidelines for Borrowers would be used to let contracts for civil works amounting to about US$5 million; and to procure pumping station and hydraulic equipment, tractors and implements costing about US$0.9 million. Civil works contracts would be broken down into sizes small enough for local contractors to execute. Contractors, whether local or foreign, would be permitted to bid for all or any of the contracts. This arrangement should give optimum encouragement for foreign and local contractors to compete in the bidding. Contracts for the construction of houses and offices estimated to cost US$0.27 million would be let by local competitive bidding, as would be any contracts for minor on-farm development works that SAED decided to exclude from international competitive bidding. In the latter case local contractors would be pre-qualified. Vehicles, motorcycles, furniture, office equipment, tools and other small equipment, valued at a total of US$0.08 million, would be procured by local competitive bidding. The remainder of project costs would be SAED expenditures on items such as salaries, research and training. Senegal has preferential trade agreements with members of the European Common Market and other members of the African Entente countries but these would not act as barriers to goods procured under international competitive bidding since such imports would be duty free, see para 5.02.

5.06 Disbursement. Disbursements from the proposed IDA credit would finance:

- The c.i.f. cost of imported hydraulic and agricultural equipment,
- 60% of the cost of land development works, construction of houses and offices, vehicles and operating costs, and
- 100% of the cost of engineering services.

In addition it is proposed that the costs of topographic surveys amounting to about CFAF 25 million, and now being carried out, should be financed retroactively under the project at 100% reimbursement. Disbursement claims would be supported by contracts, shipping documents and certified records of expenditure. A schedule of estimated disbursements is at Annex 11. It is proposed that any credit funds remaining at the completion of the project should be cancelled.

5.07 Accounts and Audit. SAED would establish a project account within which expenditures on the three major sub-projects, including management and overhead costs, and those on research and training would be recorded separately and in such detail as to identify the purpose and function of each expenditure. SAED would continue to maintain individual accounts for farmers receiving credit for inputs and machinery services and open a new consolidated fee account, see para 6.11. As a Government agency SAED accounts are subject to annual audit by the Office of the Accountant General; unfortunately such audits are irregular in frequency and generally inadequate. Consequently, during negotiations assurances were obtained that the above accounts would be established and maintained, that a firm of commercial auditors satisfactory to IDA would be employed to audit SAED accounts and that copies of audited SAED accounts together with the auditor's report would be submitted to IDA within a six months of the close of each fiscal year.

VI. ORGANIZATION AND MANAGEMENT

6.01 Project Administration. Societe d'Amenagement et d'Exploitation des Terres du Delta (SAED) would carry out the project. SAED was established in 1965 as a State corporation responsible to the Minister of Rural Development. Its Board is made up of civil servants representing the Ministries of Rural Development (Chairman), Finance, Planning, and Water Development. SAED's objectives are to develop the agriculture of the Delta through constructing, operating and maintaining water control works, and providing extension, land cultivation, credit, processing and marketing services to farmers. Up to now SAED has restricted its activities to rice but this will change with construction of Dagana. Further details of SAED are at Annex 12.

6.02 While SAED is competent technically, it has several problems. The principal problem is that until 1970 it was unable to guarantee irrigation water to any of its farmers, and even today can guarantee water to only some. As a consequence SAED has been unable to charge farmers either for the costs of operation and maintenance of irrigation structures or for irrigation water. Also, farmers naturally have been reluctant to put any substantial amount of work into their farms due to the past high incidence of crop failure. This has caused SAED to expand its machinery hire service to ensure that its polders are cropped, and to adopt generally an overly paternalistic and non-commercial attitude toward participants in its schemes. The foregoing have resulted in SAED recurrent expenditures greatly exceeding annual revenues and the need for substantial subsidies by Government. In turn this has led to Government exercising an extremely tight control on SAED expenditures; in practice this control is so tight as to be counter-productive and large sums are wasted in the effort to save small amounts. The situation is unsatisfactory, and can be corrected only by SAED developing viable schemes and levying participants in these schemes reasonable charges for the services that they receive; and by Government affording SAED a greater degree of financial autonomy. During negotiations, therefore, assurances were obtained from Government that all farmers with assured water supplies would pay a fee that would allow recovery

of project investment costs, as well as the costs of operation and maintenance (para 6.10); and that farmers would pay the full cost of mechanized cultivation services (para 7.10). Also to ensure that SAED operations would not be impaired by unnecessary financial constraints and procedures, assurances were obtained in addition to those at para 5.04 that working capital required by SAED to implement the project and carry out its other activities would be made available by Government in advance and that such funds would be deposited in an account with BNDS that would be operated directly by the SAED Financial Controller.

6.03 Since 1967 SAED has received technical assistance from France through Societe d'Aide Technique et de Cooperation (SATEC) and Societe Centrale pour l'Equipement du Territoire (SCET) which provide currently seven French technicians. Five of these occupy executive positions as heads of the Office of Agricultural Studies and Evaluation and the Divisions of Agricultural Development; Agricultural Operations; Engineering and Construction; and Machinery and Equipment; the other two are in charge of the Survey Unit and the rice mill, see Organization Chart. The Director General is Senegalese, as is the Financial Controller. Both these officials are satisfactory but, during negotiations, assurances would be obtained that the posts of Director General and Financial Controller would be filled at all times by persons with qualifications and experience satisfactory to IDA. In addition assurances were obtained that expatriate technicians would be replaced by Senegalese staff only after the latter had gained practical experience that was considered adequate by IDA. The latter assurance would be obtained since SAED's operations would suffer drastically if a significant number of expatriates were to leave prior to that replacement by suitably experienced and qualified Senegalese.

6.04 To undertake the project, SAED would engage consultants to prepare tender documents and detailed designs for major project works and to supervise their execution. During negotiations assurances were obtained that such consultants would be employed under terms of reference and conditions satisfactory to IDA, see Annex 13. SAED would also need the additional staff listed in Annex 9 and at negotiations assurances were obtained that Government would provide SAED with this staff and that they would be replaced if found unsatisfactory by SAED. Most vacancies would be in the field assistant grade; those recruited would receive in-service training at Savoigne and Dagana (para 4.06). Each field agent would be responsible for supervising about 60 rice growers or 30 to 35 farmers growing other crops. SAED would provide support services, importantly, extension, credit and marketing to all farmers working land in the subprojects. To facilitate this farmers would be organized in mutual guarantee groups of 10 to 15 members (para 3.12).

6.05 Irrigation Operations. SAED's Engineering Division would be responsible for operation and maintenance of irrigation systems. The Division is directed by an expatriate engineer; at negotiations assurances were obtained that a Senegalese with a degree in irrigation engineering or a suitable equivalent would be assigned as his deputy to obtain experience with the project during design, construction and operation stages. SAED has 12 ditch riders who would be able to supervise at Debi and Lampsar, but would recruit and train an additional eight for Dagana.

6.06 Project Evaluation. Evaluation of the economic impact of the Debi and Lampsar subprojects would be simple and part of SAED's routine operations. Dagana with its greater sophistication would pose more difficult evaluation problems and, in view of the importance of this experience for future irrigation schemes, a special evaluation unit would be established for Dagana (see Annex 14).

6.07 Farmer Selection. Principal criteria for farmer selection would be that each participant had a family containing at least two active adult persons; was himself over 25 years of age but not more than 45 years; derived his main revenue from agriculture; lived in the area within convenient walking distance of his farm; had no adverse credit rating; and would be willing to sign a land use, cropping, and marketing contract with SAED. Agreement between SAED and IDA on a form of contract specifying farmers' and SAED rights and obligations would be a condition of credit effectiveness.

6.08 Farm Size and Cropping Pattern. At Debi and Lampsar individual holdings would be about 3 ha each and would grow a single crop of paddy each year. A farm of this size could be managed by the average Delta family of three working adults without recourse to mechanization except for land preparation.

6.09 At Dagana farms would be 3.5 ha, 3 ha and 2 ha in size depending on location. The 3.5 ha holdings would grow two crops of rice annually, 3.5 ha in the wet and 2.7 ha in the dry season. The 3 ha and 2 ha holdings would be located on higher ground not suitable for rice. A variety of crops could be grown on these holdings but for project calculations, the range has been restricted to tomatoes, onions, potatoes and sorghum. On the 3 ha holdings in Sectors A and C, farmers would grow 1 ha of tomatoes and 4 ha of sorghum (or alternatives) annually. On the 2 ha holdings in Sector B, cropping would be more intensive with the average farm growing 0.5 ha tomatoes, 0.5 ha onions, 0.5 ha potatoes and 2 ha sorghum each year. Further details of cropping patterns are at Annex 15. On Sector C 80 ha would be set aside for trials with citrus and other tree fruits. During negotiations assurances were obtained that the contract between SAED and participants would permit the reduction in size of any holding shown to be beyond the capacity of its operators to work efficiently.

Recovery of Costs

6.10 Farmers cultivating land developed under the project would have incomes that would permit them to pay for a substantial part of the services provided to them. Consequently it is proposed that farmers at Debi, Lampsar and Dagana would pay an annual consolidated fee for each ha allotted to them. The fee would cover project operation and maintenance costs and all direct investments, including taxes, chargeable to the project The fee would be increased by three steps during the farmers' first five years of participation in the project and would be in line with the increase in income expected as the farmer improved his holding and gained skills. The fee would vary both with the crops grown and the number of crops

grown in each year. At Debi and Lampsar the fee would increase from CFAF 2,500/ha by three steps to CFAF 10,000. At Dagana, rice, tomato and sorghum farmers would pay CFAF 16,000 by their sixth year; but those farming potatoes and onions would pay an additional CFAF 14,000/ha per crop. Fees paid by Dagana farmers would be in the ranges of 16% to 27%, and 27% to 37% in terms of gross and net incomes respectively. SAED considers these fees realistic and believes that they would not have any adverse effect on production and farmers' willingness to participate in the project. During negotiations, however, assurances were obtained that SAED would consult with IDA before finally establishing or changing the fees which would be charged to participants; and in addition that equivalent fees would be charged in other areas with controlled irrigation water supplies, and that SAED would make a detailed study of the ability of participants in its schemes to pay charges.

6.11 Project investment costs excluding research and training costs but including management costs during the development period are estimated at CFAF 1,480 million, and operation and maintenance costs excluding extension service costs over the life of the project at CFAF 1,190 million. Discounting the revenue and cost streams indicates that direct investments in the project would be recovered at 1% interest after full recovery of all operation and maintenance costs. Annex 16 gives details of the method of calculating operation and maintenance costs. Revenues accruing to SAED from consolidated fees, which include approximately 1% interest on direct investment costs, are estimated to reach CFAF 101 million annually when the project is fully developed and to CFAF 3 billion over the 35-year life of the project. If full project costs and the projected net revenue from consolidated fees are discounted over the life of the project at slightly more than 8%, the average cost of money in Senegal fixed by the Central Bank, the present value would amount to about US$3.4 million or 50% of costs. The proposed consolidated fee recovery rate is considered reasonable to assure adequate incentives to farmers and the present value of the national subsidy to participants would therefore amount to about half the total cost.

VII. YIELDS, PRODUCTION, MARKETS AND PRICES, FARMERS' BENEFITS, GOVERNMENT REVENUES

7.01 Yields and Production. Yields assumed in project calculations and production estimates are at Annex 15. Rice yields at Debi and Lampsar are forecast to increase from 1.5 tons of paddy/ha in the first year of project operation to 2.7 and 2.5 tons respectively by the seventh. These compare with average yields in the past of 1.0 and 0.8 tons respectively. At Dagana yields are expected to start at 1.8 tons of paddy and to rise to 3.2 tons/ha in six years. On the basis of past performance in polders where irrigation water is controlled the yield forecasts are considered achievable. Incremental project paddy production is estimated at 13,500 tons annually at maturity.

7.02 The yields of other crops are expected to develop over an average three-year period as follows: sorghum 2.2-3 tons/ha, and at maturity an annual production of 4,000 tons; tomatoes 25-35 tons/ha, 11,700 tons; potatoes 10-13 tons, 3,000 tons; onions 8-10 tons/ha, 2,280 tons. The yield estimates for these other crops are based on commercial experience in Senegal and the results of IRAT trials in Senegal and elsewhere in West Africa under similar ecological conditions.

7.03 Markets and Prices. There would be no problem in marketing project production of 9,000 tons of milled rice annually since it would substitute for imports. In Annex 17, the price and market prospects for project production are discussed SAED would purchase paddy from growers, mill, and sell the milled rice to ONCAD which has a monopoly for the distribution of both locally grown and imported rice. The current farm gate price for paddy is CFAF 21,000/ton; Government's intention is to maintain this price to encourage domestic rice production and it has been used in farm budgets and other project financial calculations. This level of support appears to be necessary to induce farmers in rainfed areas to grow rice for sale in preference to groundnuts for which prices in recent years have been favorable. In economic calculations a value for paddy of CFAF 15,300/ton at constant 1972 prices is employed since this would be the cost to the economy of importing paddy of a similar quality. Government's rice marketing and price policies are based on maintaining high retail prices and using surpluses made by ONCAD in selling imported rice to subsidize domestic producers. During negotiations assurances were obtained that ONCAD would pay SAED promptly for rice deliveries.

7.04 The other crops grown also would substitute for imports and marketing problems are not envisaged, see Annex 17. Of these crops only tomatoes would require sophisticated processing. Project tomatoes would be processed into tomato paste by Societe de Conserves Alimentaires du Senegal (SOCAS) at its Ross-Bethio factory. Caisse Centrale de Cooperation Economique is providing finance for an extension of the SOCAS facility to permit an annual intake of 21,000 tons of tomatoes by 1977/78 of which 12,000 tons would be allocated to the Dagana polder. With its planned throughput SOCAS would produce about 40% of domestic requirements of tomato paste; the remainder would be imported. Annex 17, Table 2, shows that the current producer price of CFAF 7,000/ton for tomatoes approximates to their economic value.

7.05 About 15% of project sorghum production is estimated to be consumed on-farm and the remainder to be sold locally. A strong domestic market exists for Sorghum. Eventually project farmers are expected to reduce sorghum output and substitute other crops. Sorghum prices are based on current prices of CFAF 18,000/ton for the financial analysis, and the projected 1980 international price is the basis of that used for economic rate of return calculations.

7.06 Onions are imported in large quantities and demand is growing. Project production will fill some of this demand, although it is not believed that it will materially reduce imports. A price of CFAF 25,000/ton has been used in economic analyses. This is considered conservative being well below

the recent cost of imported onions. In the financial analysis, the current farm gate price of CFAF 20,000/ton has been used. The domestic price for onions is lower than the import price and reflects both a preference for imported onions and inefficiencies in the marketing of locally produced onions.

7.07 There is a large and growing demand for potatoes which is met largely by imports. In the economic analysis of the project a price of CFAF 17,500/ton has been used and is the average cost of imported potatoes in recent years. For the financial analysis, a farm gate price of CFAF 20,000/ ton has been employed since this is the price currently paid for new potatoes coming into the market in January and February when they would be produced by project.

7.08 Subsidies on Fertilizer and Tractor and Implement Hire. SAED farmers benefit from subsidized fertilizers and subsidized tractor and implement hire charges. The fertilizer subsidy is common to all Senegal farmers and until the end of 1972 its cost is being met by a FED grant. Irrespective of their formula fertilizers are sold to farmers at a flat rate of CFAF 13/kg. On the average rice farm the subsidy amounts to CFAF 2,800 per ha and per crop. The object of the subsidy is to stimulate fertilizer use. While the subsidy is financed by external grants it is unrealistic either to require farmers on IDA financed projects to forego the subsidy or to insist, as a condition of IDA financing, that an across-the-board reduction, or elimination, of the subsidy be made. As shown in Annex 18, project farmers would be able to pay the full cost of fertilizers and a continuing subsidy would not be essential for the success of the project. Since it is unlikely that FED will continue to subsidize fertilizers at present levels and improbable that Government will have the resources to directly undertake this financial burden, it is assumed in project calculations that the fertilizer subsidy would be eliminated by 1977. Abrupt changes in fertilizer subsidy levels are undesirable since they would have significant impacts on production; thus in other IDA financed projects in Senegal IDA has obtained assurances from Government that the matter of fertilizer subsidies would be reviewed annually with IDA with the objectives of avoiding changes likely to have a serious adverse effect on production and of eliminating subsidies by 1980. Similar assurances were obtained during the negotiation of this project.

7.09 The subsidy paid to participants in SAED projects who use tractor hire services is CFAF 2,500/ha cultivated. This may be justified in polders where water is not controlled and yields and incomes are low. Conversely where water is controlled the subsidy leads to the substitution of mechanization for animal powered cultivation and hand labor. With project improved conditions at Debi and Lampsar and the high degree of water control that would be practised at Dagana, the subsidy could be eliminated provided that in order to give each farmer an initial impetus, it was retained for the first year of participation of each farmer in the project. During negotiations assurances were obtained to this effect, and also that farmers on other SAED schemes with water control would be treated similarly.

7.10 Farmers' Benefits. Per capita income in the Delta are about CFAF 8,000 of which about CFAF 4,000 cash; on a per family basis CFAF 48,000 and CFAF 24,000 respectively. Families of farmers at Debi and Lampsar would continue some of their ongoing productive activities in addition to cultivating their rice farms in the polders. The rice farms would generate additional estimated family cash incomes of CFAF 58,000 and CFAF 43,000 for Debi and Lampsar respectively, see Annex 18. Due to the work load Dagana farmers would abandon all ongoing activities but would be rewarded by cash increases of about CFAF 170,000 for these growing two rice crops a year, and an average of CFAF 157,000 fo/these engaged in mixed cropping. All cash increases given above are net of CFAF 21,000 estimated as the cost of farm produce consumed by the farm family. Total annual incremental cash income would amount to CFAF 198 million (US$0.77 million) as a result of project implementation.

7.11 Government Revenues. Revenues accruing to Government from implementation of the project would be loan repayments made by SAED, and the taxation component of SAED recurrent costs. As shown in Annex 19, these would be adequate to repay the IDA credit and over the 35 year life of the project the annual surplus would amount to an average CFAF 5 million. It is reasonable to expect, however, that additional taxation revenue would be generated indirectly by implementation of the project.

VIII. BENEFITS AND JUSTIFICATION

8.01 The project's principal immediate benefits would be the incremental production of rice from the Lampsar and Debi polders, and the new production of rice and other products generated by development of the Dagana polder. On the basis of the yield, production and price estimates in Chapter VII, the investment and operating costs in Chapter V, and assuming a project life of 35 years, the economic rate of return of the project is estimated at 14%, see Annex 20. Separate rates of return have been calculated for the three sub-projects and are Dagana 14%, Debi 19%, and Lampsar 17%. In the economic analysis, a shadow rate of exchange of CFAF 320 = US$1 or 25% above the current official rate (CFAF 256 = US$1) has been used. This reflects Senegal's high protective tariffs on most imports, averaging between 40 and 50%. Without this assumption, the economic rate of return would be 12%. The value of on-farm labor has been excluded from project costs since project farmers are not expected to hire labor, and for most participation in the project would mean an intensification of family effort and consequently, a greater use of family labor. This additional use of family labor would entail no additional cost to the economy since at the time it would be required no alternative employment opportunities would exist.

8.02 The Dagana sub-project would be the first irrigation development in Senegal where farmers would participate in a technically sophisticated scheme involving double cropping and the cultivation of non-traditional crops. Thus it is not possible to guarantee that farmers would react as predicted in this

report. However, the yield projections used are conservative, and the average cash returns on both annual farm and per manday employed bases, CFAF 160,000 and CFAF 500 respectively appear sufficient to ensure satisfactory farmer performance. Further, SAED has more than 3,000 applications for irrigated holdings and demand is increasing in view of a recent succession of dry years in which rainfed crops have been poor. This demand and SAED's ability to discipline unsatisfactory performers should assist in the achievement of project targets. The sensitivity of the project's rates of return has been tested to a number of adverse factors and the results are at Annex 20. Among others, changes resulting in a 10% increase in costs and a 10% decline in benefits would result in a fall in the project's rate of return to 10%, and to 12%, 11% and 10% respectively for Debi, Lampsar and Dagana. Achievement of forecast yields in 16 rather than 8 years would reduce the rates of return to 10%, 15%, 12%, and 10% respectively. While low, these rates are still acceptable considering the conservative assumption that 62% of the land at Dagana would be cropped in sorghum for which several high value alternatives exist.

8.03 A principal objective of the project would be to save foreign exchange. Project induced net foreign exchange savings are estimated to amount to about US$1.2 million annually at maturity of the project.

8.04 The project would benefit some 1,700 farm families comprising about 10,000 people in all. Per capita incomes of participating families would increase from the average CFAF 8,000 (including the value of farm products consumed) enjoyed at present in the project area to an average of CFAF 30,000 at Dagana and an approximate of CFAF 23,000 at Debi and Lampsar. Since incomes in the project area are below the rural average of about CFAF 25,000 per capita, the project would benefit a particularly underprivileged segment of the population.

8.05 The Dagana sub-project would be especially important since it would act as a pilot for the further development of irrigation in the Sengal Basin. It is estimated that with appropriate structures the Senegal could be used to irrigate year around some 50,000 ha of land. This will not be possible, even if finance is available, unless Senegal can develop the skills needed to efficiently manage and exploit irrigation projects. As the country's only irrigation development based on small farmer participation and involving double cropping, the Dagana sub-project would have a unique role in the development of irrigation experience and skills.

IX. RECOMMENDATIONS

9.01 During negotiations assurances were obtained that:

(a) the Dagana training center would be under the supervision of a suitably qualified training specialist (para. 4.06);

(b) the research contract between SAED and IRAT would be satisfactory to IDA and the research program would be reviewed annually with IDA (para. 4.07);

(c) Government would inform IDA of any new irrigation development above Dagana and agree with IDA on the necessary limitation on quantities of water to be pumped from the river upstream of Dagana (para. 4.12);

(d) SAED would cause the consultants to review preirrigation procedures to determine if any cost savings would occur through adoption of modified preirrigation schedules (para. 4.15);

(e) Government would not permit construction of the Lampsar sub-project should it adversely affect the city water supply (para. 4.16);

(f) PWD would have no objection to SAED carrying out the Lampsar sub-project (para. 4.17);

(g) SAED would cooperate with the Ministry of Health in ensuring that regular checks would be made to enable the early detection of bilharzia and of its vector in the event that they become present (para. 4.18);

(h) SAED would open a Bank account with BNDS project into which government would deposit three months in advance the funds required for the project on basis of an annual budget prepared by SAED and approved by MDR and IDA (para. 5.04);

(i) SAED would establish a project account broken down by subprojects; all SAED accounts would be audited by a firm of commercial auditors satisfactory to IDA and such audited SAED accounts together with the auditor's report would be submitted to IDA within six months of the close of each financial year; and that SAED would maintain individual farmer's credit accounts and a consolidated fee account (para. 5.07);

(j) working capital required by SAED for project and other operations would be made available by Government in advance and that such funds would be deposited in an account with BNDS that would be operated directly by the SAED Financial Controller (para. 6.02);

(k) SAED would engage consultants to prepare tender documents and detailed designs for major project works and to supervise their execution, under terms of reference and conditions satisfactory to IDA (para. 6.04);

(l) the post of SAED Director General and Financial Controller would be filled at all times by persons with qualifications and experience satisfactory to IDA; expatriate technicians would be replaced by Senegalese staff only after the latter had gained practical experience considered adequate by IDA; Government would provide SAED with additional personnel needed for the project and such personnel would be replaced by Government if requested to do so by SAED; and a Senegalese with a degree in irrigation engineering would be assigned to SAED Engineering Division (paras. 6.03 and 6.05);

(m) the contract between SAED and project participants would permit the reduction in size of any holding shown to be beyond the capacity of its operators to work efficiently (para. 6.09);

(n) SAED would consult with IDA before establishing or changing annual consolidated fees, and that equivalent fees would be charged in other areas with controlled irrigation water supplies, and that SAED would make a study of the ability of participants in its schemes to pay charges (para. 6.10);

(o) ONCAD would pay SAED promptly for rice deliveries (para. 7.03);

(p) fertilizer subsidies would be reviewed annually with IDA (para. 7.08); and

(q) subsidies on tractor hire services would be eliminated on all SAED schemes with water control (para. 7.09).

9.02 During negotiations confirmation was obtained that Government would exempt equipment imported for the project under international competitive bidding from import duties and taxes (para. 5.02).

9.03 Conditions of effectiveness are:

(a) signature of a financial agreement satisfactory to IDA between SAED and Government (para. 5.03);

(b) agreement by IDA of a form of contract to be signed by participating farmers and which would specify farmers' and SAED's rights and obligations (para. 6.07).

9.04 The project is suitable for an IDA credit of US$4.5 million.

November 15, 1972

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Description of the Senegal River Basin and Delta Region

Drainage Area

1. The Senegal river is an international stream some 1,800 km in length. It originates at the headwaters of its tributary, the Bafing, in the high rainfall area of the Massif du Foota Djalon in Northern Guinea. The Senegal river proper begins at the junction of the Bafing and the Bakoy at Bafoulabe, in Mali. In its upper course it drains the western part of Mali, and small portions of Northern Guinea and Eastern Senegal. As it leaves Mali upstream of Bakel, Senegal, the river marks the international frontier between Senegal and Mauritania throughout practically all of the remainder of its route. It flows generally to the north and northwest until it reaches the vicinity of Boghi, Senegal, where its course then runs primarily to the west, finally emptying into the Atlantic Ocean at Saint Louis, Senegal. Its total drainage area is approximately 300,000 km^2 (see Map 3983). The average annual discharge at Dagana, drainage area 283,000 km^2, is 690 m^3/sec.

2. No significant areas of irrigable land exist upstream from Bakel. Therefore, for the purposes of identifying development areas, the following approximate geographical designations are used to describe the flood plains of the Senegal river from Bakel to Saint Louis. The reports of several different agencies working in the Senegal River Basin are not completely consistent in their nomenclature of the various areas. The designations made hereafter are considered to be reasonable compromises.

Valley (Bakel to Richard-Toll)

Upper Valley - From Bakel downstream to Kaedi

Middle Valley - from Kaedi downstream to Boghe

Lower Valley - from Boghe downstream to Richard-Toll.

Delta (Richard-Toll to Saint Louis)

Upper Delta - From Richard-Toll to Diambar

Note: While the Dagana project area geographically is located at the downstream end of the Lower Valley area, for administrative purposes it is considered a logical extension of the adjacent Upper Delta area

Middle Delta - from Diambar to Ile aux Caimans. Most of the Lampsar Valley is included

Lower Delta - From Ile aux Caimans to Saint Louis. The Debi area is included.

3. Map 2984 indicates the foregoing areas. It is usual for the drainage area above Bakel to be designated the "Upper Basin", and the total Valley and Delta areas from Bakel to the sea as the "Valley".

Topography

4. While a few portions of the Upper Basin are mountainous, the relief of most of it is slight, with elevations of 400 m or less. The average elevation of the entire basin is 200 m.

5. The valley floors have general slopes of about 4.5 cm/km, and the Delta lands of about 2.5 cm/km or less. The Valley and Delta lands are characterized by a vast extent of uniform relief, with practically no elevations more than 12 m above sea level (IGN) anywhere west of the 13th meridian.

6. The flood plains between Bakel and Saint Louis have the following approximate gross areas:

Upper Valley	-	Average width = 13 km	220,000 ha
Lower and Middle Valley	-	Average width = 20 km	440,000 ha
Delta	-	Average width = 28 km	370,000 ha
		Total	1,030,000 ha

River Profile

7. At its highest point, near its origin in Guinea, the Senegal is slightly more than 1,000 m IGN. At Bakel, 790 km from the sea, the river level elevation at low flows is around 12 m IGN, at Kaedi, 530 km, the level is about 4.2 m IGN; and at Dagana, 190 km, just prior to the start of the Delta, the low flow level is only slightly above sea level. At medium and high flows the river slopes and depths increase, and the river has been used for navigation during these periods up to Bakel.

8. At times of minimum river flows, salinity effects from the sea can extend as far upstream as Dagana. This riverine sea water intrusion is a critical limiting factor on irrigation in the entire Delta area, and is discussed later in this Annex, and in more detail in Annex 8.

Climate

9. The Senegal River Basin lies between the tropical regions and the Sahara Desert. In January and February, brisk, fresh breezes generally blow from the north and along the coast, flowing from the high pressure area

centered over the Azores towards the equatorial zones of low pressure. In February-March a continental wind from the east, the Harmattan, brings dry, sometimes hot, air from the Sahara over the Basin. As the tropical low pressure areas move to the north under the movement of the sun, humid winds from the south-west move towards the interior; when these meet the Harmattan winds from the desert, low pressure areas, tornadoes, and rains occur along the front between the two air masses. By August rainfall is general and continues to be abundant through September. The rains usually cease by mid-October, and by November the fresh maritime winds from the Azores again begin to be the primary daily climatic influence.

10. Annual average rainfall in the mountains of the Guinean headwaters may exceed 2,000 mm, but the average decreases rapidly with distance in a northerly direction, being less than 700 mm at Bakel in the Upper Valley and only about 310 mm in most of the Delta region. For Rosso, a station located in the central part of the Delta, the mean monthly rainfall, temperature, and Piche evaporation measurements are as shown in the following table. Also shown are evaporation measurements at Lake R'Kiz, about 40 km north of Dagana.

Average Climatic Data

Senegal River Delta Region

Parameter	Month												Average
	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Rainfall (mm)	0	1	0	0	3	8	40	147	79	30	3	1	312
Temperature (°C)	22	24	27	29	30	31	30	29	29	29	26	23	27
Evaporation (mm)													
Piche	281	272	360	368	382	330	250	203	157	194	201	248	3,246
Lake R'Kiz	180	190	250	260	270	220	200	170	150	180	160	170	2,400
ETP (Penman) (mm) (per E. A. Bernard)	174	207	248	272	260	203	198	206	191	181	164	164	2,473

11. The Delta Region falls entirely within the Sub-Sahara (Sahelien) climatic regime, which is delineated by 200 and 500 mm annual rainfall isohyets, with its typical sparse vegetative cover. The Soudan climatic regime (500 to 1,000 mm annual rainfall), and the Guinean climatic regime (annual rainfall greater than 1,000 mm) are found in the southern part of the Basin.

12. Thus, the Delta is characterized by a very short, wet (rainy) season, July through September, a dry season which is almost absolute beginning in October and extending well into June, and by low temperatures

in December-February with highest temperatures in the March-July period. Temperature extremes are not great. Average maximum daily temperatures during a single month are about 40°C (May), and the minimum daily temperatures average 14°C (January). The average relative humidity is low, 25%, with monthly averages ranging from 13 to 45%.

13. Rainfall, while very regular in its annual distribution pattern, varies greatly in amounts and intensities in the Delta. At Dagana, annual averages over a 45-year period have varied from 120 mm to 750 mm. A single daily rainfall, unprecedented and unequalled, of 242 mm, was recorded at Dagana on August 25, 1933.

14. A one-day precipitation of 100 mm or more in the rainy season is not unusual. A two-day storm of 140 mm has been estimated to have a frequency of about 5%. The six-day total of 285 mm recorded from September 5 - 10, 1955 had an estimated frequency of about 2%.

Soils

15. In contrast to the poor sandy soils of Senegal's plateaus, the alluvial soils of its river valleys and deltas have substantial potential. The soils of the Senegal River Valley can be divided into two broad groupings, each covering gross surface areas of about 250,000 ha, as follows:

> Soils of the cuvettes (depressions), which are vertisols with a high percentage of expansive clays, extremely hard when dry, and with flat relief; and
>
> Levee soils, with clay percentages varying between 10 and 30%, easily erodible, and parts of which (in old arms of the river) present a very irregular relief.

A preliminary reconnaissance study of subsoil conditions indicates the probable existence, throughout the Valley of beds of fine sand of low permeability, lying at depths of 1-5 m below the surface. The soils of the Senegal River Delta can be classified into the same two groups, but many of these soils are too saline for use. The subsoil also has fine sand beds, although at shallower depths than those in the Valley. The surface soils have depths of from 0.5 to 1.5 m, and cover an estimated 100,000 ha. The soils of the Debi and Lampsar polders belong to the delta soils group, those of the Dagana polder to that of the valley soils.

16. Alluvial soils in the depression of the Debi polder are flat and uniform. Those to be included in the project are selected on the basis of a soil classification into five salinity groups, and are situated between 0.50 m and 1.10 m + IGN. They have a fine texture, and their pH ranges from 5 to 7. While high salinity in the top soil occurs mainly on high land, in the depression it is found only in the deeper soil layers which are often also rich in sulphates, but at a level beyond reach by plant roots. Only

soils with a conductivity below 1,000 micromhos are suitable for rice cultivation. Soils in the Lampsar polder are typical alluvial sandy-loam, sandy-clay and loam soils and have been classified in four categories of salinity. Class 1 with no or little salinity, and class 2 with a conductivity of less than 1,000 micromhos are included in the project and would be suitable for rice only. Classes 3 and 4 would require desalinization and are excluded from the project.

17. The Dagana polder comprises four geomorphological zones, as follows:

(a) high soils (levees) in the north and east of the polder;

(b) depression soils (cuvette) in the southeast near Dagana village which are inundated with the first seasonal river floods;

(c) transition soils between (a) and (b); and

(d) southern dune soils along the main road and bordering the depression.

18. Characteristics of the four major soil types are as follows:

(a) Levee soils: high soils proper: homogenous, permeable, yellow-brown or brown-yellow sandy-loam or loamy-sand soils on top of brown loamy clay; a sandy layer occurs at a depth of 1.50 to 2.00 m except in the river banks proper; suitable for crops other than rice.

(b) Depression soils: homogenous, alluvial, brown clay soils with clay-loam contents of up to 95%. These soils are very hard and cracked in the dry season and muddy in wet condition; only suitable for rice.

(c) Transition soils:

(i) heterogenous grey sandy gley soils with varying contents of brown clayey-loam sediments originating from floods and yellow sandy-loam elements brought in by runoff from surrounding high lands; intermittent upstream and downstream flood directions created a mixture of soil layers which may change at short distances; land suitability for crops other than maize and sorghum has to be determined through detailed soil mapping; and

(ii) grey clayey gley soils in depression between ridges of high land; especially the upper and middle horizons of the soil profile have high clay contents; texture and soil structure are similar to that of the soils

in the southwest depression (see (a)), but soil aggregates are more stable and cultivation is easier; mainly suitable for rice.

(d) Dune Soils: sandy gley soils; suitable for crops other than rice provided application of fertilizers and manure according to specific crop needs.

19. Generally, all soil types are rich in iron; and poor in organic matter and nitrogen. While potash contents are satisfactory, phosphate is lacking in most soils. Traces of residual salinity (gypsum concretions) exist in the lower soil layers of the depression soils, but in some high soils salinity is a common phenomenon in the middle and upper soil layers. It is probably the result of an ancient marine intrusion that deposited a salt laden fine clayey and sand layer at a uniform level of about 3.50 m IGN. Salt migration to other soil horizons in the profile occurs, but in Dagana itself no salinity problems prevail that cannot be controlled through proper drainage and irrigation. While sulphate acidity is encountered in the Delta, it is not found in the Dagana polder.

Population

20. 1971 population estimates are as follows:

Upper Valley	190,000 inhabitants	
Lower Valley	200,000 inhabitants	
Delta	110,000 inhabitants	(80,000 in the city of Saint-Louis)
	500,000 inhabitants.	

21. The majority of the population is from the Toucouleur tribe, followed in order of magnitude, by the Moors, Peuls, Wolofs and the Sarakoles. The Delta population is a mixture of all of these tribes, living and working in the same area with no frictions among the different groups.

Infrastructure

22. The Delta region is especially favored in having an excellent supporting infrastructure for agricultural development. A modern paved highway and a railroad connect Saint Louis at the mouth of the Senegal, with Dakar, the capital city, which is 267 km to the south, by road. From Saint Louis another modern, and relatively new, paved highway runs past Dagana up to Orefonde, in the Middle Valley. Dagana is only 129 km by road from Saint Louis. Saint Louis is the Regional Government capital, and has schools, a hospital, and a very good airport.

Area Cultivated

23. Valley. Traditional agriculture in the valley consists of a rainfed crop from July to October, and a crop raised on flood plains as the flood levels subside, during November through February. Average areas estimated by FAO to be farmed annually are as follows:

	Rainfed ha	Floodplains ha
Upper Valley	43,000	65,000
Lower Valley	37,000	60,000
	80,000 ha	125,000 ha

24. A typical family of 6.2 persons cultivates, on the average, 2.3 ha of flood plains and 1.5 ha of rainfed crops. The principal rainfed crop (85%) is millet, plus some peanuts and cowpeas. Sorghum comprises 70% of the floodplain culture, with cowpeas and millet being the other main crops. Average yields are very low - from 350 to 400 kg/ha.

25. There are small, more intensively farmed and irrigated, plots at Guede (1,000 ha) and Salde, with additional 1,000 ha experimental plots under way or planned for the immediate future by FAO-UNDP at Podor (Lower Valley), Kaedi (Middle Valley) and Matam (Upper Valley). On the Mauritanian side of the river there are small developments at Tickane and Vinding.

26. Delta. With one exception, all existing agricultural development in the Delta is limited to one crop per year, because of the intrusion of sea water into the Delta river channel at times of low flow. The exception is the 6,000 ha polder at Richard-Toll, of which about 5,000 ha are cultivated annually. Large-scale rice cultivation began in 1945 at Richard-Toll, located at the head of the Delta. Most of its irrigation water comes from Lake Guiers, part of the Ferlo River drainage basin. While the Ferlo Basin is connected to the Senegal at Richard-Toll, it is not actually a Senegal tributary. This is because Lake Guiers is in a depression, with a resulting water surface below sea level (-2 IGN ±), and lower than the Senegal. This water remains suitable for irrigation throughout the year, and thus permits double cropping. During those periods of the year when the Senegal river at Richard-Toll is not saline, water from the Senegal is diverted into the polder for a supplemental supply. Rice yields under poor farm management conditions here have averaged 1,500 kg/ha per harvest, with two crops per year being possible. Under good management, yields of 2,500 to 5,000 kg/ha per harvest have been realized. At the present time all Richard-Toll lands (with the exception of some experimental plots) are being converted to sugarcane production.

27. The activities of SAED, beginning in 1965, have resulted in the development of the following areas in the Delta for one- of crop of rice per year, except where indicated otherwise:

Djeuleuss-Thiagar	1,900 ha	
Boundoum North	3,135	
Kassak North	795	
Kassak South	485	
Grande Digue	425	
Telel	610	
Lampsar	1,000	(880 ha cultivated)
Debi	450	(260 ha cultivated)
Savoigne	400	(primarily for tomato cultivation)
Total	9,200 ha	

(Note: Another 1,000 ha were developed by SAED during the same period, but have been temporarily abandoned.)

28. On the Mauritanian side of the Senegal in the Delta region, only the irrigated area near Rosso is of any significant size -4,000 ha total, with 1,000 ha cultivated per year. Here again, only a single irrigated crop can be grown because of river salinity during low flow periods.

SAED Investments in Delta Irrigation Development

29. During the eight-year period 1964 through 1971, SAED expenditures on research, planning, design, construction, maintenance, and operation of works for the irrigation of Delta lands, has totalled more than 3.8 billion CFAF (US$15 million). Some of the principal investments have been as follows:

Item	COST	
	CFAF	US$
Grand Perimeter Dike - 84 km	850,000,000	3,400,000
Pumping Stations (9)	285,000,000	1,140,000
Rice Factory & Silos	145,000,000	580,000
Canals, Drains, Earthworks and related structures	686,000,000	2,744,000
Housing & Buildings	224,000,000	896,000
Dike Maintenance	130,000,000	520,000
Studies, Research, Technical Assistance	527,000,000	2,108,000

The remainder of the funds has been used for operating and maintenance expenses, purchases of machinery and equipment, and miscellaneous construction. Names and locations of the SAED projects are shown at Map 2984.

Flow Characteristics of Senegal River in Delta Region

30. Many years of records are available on water levels at several stations along the river, the earliest known being of water levels measured at Richard-Toll from 1823 to 1827. At Dagana, located just before the beginning of the Delta proper, continuous records since 1916 are available.

31. Two of the most striking features of this river in the Delta are: (a) the fact that the Atlantic Ocean influences river levels more than 260 km inland, and river salinity more than 200 km inland; and (b) the regular annual pattern of a single flood per year, having a slow rise and fall extending over several months.

32. In June or July flows begin to increase in response to the start of the rainy season in the headwaters area. At Dagana (190 km) flood crests occur between September 16 and November 23. At Debi, highest levels generally are reached five to seven days after Dagana crests. During the flood season the river waters downstream past Debi are suitable for irrigation.

33. Saline water begins to appear at Debi in December, but the intruding wedge does not reach Dagana until about June. At Debi the water is unsuitable for irrigation usually from sometime in December until the following August. At Dagana the maximum period of excess salinity is only about one month. The change at Dagana from a saline to a non-saline condition takes place fairly rapidly at the beginning of the new water year. Normally the water becomes useable in June or early July, salinity levels dropping to less than 100 ppm within a few days, and the water remains useable until the very low flows of the following late-spring season.

34. Historical flow records downstream from Dagana are not available because of the difficulties of measurement under the strong tidal influence. At Dagana some of the principal flow characteristics are as follows:

Drainage area (190 km)	268,000 km^2
Average annual discharge 1903-644 (62 years)	691 m^3/sec
Maximum annual discharge 1924-25	969 m^3/sec
Minimum annual discharge 1941-42	406 m^3/sec
Estimated maximum flood, October 4, 1936 at +4.50 m IGN	3,570 m^3/sec
Estimated minimum daily discharge June, 1942-43	4 m^3/sec
Approximate average June discharge	33 m^3/sec
Lowest average July discharge	70 m^3/sec

Future River Regulation by Dams

35. Preliminary studies have been made, and further studies are in progress by UNDP-FAO, to assess the potential feasibility of regulating the Senegal River by means of one or more large dams. No conclusions as to feasibility can yet be drawn, but some of the preliminary findings are of interest.

36. High Dam in Upper Valley. Several sites have been investigated. Currently the more feasible of the high dam alternatives seems to be a dam at Manatali, on the Bafing river, in Mali. The estimated cost of the dam and hydroelectric plant is about US$114 million. It would provide, in addition to electrical energy, a minimum flow of 300 m^3/sec downstream. This

would permit navigation beyond Bakel, and prevent excess salinity from occurring in the Delta above Debi. If any of this minimum flow were to be diverted from the stream for irrigation, the saline tongue would advance upstream of Debi, the distance depending upon the amount diverted.

37. Low Dam in Lower Delta. A long, low dam in the Lower Delta, near Diama (28 km) would prevent salinity intrusion beyond that point. It also would permit navigation by means of locks, and reduce pumping lifts in the Delta region. It would permit the irrigation of an additional 50,000 ha of Delta lands. Estimated construction cost would be about US$28 million or more.

38. High and Low Dam. If both the preceeding dams were to be constructed the irrigation benefits would be increased greatly, with no decrease in the other beneficial uses of the river water. The feasibility of such a combination has not yet been studied.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Irrigation Systems - Dagana

Existing Situation

1. The Dagana project covers a total area of 5,000 ha within a large bend of the Senegal River about 200 km by river from the Senegal mouth (see Map 3984). It is bordered on the south by a low plateau, upon which runs the main Saint-Louis/Dagana/Matam highway. It is separated from the river by a pronounced levee whose elevation varies from about +5.00 m IGN on the upstream end of the project to about +4.00 m IGN on the downstream end. The levee is breached by three small channels, one of which plays a key role in the project, and, by a much larger and deeper opening or depression which occurs at Dagana, on the far downstream end.

2. Approximately 3,500 ha would be included in the project area, of which 2,700 ha would be irrigated. At present the area includes 160 ha of rice and 480 ha of sorghum traditionally cultivated on flood lands. Double-cropping of 1,420 ha of rice and 1,310 ha of assorted crops (polyculture) would be possible, since irrigation water of suitable quality would be available on a year-round basis. Selection of lands for irrigated farming has been based on analysis of detailed soil surveys.

Proposed Development Plan

3. Complete water control is planned, with water being provided on a 12-month basis to farms of three ha each. In addition, major earth moving, land planing and the construction of farm ditches and drains, would be performed as part of project development.

4. The soils and topography are such that the irrigation systems can be planned conveniently in three independent sectors, each having varying proportions of rice and polyculture (see Table 1).

Dagana Subproject

Table 1: NET IRRIGABLE AREAS

Principal Crop	Sector A	Sector B	Sector C	Total
	(----------Hectares			----------)
Rice	610	720	90	1,420
Polyculture	114	912	204	1,230
Orchard	-	-	80	80
Total	724	1,632	374	2,730

Sectors A and B would have a common drainage system, but Sector C would, to a large extent, be independent of the other two sectors.

5. Each sector would be equipped with its own pumping station, with electricity supplied by diesel driven generators. Station B would function solely to lift irrigation water, with drainage from Sector B flowing into Sector A. Station A would lift irrigation water to both a high and low service areas, within the sector, and would handle drainage from both Sectors A and B. Station C would lift water to high and low service areas in Sector C, as well as pumping, or passing, drainage water from the sector.

6. Irrigation canals would be unlined. The network in each sector would be closely regulated by a system of automatically-operating Neyrpic-type gates and vanes. The system would be designed to minimize pumping and manpower requirements.

7. A large natural channel ("D" on Map 10041) would serve as an important water flow regulator for Sector B, permitting the Station B pumps to operate on a 24-hour basis even though polyculture irrigation would be done primarily on a 12-hour basis. Another very important reservoir, to be located near Pumping Station A, would have a dual function. Firstly to store excess drainage water from Sectors A and B during storm periods, when the runoff and subsurface drainage exceed the capacity of Station A pumps. Secondly to store and transmit fresh water, which would be conveyed from Station B via Channel D and a main drain, during those times (maximum time of two months) when Station A cannot pump from the Senegal because of excessive salinity.

8. Rice fields would be within dikes built along contour lines at least 30 m apart, with differences of 10 cm in water level between adjacent paddies. Dike heights would be about 45 cm. The lands would be rough-levelled and drainage ditches installed, prior to first year of cultivation, to reduce erosion and improve yields.

9. In the polyculture zones furrow irrigation is contemplated, with prior land levelling to be executed by the "touches de piano" method (all furrows need not be at the same slope in a single field). Plastic siphons would be used to convey water from the farm ditches to the furrows.

10. A network of principal and secondary roads and small bridges would provide internal access. Road surfaces would be of compacted lateritic materials, which have proved to be well-adapted to the traffic and weather conditions in the project area.

11. As stated in Annex 8 fresh water from the Senegal River would be available every year at all three pumping stations until April. In May and June water would be available at Stations B and C, even in the driest years. Saline water could occur frequently at Station A, for about a month, near the end of May. Fresh water would again be available at Station A by the end of the first week in July, or possibly earlier.

12. In an exceptionally dry year, which can be predicted in advance by hydrologic data, water may be excessively saline for a brief time at Pumping Station C, or (a more remote possibility) at Station B. In this event, the summer (flood) season crop planting dates could be delayed by a few days without unduly upsetting farming operations for the remainder of the year.

13. When river water at Station A is too saline, water from Station B could be conveyed to Station A by means of Channel D, one of the main drains, and the large reservoir near Station A. This would occur only in late May, June, or early July, and there would be some reserve pumping capacity in Station B to permit this, if desired.

14. Most of the time the water quality at all three pumping stations would be excellent, having less than 100 parts per million of dissolved solids.

15. Peak pumping rates at the pumping stations would be as shown in Table 2.

Dagana Subproject

Table 2: PUMPING RATES

Station	Month	Peak Pumping Ratio Each Station (m^3/sec.)	Peak Pumping Ratio Each Station (m^3/hour)	Peak Combined Pumping Rate (m^3/sec.)	
A	July	1.800	6,500	July	1.800
B	Dec.	2.520	9,100	July	2.386
C	July	0.629	2,300	July	0.629
			Total		4.815

16. Peak delivery rates would be as shown in Table 3.

Dagana Subproject

Table 3: MAXIMUM UNIT FIELD DELIVERY RATES

Rice			
Pre-irrigation (Imbibition)	4.6	1/sec/ha	(3 days)
Period of Submersion	2.5	1/sec/ha	
Polyculture			
24-hr continuous	1.0	1/sec/ha	
12-hr per day	2.0	1/sec/ha	

NOTE: Above rates include field losses (70% efficienty for polyculture), but do not include conveyance losses.

Specific Project Works

17. The principal elements of the proposed project are summarized in the following paragraphs (see Map 10041).

18. A major perimeter dike, 18,900 m in length, would protect the area from flooding by the Senegal River. It would be continuous, extending in a semi-circular loop from the high ground at Dagana in the west to Gae in the north, and terminating on the high ground near Bokhol in the east.

19. A very careful study was made of the design crest height, in which computer calculations of the Senegal River Delta area made by SOGREAH for FAO were utilized. These calculations gave flood levels to be expected under a great number of conditions, including the diking of both the left and right banks of the Senegal, and the construction of a Delta dam near Diama. A crest elevation of +5.60 m IGN on the eastern (upstream) end of the project was selected, grading down to +5.30 m IGN at Dagana on the downstream end. This would provide a freeboard of 0.55 m above the 100-year flood crest with dikes at Dagana and downstream on the right bank.

20. Most of the dike would be from 0.5 to 1.5 m high, but a Station A a maximum height of 4 m, for about 150 m in length, would be required. A very short dike section near Station B also would be higher than 1.5 m. The standard crest width would be 1.5 m, except in the deeper sections where an increased width would be appropriate to facilitate maintenance, or where the crest is used as a roadway. In the latter case the crest width would be 5.0 m. Generaly, however, roadways are inside the dike and the crest would not be used for vehicular traffic. Side slopes would be 2 on 1 up to a maximum height of 3 m. The lower portion of any dike cross-section with a height greater than 3 m would have 2.5 on 1 side slopes.

21. The irrigation canal network has been planned to bring as much land as possible of fairly regular topography and suitable soils under irrigation, without excessive costs. There would be three separate canal networks, corresponding to the three area sectors specified in paragraph 4 of this Annex, and each would be served by its own pumping station. Canals would unlined. If a canal were to cross an area where the soil permeability would cause excessive conveyance losses, buried plastic members would be used to reduce seepage. While such areas are not expected to be extensive, their number and extent will not be known until field samples are taken at fairly close intervals along the proposed routes. Some field sampling has been done, which indicates that canals not greater than 1.00 m to 1.20 m in depth will probably not experience excess seepage.

22. Control of water levels and rates of flow in primary, secondary, and tertiary canals would depend upon Neyrpic-type gates, sills, modules, dividers and orifices. Such devices are expensive, but greatly reduce the numbers of required ditch riders and gate tenders, conserve water, and permit prompt response to the canal system requirements. The project consulting engineers have had previous experience with these systems in lesser

developed countries, and believe that the increased investment costs are fully justified by the better water control attained and reduced labor and management costs.

23. The canal network in Sector B would make special use of natural Channel "D", not only as a canal, but also as a regulating reservoir. It has sufficient capacity within its normal operating levels to enable it to store one-half of the daily polyculture area water requirement. Thus the pumps could operate at a lower rate for 24 hours, although the canal network must have the capacity to carry 12-hour polyculture and 24-hour rice irrigation requirements.

24. In late May, June, or July, in those years when river salinity at Station A would prevent pumping into the system at that point, extra pumping capacity at Station B could be used to pump water into the A Sector. The water would go into Channel D, down a drain in Sector A to the large reservoir near Dagana, and thence to Station A where it could be re-pumped to Sector A canals. Under the cropping plan contemplated, this procedures would seldom be needed, but it is a desirable safety feature.

25. The project drainage system would perform three important functions:

(a) remove excess surface runoff from storms;

(b) handle large quantities of rice field drainage water at the end of the rice-growing season;

(c) keep the subsurface groundwater levels below the crop root zones where necessary.

All drains would be of the open-ditch type.

26. All drainage from Sectors A and B would be disposed of through Station A, by gravity and/or pumping, depending upon the relative elevations of the river and the large drainage storage reservoir near Station A.

27. Rice field drainage could be handled within the pumping capacity of Station A, if this can be done within 14 days. Should a shorter time be desired because of the crop calendar, reservoir storage would be required. Sector C rice field drainage would be easily handled by Station C pumps.

28. Subsurface drainage (Item c) would require field drains about 2 m deep at a spacing of 600 m, or 20 meters of drain per hectare. If a sand layer were to be found less than 2 m beneath the surface, the depth could be reduced. Costs of these field drains are included as part of the project costs.

29. Drainage of storm runoff (Item a) is more critical, even when the rice fields are depended upon to store temporarily some of the excess runoff. A natural storage basin exists near Station A and Dagana. The project would have this storage increased by a perimeter dike with crest elevation +1.50 m

IGN, length of 8,100 m, a crest width of 0.5 m, and side slopes of 2 on 1. The reservoir so formed would have a surface area of 225 ha, and a storage volume of 2,290,000 m^3. This storage, plus the volume which could be removed by the Station A pumps (about 790,000 m^3 in 72 hours), could prevent crop damage if storms deposit no more than about 145 mm in two days on the area.

30. However, a 50-year frequency rainstorm could cause flooding such that 40% of the wet season harvest in Sector A rice could be lost. If the largest rainfall ever recorded in the last 100 years (240 mm in one day) occurred again, in August, almost all of the Sector A rice crop would be lost, and the excess might not be drained out of the sector in time to permit planting of the dry season rice crop. These risks should be recognized, but are not considered excessive.

31. The reservoir also could serve as fresh water storage for Station A during the late spring months, and could receive additional fresh water from Station B, see para 7.

32. Pumping Stations. Three low-lift pumping stations, one for each sector, would be constructed to elevate water to the lands to be irrigated. Stations A and C also would pump drainage water during times when the river levels are above the inside drainage canal water levels. When the drainage canal water levels are above river levels, drainage would leave the area by gravity flow through gates in the pumping stations. Station B would perform no drainage function. Station A would handle drainage water from both Sectors A and B. Both Stations A and C would have high and low irrigated service areas.

33. Major machinery elements for each station would be as follows:

Station A

Pumps - Four identical helix-type

Capacity of each at total manometric head of 4.15 m = 2,500 m^3/h

Capacity of each at total manometric head of 2.45 m = 2,750 m^3/h

Total capacity at total manometric head of 4.15 m = 10,000 m^3/h

(Note: Drainage pumpage requirements are greater than maximum irrigation requirements, and govern maximum total discharge capacity.)

Pump Motors - Electrical, 50 KW each, 220/380 volts, 50-cycle

Generators - Three identical alternators: 200 kva, 220/380 volts, 50-cycle

Three diesel engines: 240 hp each at 1,000 rpm

Total installed generator capacity - 600 kva

(one generator provided for reserve)

Station B

Pumps - Four identical helix-type

Capacity of each at total manometric head of 6.80 m = 2,460 m^3/h

Capacity of each at total manometric head o 3.50 m = 3,100 m^3/h

Total capacity at total manometric head of 6.80 m = 9,840 m^3/h

Pump Motors - Electrical, 90 kw each, 220/380 volts, 50-cycle

Generators - Three identical alternators 350 kva, 220/380 volts, 50-cycle

Three diesel engines: 400 hp each at 1,000 rpm

Total installed generator capacity - 1050 kva

(one generator provided for reserve)

Station C

Pumps - Two identical helix-type

Capacity of each at total manometric head of 6.80 m = 1,300 m^3/h

- One centrifugal pump

Capacity at total manometric head of 3.00 m = 575 m^3/h

Total capacity = 3,175 m^3/h

Pump Motors

For 1,300 m3/h pumps: Electrical, 45 kw each, 220/380 volts, 50-cycle

For 575 m^3/h pump: Electrical, 11 kw, 220/380 volts, 50-cycle

Generators

Three identical alternators: 135 kva, 220/380 volts, 50-cycle

Three diesel engines: 150 hp each at 1,000 rpm

Total installed generator capacity = 405 kva

(one generator provided for reserve)

34. Each station would be equipped with necessary cranes, internal drainage pumps, fuel storage tanks, electro-mechanical switching and control equipment, and other necessary gates, valves, piping, and equipment. The buildings would be similar in design, but not identical. Machine shop space would be provided.

35. Land Clearing and Preparation. A considerable portion of the area is covered by trees and other vegetation of the Sub-Sahara climatic zone, which would be removed before construction of the farm irrigation systems. It is proposed also to deep-plow or subsoil to a depth of about 40 cm, to remove small vegetation and loosen the topsoil prior to land levelling.

36. Estimates of tree population densities were made with the aid of aerial photographs. Estimated areas and tree densities, and per hectare clearing costs, are presented in Table 4.

Dagana Subproject

Table 4: ESTIMATED TREE DENSITIES, AREA, AND UNIT CLEARING COSTS

Sector		Tree Densities, in Trees/Ha			
		0-20	20-60	60-90	More than 90
A		470	183	-	10
B		1149	357	94	5
C		199	134	27	30
Total		1818	674	188	45
Cost/ha	CFAF	10,000	26,000	40,000	65,000
	US$	40	104	160	260

Cost of deep plowing and subsoiling have been estimated at CFAF 17,000 ha (US$68/ha).

Land Levelling, Farm Canals and Ditches

37. All farmlands would be shaped and sloped to the degree deemed necessary to provide a basis for good yields in the first years of farming. Farm canals and drainage ditches, with the necessary structures, would also be provided.

38. Land levelling estimates were made by preparing detailed studies of about 10 ha of typical rice lands, and about 30 ha of typical polyculture lands. 1/2000 scale maps with 10 cm contours were used. The polyculture lands were further divided into three general classes, ranging from mild slopes to fairly irregular topography.

39. For rice lands, small dikes, or rice checks, would be laid out at contour intervals of about 10 cm. Minimum distance between checks would be 30 m. Check heights would be 0.45 m. The land between checks would be rough-levelled by bulldozers, with earth-moving limited to a 100 m distance. Following these operations, the final irrigation ditches, drains, and structures would be installed. For polyculture, levelling would be done using the "touches de piano" method. This method can be used for land to be irrigated by furrows, and permits adjacent furrows to have slightly different longitudinal slopes; it therefore requires less earth-moving per hectare. Water would be obtained from farm distribution canals by means of plastic (PVC) siphons, or similar devices.

40. Certain areas of the polyculture lands include some fairly irregular slopes, and thus require the use of a number concrete drops or chutes to dissipate excess energy in the distribution canals. Consequently, unit development costs would be higher for such areas.

41. Unit area development costs for all of these items are summarized in Table 5.

Dagana Subproject

Table 5: ESTIMATED COSTS PER UNIT AREA OF LAND AND CONSTRUCTION OF FARM CANALS AND DITCHES

	Category of Cultivated Land	Estimated Cost per Hectare	
		CFAF	US$
(a)	Rice	54,100	220
(b)	Polyculture		
	Class 1 - Slope between 0.1 and 1.2%	40,100	160
	Class 2 - Slope more than 1.2%	183,700	735/1
	Class 3 - Slope less than 0.1%	47,900	190

/1 Including calibrated drop structured weirs in quaternary channels, mainly in Sector C. Only 210 ha of class 2 lands are included. Development costs for these lands represent about 3% of total project costs.

42. Roads. The main paved highway up the Senegal River from Saint-Louis passes through Dagana just south of the southern project boundary. Within the project area it is proposed to construct a principal and a secondary road system. Both would be constructed of lateritic materials which are located within a distance of 4 km of the center of the polder. Such roads have proven to be very satisfactory in the Senegal Delta region.

43. Principal roads would be an average height of 15 cm above the surrounding surface. The top width would be 7 m, with the road surface being 5 m wide. Secondary roads also would be 15 cm above natural ground surface, have top widths of 5 m and a traffic surface of 3.5 m. All bridges across canals and ditches would be only as wide as the road. All agricultural machinery planned for use by the project could cross these widths.

Construction Costs

44. The planned construction period would be three years. Table 6 summarizes the major elements of construction costs net of contengencies.

Dagana Subproject

Table 6: SUMMARY OF ESTIMATED CONSTRUCTION COSTS
(all taxes and duties included)

Item	Cost CFAF	Cost US$
Engineering Services	102,600,000	401,000
Perimeter Dike	39,000,000	156,000
Irrigation Network	252,867,000	989,000
Drainage Network	151,000,000	604,000
Pumping Stations	253,990,000	993,000
Land Clearing and Preparation	89,900,000	359,600
Land Levelling and Farm Irrigation Works	137,700,000	550,800
Roads	35,800,000	143,200
TOTAL	1,062,857,000	4,155,000

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Irrigation System - Debi

Existing Situation

1. The Debi subproject area is located inside a bend of the Senegal river in the lower Delta (see Maps 3984 and 10008). It is a depression or cuvette, typical of the Senegal River Delta and Valley region. Its southern boundary is the "N'Depetout" river slough (marigot). The relief is slight, with the lowest elevations being about +0.50 m IGN above sea level. The plain is bounded naturally by alluvial river banks having elevations of about +1.5 to 1.7 m IGN. Total surface area is around 1,500 ha, but less than 75% of this is suitable for irrigation development. An existing large dike with crest elevation +3.88 m IGN, built in 1963-65, protects the area on the west and north from Senegal river floods. The ten-year frequency river flood level is +1.75 m IGN, and the 100-year level about +1.80 m IGN. This dike is 84 km in length, and extends in both directions beyond the Debi area (Line E5-I-M-L on Map 10008). Presently, approximately 260 ha are in elementary rice cultivation, the water being both supplied and drained by gravity through a dual-function structure on the west side (E5 on map 10008).

Proposed Development Plan

2. The cuvette would be divided into two topographic zones for irrigation, with maximum variations in elevation in each being 30 cm.

Zone I - Land varying in elevation from	+0.5 to +0.8 m -	340 ha
Zone II - Land varying in elevation from	+0.8 to 1.10 m -	685 ha
	Total	1,025 ha

A dike with crest elevation +1.70 m IGN would separate the two zones ($B-C-N-O-E-E_2$).

3. Only soils having electrical conductivities of their 1/10 saturation extracts of 1,000 microombos or less, would be considered suitable for rice cultivation and would be included in the area to be developed under the project.

4. Water would be pumped, or allowed to enter by gravity flow, from the Senegal river through a pumping station to be constructed under the project (Point M). From there it would flow by gravity through a simple

network of unlined canals. The water level in the canals will be above ground surface. In Zone I the maximum water level would be about +1.30 IGN, with +1.10 IGN to +1.20 IGN being the normal field and canal water surface elevations during flooding. In Zone II the maximum water level would be about +1.00 IGN, and the normal flooding elevation about +0.80 m IGN to +0.90 m IGN. Only one irrigation season per year is planned, and this during the period of flood (fresh) water flow.

5. The water delivery canals would serve also as drainage canals for excess surface run-off, and for draining the polders at the end of the rice flooding season.

6. Water would drain from the rice areas into the N'Depetout slough through drainage structures E2 and H1. The slough would empty into the Senegal river through the existing structure E5.

7. Static rice irrigation depths in each area would vary from a minimum of 20 cm to a maximum of 50 cm, as compared to a present depth range of twice these levels. This would be a substantial improvement in the degree of water control, and rice yields are expected to increase in response to the decreased average depths of submersion. However, the planned system is not intended to provide full water control immediately. This would be attained only after additional development work not included in the present project.

8. Since there are adequate access roads to the area from three directions, no additional road construction is included. The crest of the main exterior dike is 5 m wide, and would serve as a primary access route in two directions. The interior dikes would have crest widths of 3.5 m, and would be used for internal travel. While these roads have only earthen surfaces, they would be well-compacted, and would serve satisfactorily under the area weather and traffic conditions.

Water Supply

9. Water can be pumped from the Senegal as soon as it becomes fresh at the start of the new flood season each year. This usually occurs about the middle of August. As the river reaches a level above that of the canal water (about +1.50 m IGN), pumping can be stopped, and gravity flow used to supply water. The flood period usually lasts from three to four months. During this time the quality of the water is excellent, with total salinity being 100 parts per million, or less.

10. Maximum design flow is 3.8 m^3/sec, or about 3.7 l/sec/ha and allows for percolation losses which are expected to be at peak during the period of preirrigating prior to seeding. Maximum flow will be achieved when irrigation is by gravity. Maximum pumped flow, for regular irrigation, is 2.5 m^3/sec, or 2.45 l/sec/ha. These amounts are a very small fraction of the river flow during the time the water is suitable for irrigation.

Specific Project Works

11. The following are the principal elements of the project works (see Map 10008):

(a) An elementary canal network to deliver water, and at the end of the irrigation season, to act as the drainage network. Water from the canal would spread out over the fields, with no offtake structures being required, since the canal water levels are above ground surface. The network is comprised of primary and secondary canals only.

(b) A network of dikes of two types to complement the existing Senegal river perimeter dike (see para 1):

(i) Three small exterior dikes, primarily to protect against surface runoff, Dikes B-L and E2-1 are to be built to elevation +1.7 m IGN, and Dike h2-h3 to elevation +1.4 m IGN.

(ii) An interior dike built to elevation 1.7 m (B-C-N-D-E-E2), to separate Zone I from Zone II. Crest width is 3.5 m; side slopes 2 on 1.

(c) A main drainage ditch, already existing in the form of the N'Depetout slough.

(d) A pumping station (M), which also permits gravity intake from the river when its surface is above that of the interior canals. Maximum static pumping lift is about 1.5 m, with a discharge of 2.5 m^3/sec. A helix pump with capacity of 9,360 m^3/hour (2.6 m^3/sec), and total manometric head of 2.5 m is planned. Power would be supplied by a diesel engine of about 140 cv.

(e) A main intake and supply canal, O-M-N.

(f) A diversion structure (C), which takes as the intake to the secondary canal which supplies Zone 1;

(g) Two drainage outlet structures, H1 and E2; and

(h) A main drainage outlet, E5, which already exists.

Construction Quantities and Costs

12. Principal construction categories and estimated capital costs net of contingencies are shown in Table 1.

DEBI POLDER

Table 1: PRINCIPAL CONSTRUCTION CATEGORIES AND COSTS (INCLUDING TAXES)

	COST	
	CFAF	US$
Engineering	7,500,000	29,000
General Earthwork, Canals & Dikes	24,443,000	96,000
Earth excavation - 76,000 m^3		
Earth fill - 29,000 m^3		
Pumping Station	27,052,000	106,000
Concrete, plain and reinforced, 440 m^3 plus gates, steel, other materials		
Pumping Station	22,800,000	89,000
Pumps, diesel engines, and auxilliary equipment		
Other Structures	5,100,000	20,000
101 m^3 of concrete, plus metalwork, gates, and other materials		
TOTAL	86,895,000	340,000

The planned period of construction is 12 months.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Irrigation System - Lampsar

Existing Situation

1. The Lampsar project area is northeast of Saint-Louis, adjacent to the main highway between Saint-Louis and Rosso, and between the towns of Makhana and Ross-Bethio (see Maps 10042 and 10054). It consists of seven small depressions (cuvettes), two on the right bank of the Lampsar Valley and five on the left bank. The project area is considered part of the Middle Delta region, although technically the two downstream cuvettes could be described more correctly as being in the Lower Delta. Of the total area of 2,000 ha, about 1,100 ha would be irrigated for rice production. The areas to be developed range in elevation from +0.5 m IGN to +1.25 m IGN. Due to extremely poor water management and lack of drainage, rice yields are very low on the approximately 880 ha presently cultivated in the area.

Proposed Development Plan

2. A simple system of water control is proposed for the project. A single water level would be provided for each cuvette when the rice is submerged, supplied only by a simple network of primary canals. There would be no interior secondary or tertiary canals. The area to be developed in each cuvette has been selected so that the maximum variation in ground surface would be between 25 cm and 35 cm. Static water depths for a constant level during the submersion period would vary, therefore, from a minimum of 20 cm over the higher ground surfaces, to 55 cm over the lower elevations.

3. Soils vary within and between the seven cuvettes and most of the microrelief is irregular. Areas considered suitable for rice cultivation are as follows:

Cuvette	Range Ground Surface Elevation (m IGN)	Net Area to be Cultivated (ha)
2a	0.80 - 1.10	136
2b	0.80 - 1.15	138
3a	1.00 - 1.25	50
3b	0.90 - 1.20	265
4	0.75 - 1.10	230
5	0.50 - 0.85	140
7	0.50 - 0.75	124
		1,083 ha

4. Water would flow by gravity through intake structures on the Lampsar, a stream which presently receives its main supply from a pumping station at Ronq on the Senegal River. The Lampsar is also the source of water for the city of Saint-Louis. Its water levels are controlled by existing gated structures upstream at Ross-Bethio, and downstream below the confluence of the Lampsar and the Djeuss, at Dakar-Bango. The planned water level at the intakes is about 1.75 m IGN. An older control dam at Makhana can also be used to improve water control on the lower Lampsar. Additional control gates would be installed by 1974 at a joint bridge-control structure at Savoigne to be financed by FAC.

5. The water delivery canals would also serve as drainage canals to remove excess surface runoff, and to remove water at the end of the rice flooding season.

6. All cuvettes would be drained by lowering water levels, which would permit backflow from the cuvettes through the intake works to the Lampsar.

7. A series of exterior dikes, built to elevation +2.00 to +2.05 m IGN, would protect the project areas from waters of the Lampsar and the Djeuss.

8. Since the area is adjacent to the main paved road in the Delta, no access problem exists. Interior access would be improved by using the 3.5 m wide dike crests as roads.

Water Supply

9. While the cuvettes will obtain water directly from the Lampsar, the stream itself is supplied primarily by an 18 m^3/sec pumping station at Ronq, on the Senegal 113 km upstream, supplemented by gravity flows during higher Senegal floods. The pumping station was built by SAED in 1969. Pumping can begin each year at the start of the new flood season, which usually occurs about the middle of August. The flood period normally lasts from three to four months. During this time water quality is excellent, total salinity being 100 parts per million, or less. Pumping can usually continue at Ronq until sometime in mid-December, or as late as the end of January, when the water starts to become too saline for the City of Saint-Louis.

10. Irrigation requirements are based on flows of 4.5 l/sec/ha during preirrigation flooding, and 2.5 l/sec/ha during the time of maximum submersion of the rice. Total maximum required flow is 4.9 m^3/sec, including water losses. This rate can be supplied within the capacities of the pumping station, canals, and channels.

11. Sufficient water must be in storage prior to the closing of the Ronq pumps. This is done to supply the City of Saint-Louis through the dry season until the Senegal floods again in August. This requirement, plus the lack of fresh water in the Senegal at Ronq after January, restricts

rice production to one crop per year. After drawdown of the Lampsar in December for drainage of the rice fields, river levels must be raised again before the salinity rises at Ronq, so as to provide at least 6,000,000 m^3 water reserve for Saint-Louis. SCET studies indicate that this can be done.

Specific Project Works

12. The following would be the principal project works (see Map 10042 and 10054):

(a) A series of exterior dikes to protect each cuvette from the high waters of the Lampsar and/or Djeuss Rivers. Crest levels would be +2.00 or 2.05 m IGN with a free board of 30 cm, crest width 3.5 m, and side slopes 2 on 1. In the case of Cuvette No. 5, the work would consist of increasing the height of an existing dike, rather than constructing a completely new dike.

(b) A simple system of unlined primary canals, which would serve as both supply and drainage conduits. During supply, canal water levels would be above ground surface. Hence their upper portions would be merged with the large ponded surfaces of the rice areas during the time of submerged growth. Where possible, canal routes would follow old river beds or swales, in order to minimize excavation. Bottom widths would vary from 0.50 m to 3.00 m. Side slopes would be 1 on 1.

(c) Two types of hydraulic structures: Intake works which would also serve as drainage outlet works, and simple box culverts to carry water under roads or dikes. Reinforced concrete would be the principal construction material. Metal slide gates would be incorporated to control water flow.

13. Also essential to project operations are the following existing works:

(a) the diversion works and pumping station on the Senegal at Ronq;

(b) the Gorom-Lampsar canal system; and

(c) the gated water control works at Ross-Bethio, Dakar-Bango, and Makhana, on the Lampsar.

Construction Quantities and Costs

14. Only one year is needed to complete the engineering designs and construction work. Principal construction categories and estimated capital costs net of contingencies are as follows:

Principal Construction Categories and Costs (Including Taxes)

Polder	Earthwork: Canals and Dilekes			Structures: Concrete, Gates, Steel, Excav., Misc.		Total Costs	
	Excavation	Fill	Cost	Concrete	Cost	CFAF	US$
	m^3	m^3	CFAF ('000)	m^3	CFAF ('000)	('000)	('000)
Engineering						4,500,000	17.5
1a - 2b							
Quantities	9,200	52,000		20			
Costs			26,155		1,995	28,150,000	110.1
3a							
Quantities	6,600	--		12			
Costs			2,550		1,340	3,900,000	15.2
3b							
Quantitie	5,320	30,640		66			
Costs			13,100		6,500	19,600,000	76.6
4							
Quantities	12,800	32,600		123			
Costs			14,300		3,750	18,050,000	70.5
5							
Quantities	1,880	17,470		45			
Costs			7,200		1,500	8,700,000	34.0
7							
Quantities	740	42,750		52			
Costs			16,650		1,550	18,200,000	71.1
			TOTAL COSTS			101,100,000	395.0

Special Considerations

15. Of some concern is the potential impact of the Lampsar subproject on the city of Saint-Louis water supply, since the Lampsar serves as the principal source of municipal water for that city (see para 11). To drain the seven cuvettes comprising the subproject, the level of the Lampsar would have to be lowered to +0.50 IGN each year at the end of the irrigation season, December. Then the Lampsar would be filled again immediately by pumping at Ronq to provide reserve water for the city. Future city needs may require even more valley storage. The consultant, SCET-International, is undertaking a separate FAC-financed study beginning in December 1972, to be completed by June 1973, on the future water requirements of Saint-Louis and the most feasible means of meeting these needs. The study would clarify the amount of Lampsar valley storage needed in the future, and whether or not the Lampsar irrigation subproject would have any adverse effect on the city water supply. For this reason it is proposed in the main report that condition of disbursement for the Lampsar subproject would be the resolution of this question, to the satisfaction of the Bank.

16. Parts of the main Saint-Louis/Rosso highway embankment between Ndiol and Ross Bethio, where if forms the eastern boundary of Cuvettes 3a, 3b and 4, will have water ponded against them when the Lampsar water levels are raised to +1.75 IGN. Since this might weaken the highway subgrade unless a small protective barrier dike or embankment were placed on the river side of the highway additional costs of CFAF 1,000,000 (US$4,000) have been included in project costs to provide for this protection.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Dagana Training Center

General

1. Senegal has adequate facilities for basic training in agriculture. However, such training needs to be supplemented with practical in-service training.

Existing institutions include:

a) Ecole Nationale d'Economie Appliquee at Dakar, one year post graduate course;

b) Ecole Nationale des Cadres Ruraux at Bambey, Bachelor degree standard (Ingenieur des Travaux Ruraux Agricoles);

c) Centre de Formation Horticole at Camberene, subdegree standard (3-4 years after primary school; Ingenieur des Travaux Ruraux Horticoles);

d) 2 Ecoles des Agents Techniques de l'Agriculture at Louga and Ziguinchor, subdegree standard (3-4 years after primary school); and

e) 3 Centres d'Initiation Horticole at Diourbel, Thies and Saint-Louis, inferior to (c).

2. In 1972, SAED established a training center for field agents at its farm in the Savoigne polder. This center trains staff in rice extension work and would train the field agents needed for the Debi and Lampsar subprojects. Under the project a new training center would be established at Dagana to train field agents in double-cropping techniques and in the cultivation of crops other than rice. The center would be used also to: train tractor and implement operators; provide demonstrations and courses for farmers; and would include an ox training unit.

Organization

3. Permanent staff at the center would comprise a Senegalese agriculturalist who would be the chief training officer, an administrative officer, and a secretary, and these permanent staff would be financed under the project. Overall guidance would be provided by SAED headquarters which has a training officer financed by French technical assistance. The training center would collaborate closely with the staff of the project research unit which would share the center's buildings and equipment, see Annex 6.

4. Staff trainees would spend one month at the center before taking up their assignment in the field and thereafter would undertake two-week refresher courses annually. SOCAS would provide specialist training in tomato cultivation at its Savoigne farm. Tractor-drivers would be given four-day refresher courses each year.

Costs

5. Estimated costs net of contingencies of constructing, and operating the training center during the project development period amount to CFAF 24.3 million or US$95,000 equivalent. They include CFAF 7 million for building and house construction; CFAF 5.2 million for equipment (furniture, audio-visual aids and two vehicles); and CFAF 11 million for operating costs. Details of these costs are at Table 1.

ANNEX 5
Table 1

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Cost of Training Center at Dagana
(CFAF '000)

Year	1	2	3	4	Total
CONSTRUCTION					
Training Center	5,000				5,000
House: Chief Officer	1,500				1,500
House: Administrative Officer	500				500
Subtotal	7,000				7,000
EQUIPMENT					
Furniture and materials	1,000				1,000
Audio-visual aids	500				500
Vehicles (2)	1,600				1,600
Power tiller (1)	1,200				1,200
Ox training center	150				150
5 Pair of oxen and implements	500				500
Miscellaneous	200				200
Subtotal	5,150				5,150
OPERATING COSTS					
Salaries:					
Chief Officer	570	570	570	570	2,280
Administrative Officer	450	450	450	450	1,800
Secretary	300	300	300	300	1,200
Subtotal	1,320	1,320	1,320	1,320	5,280
Vehicles (2)	500	500	500	500	2,000
Operating Costs:					
Mechanized Farming	120	120	120	120	480
Oxen	100	100	100	100	400
Board and Lodging Trainees	1,000	1,000	1,000	1,000	4,000
TOTAL	15,190	3,040	3,040	3,040	24,310

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Applied Research Program in the Dagana Polder

General

1. In addition to its ongoing research programs at the Richard-Toll Station, Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres (IRAT) would carry out an applied research program in the Dagana polder to adapt results obtained elsewhere to Dagana conditions. Since research on rice in the Delta area is well advanced, IRAT would concentrate its efforts at Dagana on the other crops that are included in or considered for the Dagana cropping pattern. Trials at Dagana would include, however, fertilizer trials on rice. IRAT's Dagana operation would be sited at the Training Center. The research program financed under the project would be for the four years 1973-1976.

Research Program

2. Cereals. For maize, sorghum and wheat, trials would cover the following subjects:

- fertilizers;
- pest control;
- varieties and sowing dates;
- cultural and irrigation methods; and
- crop rotation.

Research on sorghum and wheat is advanced, and only cultural and irrigation methods have to be tested for larger-scale application. Maize is grown traditionally in the project area, and in recent years new varieties responsive to irrigation have been tested. Some additional work is required to determine which varieties would be most economic for Dagana.

3. Tomatoes, vegetables, and grain legumes. Although, in principle, applied research on these crops would cover the five principal subjects listed in para 2, not all crops require the same attention. Tomatoes have been grown successfully in the Delta since 1969 and there is no reason to believe that experience so far obtained would not be applicable to Dagana. Potatoes have been produced on small plots only, and large-scale cultivation practices have to be developed. Research on onions has been carried out by IRAT at its Tarna Station in Niger under similar ecological conditions, and only a limited number of adaptation tests would be required. Research on cowpeas is well advanced, but cultivation and irrigation methods for large-scale production have to be tested in Dagana.

4. Details on Proposed Research Subjects. In addition to fertilizer, pest control and variety experiments, experiments on cultural methods, irrigation techniques, and irrigation water consumptive use would be carried out for three years for wheat, maize, sorghum, cowpeas, tomatoes, onions and potatoes on 0.5-ha plots each, with a total of 21 experiments. Six crop rotation experiments, including three cropping patterns with either mechanical or ox-drawn implements, would be carried out for four years.

Research Costs

5. The costs of the research program, estimated on the basis of IRAT's experience and net of contingencies are given by years in Table 2. They amount to about CFAF 58 million, equivalent to US$226,500. Excluded are the costs of an expatriate research leader who would be provided by FAC under its 1972-1977 technical assistance program.

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SENEGAL RIVER POLDERS PROJECT

Applied Research Program in the Dagana Polder
(Numbers of Tests)

Year	Fertilizer Tests 1/					Pest Control 2/					Varieties 3/					Cultural and Irrigation Methods 4/	Crop Rotation
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total		
Crops																	
Rice	1	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	
Wheat	1	1	-	-	2	-	-	-	1	1	1	-	-	-	1	3	
Maize	-	-	1	1	2	-	-	-	1	1	2	2	2	2	8	3	
Sorghum	1	1	-	-	2	-	-	-	1	1	2	2	-	-	4	3	
Cowpeas	1	-	-	-	1	-	-	-	-	-	1	-	-	-	1	3	
Tomatoes	1	1	-	-	2	1	1	1	1	4	1	1	-	-	2	3	
Onions	-	-	1	1	2	-	-	1	1	2	1	1	1	-	3	3	
Potatoes	-	-	1	1	2	-	1	1	1	3	1	1	1	-	3	3	
Total	5	5	3	3	16	1	2	3	6	12	9	7	4	2	22	21	

1/ Area: 0.5 ha/test. Cost: CFAF 300,000/test.

2/ Area: 0.2 ha/test. Cost: CFAF 160,000/test.

3/ Area: 0.4 ha/test. Cost: CFAF 240,000/test.

4/ Area: 0.5 ha/test. Cost: CFAF 400,000/test.

May 3, 1972

ANNEX 6
Table 1

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Costs of Applied Research Program
(CFAF '000)

	Project Year 1	2	3	4	Total
Research Costs					
Fertilizers	1,500	1,500	900	900	4,800
Pest Control	160	320	480	960	1,920
Varieties	2,160	1,680	960	480	5,280
Cultural Methods	2,800	2,800	2,800	-	8,400
Crop Rotation	6,000	6,000	6,000	6,000	24,000
Subtotal	12,620	12,300	11,140	8,340	44,400
EQUIPMENT					
Vehicles (3)	2,400				2,400 /1
Power Tiller	1,200				1,200
Power Sprayer	1,550				1,550
Weighing Scales	250				250
Pairs of oxen and implements (3 sets)	300				300
Subtotal	5,700				5,700
PERSONNEL /2					
Senior Agronomist	1,000	1,000	1,000	1,000	4,000
Assistants (2)	960	960	960	960	3,840
Subtotal	1,960	1,960	1,960	1,960	7,840 /3
Total	20,280	14,260	13,100	10,300	57,940

/1 Included in "Project Vehicles" in Annex 9, Table 2.

/2 FAC would provide an expatriate research leader; his costs are excluded from total project costs.

/3 Included in "Local Personnel" in Annex 9, Table 1.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Existing and Required SAED Equipment

I. Existing Equipment

Agricultural Equipment

(1965/1966)	35 Caterpillar Tractors D6	
(1965)	15 Caterpillar Tractors D4	
(1965/66)	16 Fergusson Wheel Tractors	65 hp
(1967)	1 Fergusson Wheel Tractor	75 hp
(1966)	45 Disc Plows	

Heavy Equipment

(1966)	1 dragline
(1967)	2 compactor rolls
(1967)	1 land plane

II. Equipment Included in Project Costs

	1973	1974	1975	UNIT COST CIF	Total Cost 1/ CFAF 000
Wheel Tractors 60 hp	1	7	8	1.546	24,736
Sprayers		1	2	1.630	4,890
Plows		3	5	360	2,880
Disc Cultivators		4	5	285	2,565
Cultivators			1	2 235	235
Tools		1	2	100	300
Threshers 2.5t/hour		3	4	1,800	12,600
Brush Cutters		1	1	250	500
Trailers		2	2	320	1,280
Harrows		4	4	68	544
Power Tillers	2			1,200	2,400
Other					259
Tractors 65 cv	2			4,500	9,000
Land Planes	2			2,000	4,000
					66,189

1/ Without import duties.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Water Supply and Requirements

A. WATER SUPPLY

Flow Characteristics of Senegal River in Delta Region

1. The general climate and topographical features of this 1,800-km long river, having a drainage area of 300,000 km^2, have been described in Annex 1. This section summarizes the flow characteristics of the Senegal river in the Delta region, as they relate to potential quantity and quality of irrigation water, flooding, and drainage, with special emphasis on their effects on the Dagana, Lampsar and Debi sub-projects.

2. Sources of Data. Fortunately, many years of records are available of water levels at several stations along the river. The history of stream gauging and measurements of water levels on the Senegal are summarized in a treatise by ORSTOM. 1/ The earliest known records are of water levels measured at Richard-Toll from 1823 to 1827. At Dagana, located just before the beginning of the Delta proper, continuous records since 1916, or for 56 years, are available. Dagana records for 1914 and for the period 1904-11 also exist.

3. The tidal cycle of the Atlantic Ocean influences river levels upstream past Podor, some 260 km inland. Boghe, 380 km inland, is the first station whose readings are not affected by ocean fluctuations. Low flows in the river in the reach affected by tides are difficult to measure precisely. Also, the cross-sectional areas of the rivers in the lower reaches of the Valley, and in all the Delta, are subject to change during high floods. Hence there are variations in the stage-discharge curves for most key stations. Nevertheless, the intensive studies performed by ORSTOM since 1960, and by the UNDP-FAO experts since 1965, have demonstrated conclusively that good estimates can be made of stream discharges from staff gauge readings. Data analyzed and processed by these two groups are the primary basis for the descriptions of stream flow characteristics presented herein.

1/ "Apercu Hydrologique du Fleuve Senegal - Synthese provisoire des donnees hydrologiques elaborees par l'ORSTOM, by C. Rochette & P. Touchebeuf, Office de la Recherche Scientifique et Technique Outre-Mer, Mission d'Amenagement du Fleuve Senegal, January 1964.

4. General Flow Characteristics. From Bakel downstream the river follows a regular pattern annually. In June or July the flow begins to increase in response to the start of the rainy season in the southern headwaters area. There is only one flood per year. The flow increases slowly peaking 3 to 3-1/2 months later. Floods decline more slowly, in accordance with well-recognized stream hydrology patterns, reaching minimum stages in May or June.

5. At Dagana (190 km inland) the flood crests occur between September 16 and November 23. About 67% of the crests at Dagana have occurred in the period October 3-25, and 33% during the period October 16-23. At Debi, highest levels generally are reached about five to seven days after the Dagana crests.

6. As flows decrease in the Delta, saline water from the sea moves slowly inland. By early March the salinity levels at Debi are as much as 12,000 parts per million - six times the approximate maximum limits for irrigation water, and twelve times the desirable salinity limits. The intruding wedge of saline water begins to make its appearance near Dagana in June, with the water becoming unsuitable for irrigation some time during that month. The maximum period of excessively salinity is one month. At Bokhol, on the upstream side of the Dagana project area, the salinity effect is only slight, the water there normally being useable at all times. At Gae, about halfway between Bokhol and Dagana and on the north boundary of the project area, salinity can reach unsatisfactory levels for a short period of time. However, this will have no major adverse effect on proposed agricultural operations at Dagana.

7. The change at Dagana from a saline to a non-saline condition takes place fairly rapidly at the beginning of the new water year. Normally the water becomes useable in June or July, salinity levels dropping to less than 100 ppm within a few days, and the water remains useable until the very low flows of the following late-spring season.

8. Specific Flow Characteristics. Principal discharge characteristics of the river at Dagana are as follows:

Drainage area (190 km)	268,000 km^2
Average annual discharge 1903-64 (62 years)	691 m^3/sec
Maximum annual discharge 1924-25	969 "
Minimum annual discharge 1941-42	406 "
Estimated minimum daily discharge June, 1942-43	4 "
Approximate average June discharge	33 "
Lowest average July discharge	70 "

Usual July average discharge	417 m^3/sec
Earliest date of beginning of annual increased flow	June 11
Latest date of beginning of annual increased flow	July 15
Usual date of beginning of annual increased flow	June 24 to July 7

9. Because of the significant influence of tides on water levels and flows at the Debi (65 km) and Lampsar (113 km) areas water intake points, discharge measurements at those locations are extremely rare. Water level data are, however, available. Since the Lampsar and Debi projects are planned to use river water only during the months of higher flows when salinity is negligible, there is no question as to the availability of water sufficient to meet the needs of those areas during the planned months of irrigation.

10. Salinity Phenomena. The phenomena associated with the gradual intrusion of salinity upstream in the Delta region as river flows decrease following the flood season, deserve special notice. They have been studied in some detail and reported on by C. Rochette 1/, and subsequently by the UNDP-FAO study teams in the Senegal Basin. SAED-SCET has also made independent salinity measurements in the area. Among the important points noted in these studies are the following:

(a) The average river salinity in the Delta at any specific location is:

i. a function of the river flow when flows are greater than 50 m^3/sec;

ii. a function of time for flows less than 50 m^3/sec, with time "zero" being approximately the time of occurrence of flow = 50 m^3/sec during the time of gradually decreasing river flows.

(b) The date of occurrence of excessive salinity can be predicted with a considerable degree of accuracy each year, once the river discharge has clearly established its recession pattern for the dry season (this can be as early as December or January).

(c) The date of occurrence of fresh water for irrigation each year in the Delta can be forecast within about a month in any year, and within about a week, or less, in specific years once the rains increase river flows in the Upper Basin.

1/ "Remontee des Eaux Marines dans le Senegal", edited in April 164. ORSTOM. Summarized in the ORSTOM publication "Monographie Hydrologique du Fleuve Senegal - 3eme partie - Analyse des Elements du Regime Hydrologique".

(d) In 1971, which was the fourth driest year in the 42 years since 1930, maximum measured salinity at Bokhol, near the site of Pumping Plant B, was 1,000 micromhos. At Gae, further downstream and near the site of Pumping Plant C, the salinity was limited to 2,500 micromhos, which indicates a water still useable for irrigation. At Dagana, near the site of Pumping Plant A, maximum salinity was 6,650 micromhos, which was measured during the week of June 20. Two weeks later the salinity at Dagana began to decrease. On April 26, the salinity did not exceed 110 micromhos.

(e) Even with very low flows at Bokhol (4 m^3/sec or less), there remains a very large amount of fresh water stored upstream in the river channel, which tends to limit the advance of sea water.

11. Four important conclusions regarding water supply for Dagana can be derived from the foregoing studies and the area cropping plans:

(a) Fresh water will be available most years at all three pumping stations until April;

(b) In May and June useable water will be available at Pumping Stations B and C, even in the driest years;

(c) In an exceptionally dry year, which can be predicted in advance by discharge and salinity measurements at Kaedi and in the Delta, respectively, the possibility may appear of excessive salinity for a brief time at Pumping Station C, or (a more remote possibility) at Station B. In this event the flood season crop planting dates can be delayed by a few days, without unduly upsetting farming operations for the remainder of the year;

(d) While no serious problems in providing water for two cropping seasons at Dagana are foreseen under present conditions, any upstream developments which would use significant amounts of river water during low stages could, and probably would, upset the delicate saline-fresh water interface balance which occurs at Dagana each year, and cause the water at all three pumping stations to be unuseable for a period sufficient to cause crop losses in the Dagana area.

12. Therefore, while the Dagana water supply situation is considered satisfactory now, Government should make certain that present low stage flows are not impaired. In addition, more salinity and river discharge measurements should be made in the Dagana area to provide better information with which to make predictions of salinity occurrence for the project.

B. WATER REQUIREMENTS

Rice

13. Rice is the principal crop to be grown in the three project areas, would use the greatest amount of water, and require the highest delivery rates of flow. Estimates of rice water requirements were based primarily on Penman's formula, plus consideration of rice cultivation practices. For the Senegal River Delta region, Table 1 below summarizes typical rice water requirements on a per hectare basis. All field losses are included, but not conveyance losses in canals.

Table 1: TYPICAL RICE FIELD WATER REQUIREMENTS PER HECTARE

Senegal River Delta Region - Moderately Permeable Soil

Period of Culture	Duration In Days	Water Use m^3/day	Water Use m^3	Water Use 1/sec
First Campaign (June-August)				
Pre-irrigation (Imbibition)	3 (or less)	400	1,200	4.6
Submersion	15	190	4,750	2.2
Maintenance	40	110	5,500	1.27
			11,500	
Second Campaign (November-February)				
Pre-Irrigation-Imbibition	3 (or less)	400	1,200	4.6
Submersion	25	170	4,250	2.0
Maintenance	70	90	6,300	1.0
			11,750	

14. While the preceding data are representative, actual requirements would vary with the variety of rice grown, date of planting, permeability of the soil, amount of fertilizer used and degree of farming expertise. The values shown were used in planning the Dagana project. Debi and Lampsar values were slightly different. All design values are within normally expected ranges for the climate, soils, and manner of cultivation considered.

Polyculture

15. Water requirements for the various crops to be grown in the Dagana polyculture areas were estimated by Penman's method and applicable crop growth coefficients. Maximum values for Penman's Evapo-Transpiration Potential (ETP) occur in April, May and June, with May normally being the highest. These results were consistent with evaporation measurements made in the area.

16. Estimates were made of the monthly water requirements for tomatoes, corn, cowpeas, potatoes, onions, wheat, and sorghum. All of these, were combined in varying proportions to estimate the requirements for three different crop rotations. Monthly requirements, assuming 70% field efficiency, but with no allowance for canal delivery losses, are as follows:

Table 2: MONTHLY CROP WATER REQUIREMENTS - DAGANA AREA

(m^3/ha at farm headgate, assuming 70% field efficiency)

Month	Sectors A/C	Cropping Pattern Sector B
July	1,200	950
August	1,600	1,100
September	2,200	1,750
October	1,500	1,800
November	1,200	1,300
December	1,600	1,500
January	2,000	1,400
February	2,000	1,200
March	500	850
April	-	-
May	-	-
June	-	
Total	13,800	11,850

17. The preceding table makes no allowance for the amount of rainfall which may be utilized by the crop. The average annual rainfall is 310 mm, and only part of that can be used by the crop. If half of the rainfall were to become available for crop use, the error is well within the inherent reliability of the basic estimates.

18. The maximum crop rotation delivery rate requirement is during the first half of October, when 1,250 mm are required. This is equivalent to a delivery rate of 1.0 l/sec/ha on a continuous basis, and is based on maximum two-week period consumptive use estimates and 70% field efficiency.

19. For vegetables grown during the months of April, May or June, the required continuous delivery rate is about 10% higher; or 1.1 l/sec/ha. This requirement was not considered in the proposed plan.

Conveyance Losses

20. Water lost primarily by percolation from the unlined conveyance canals has been estimated for the Dagana project as follows:

Transmission distance up to 1,500 m - no increase.

Transmission distance between 1,500 and 1,700 m - increase by 20%.

Transmission distance greater than 1,700 m - increase by 25%.

Overall conveyance losses for Dagana have been estimated at between 15 and 20%.

Daily Irrigation Durations

21. Farmers would irrigate their rice fields on a 24-hour-per-day basis. This is not a difficult task.

22. For polyculture, however, it is more realistic to plan on farmers irrigating their fields no more than 12 hours in any one day. Night irrigation requires a great deal of experience and ability to be performed successfully. Polyculture irrigation at Dagana would be on a 12-hour basis. Field delivery requirements, then, would be double the continuous delivery rate, or 2 l/sec/ha in the case of the October polyculture crops. However, it should be noted that the pumping requirements for Station B are based on a 24-hour basis, even though polyculture irrigation is to be performed only on a 12-hour basis. The reason for this is that the water pumped during the 12-hour night period can be stored in Channel D, for later release during the day. Delivery canals still would have to be able to carry a double flow rate to the fields for all of Sector B polyculture.

Summary of Delivery Requirements

23. With the foregoing delivery rates and quantities as a basis, Table 3 has been prepared as a summary of key water delivery factors.

Table 3: SUMMARY OF PRINCIPAL IRRIGATION WATER REQUIREMENT FACTORS

Project Area	Maximum Flow Rates: Peak Unit Water Delivery Rates Imbibition (1/sec/ha)	Maximum Flow Rates: Peak Unit Water Delivery Rates Normal (1/sec/ha)	Area (ha)	Maximum Flow Rates: Maximum Diversion Rate (m^3/sec)	Total Annual Water Diversion (m^3)
Debi					
Rice	3.7*	2.45	1,025	3.80 (Sept.)	13,500,000 (one crop)
Lampsar					
Rice	4.5*	2.5	1,083	4.90 (Sept.)	14,300,000 (one crop)
Dagana					
a) Rice	4.6	2.75	1,420	3.90 (July)	37,500,000 (two crops)
b) Polyculture					
24-hr rate	-	1.23	910	1.12 (Oct.)	13,100,000
12-hr rate	-	2.32	319	0.74 (Oct.)	4,600,000
c) Maximum					
(Rice and Polyculture)	-	-	2,729	4.82 (July)	55,200,000

* See paragraph 24.

NOTES: Above values used in Consultant's designs.
Above quantities include 20% conveyance losses.

24. The Debi and Lampsar sub-projects are designed for the unit flow rates given in the above table, and the maximum diversion rates have been calculated accordingly. While approximately the same magnitude of unit flow rate is required at Dagana for any one rice field, the plan is to rotate the imbibition schedule among fields, so that no more than about half of them are being irrigated at one time. This is the logical way of operating, since only three days are required to flood one hectare of land at these rates. SAED has been asked to ensure that in the case of both Debi and Lampsar the consultants will design the most economic pre-irrigation rotation plans.

C. COMPARISON OF SUPPLY AND DEMAND

25. A comparison between the maximum required flow rates of Debi plus Lampsar plus Dagana in Table 3, which total less than 14 m^3/sec at any one time and normally expected discharges shows that even in the low months shown in paragraph 8, page 3, the sub-projects jointly would take only a small fraction of the available water, with the exception of the critical period which can occur in June or very early July. A similar situation exists as far as the quantity to be used is concerned.

26. The principal problems of all three areas involve the dates when the water becomes fresh, and/or the dates when it may become saline from the slowly advancing tongue of sea water from the Atlantic. Farming operations must be started in time to utilize the fresh water at Debi and Lampsar at the earliest possible date. This is especially important in a dry year, as the duration of fresh water at the pump intakes will be minimal in such years. Normally at least 90 to 120 days will be available to pump fresh water for those projects. The reliability of the supply seems adequate.

27. In the case of the Dagana area, the situation is more complex, because of the double-cropping program planned. Even here the normal schedule calls for all rice and polyculture irrigation to be completed by the end of March. The four conclusions stated in para 11 are the key to the supply situation. There should be few, if any, occasions when significant crop losses would result from lack of fresh water supply at Dagana. Use of all advanced hydrological data for predicting water stages and salinity at Dagana, is a key necessity. When this is done, and farming plans are adapted accordingly farmers would be assured of receiveing fresh water when needed.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Project Costs
('000 CFA)

	1973	1974	1975	1976	Total	Debi	Lampsar	Dagana
Development Costs								
Land Clearing	19,350	29,450	41,100	-	89,900	-	-	89,900
Earthworks	159,036	291,649	217,862	-	668,547	24,443	80,917	563,187
Civil Works	60,720	77,622	65,959	-	204,301	31,952	16,609	155,740
Embanking Dagana	39,000	-	-	-	39,000	-	-	39,000
Sub-Total	278,106	398,721	324,921	-	1,001,748	56,395	97,526	847,827
Construction								
Staff Housing	14,000	8,000	4,000	-	26,000	4,000	4,000	18,000
Field Assistants Housing	3,500	7,200	4,800	-	15,500	1,200	1,800	12,500
Offices and Stores	10,150	6,000	-	-	16,150	6,000	-	10,150
Sub-Total	27,650	21,200	8,800	-	57,650	11,200	5,800	40,650
Materials								
Hydraulic Equipment	68,997	51,093	15,140	-	135,230	22,800	-	112,430
Tractors and Accessories	4,200	34,344	27,645	-	66,189	-	-	66,189
Research Training Equipment	2,400	550	600	100	3,650	-	-	3,650
Vehicles	4,000	4,000	2,400	-	10,400	1,600	800	8,000
Motor Bikes	300	1,100	1,650	50	3,100	250	500	2,350
Sub-Total	79,897	91,087	47,435	150	218,569	24,650	1,300	192,619
Engineering Services	64,000	31,500	19,100	-	114,600	7,500	4,500	102,600
Management and Operating Costs in Development Period								
Salaries:								
Expatriates	-	12,600	16,800	-	29,400	6,300	2,100	21,000
Local Staff	4,500	12,780	24,800	4,500	46,580	4,540	3,970	38,070
Operating Costs:								
Vehicle Maintenance	1,780	5,120	7,900	1,780	16,580	2,150	1,150	13,280
Training/Evaluation	1,720	1,720	1,720	1,720	6,880	-	-	6,880
Research	12,620	12,300	11,140	8,340	44,400	-	-	44,400
Sub-Total	20,620	44,520	62,360	16,340	143,840	12,990	7,220	123,630
Compensation to Dagana Farmers	3,600	-	-	-	3,600	-	-	3,600
Total	473,873	587,028	462,616	16,490	1,540,007	112,735	116,346	1,310,926
Physical Contingencies	41,715	59,808	48,738	-	150,261	8,458	14,629	127,174
Price Contingencies	30,935	79,949	97,668	4,329	212,881	12,452	20,641	145,828
Total	546,523	726,785	609,022	20,819	1,903,149	133,645	151,616	1,583,928

ANNEX 9
Table 1

SENEGAL

SENEGAL RIVER POLDERS PROJECT

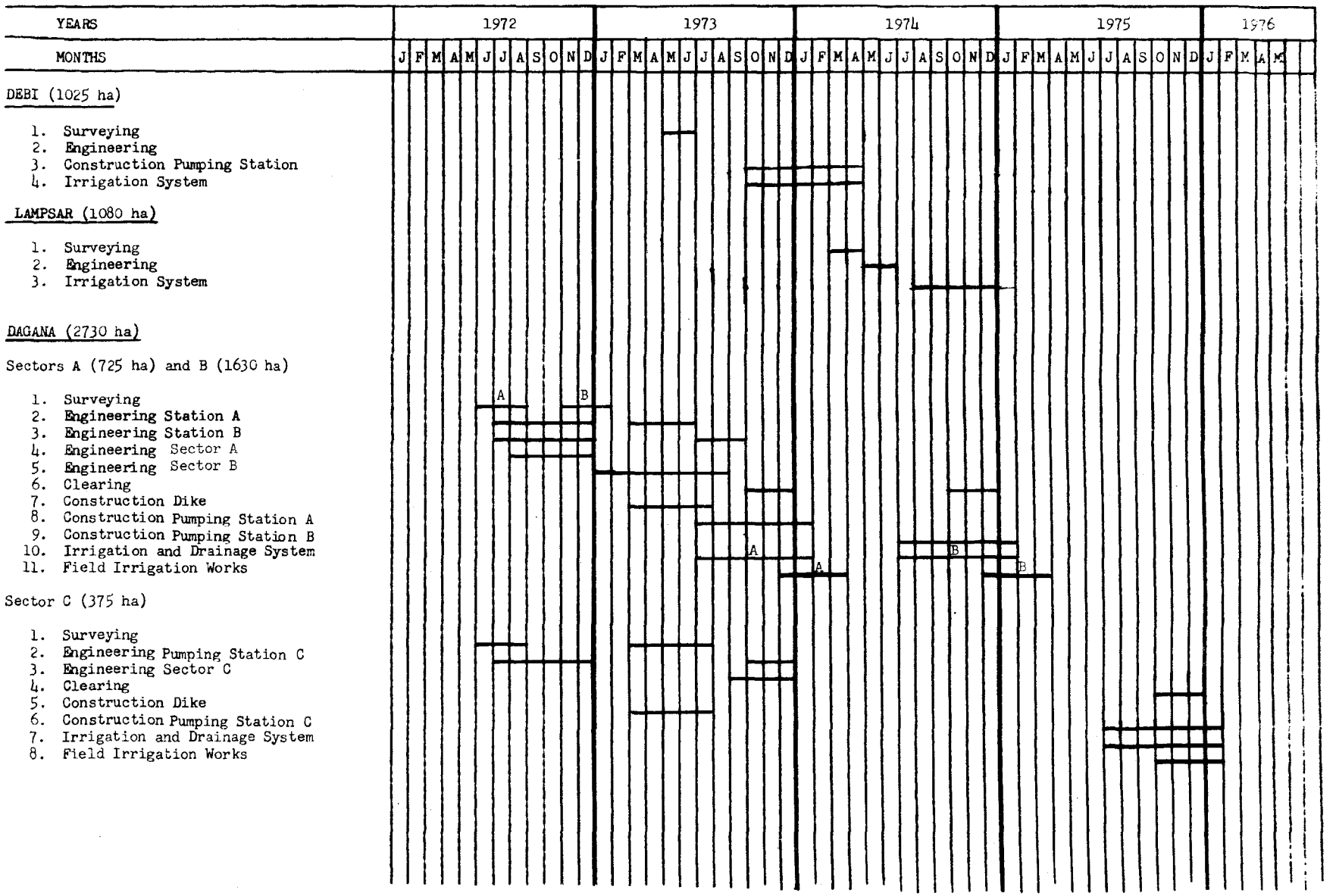
Housing and Vehicles

	1973	1974	1975	1976	Total	Cost (CFA)
I. Construction						
Housing						
Senior Staff:						
Debi/Lampsar		1			1	4,000,000
Dagana	2	1			3	12,000,000
	2	2			4	16,000,000
Technicians:						
Debi		1			1	2,000,000
Lampsar			1		1	2,000,000
Dagana	2	1			3	6,000,000
	2	2	1		5	10,000,000
Field Assistants:						
Debi		4			4	1,200,000
Lampsar			6		6	1,800,000
Dagana	12	20	10		42	12,500,000
	12	24	16		52	15,500,000
Offices and Stores:						
Debi		1			1	6,000,000
Dagana						
Training Center Office	1				1	10,000,000
Oxen Training Center	1				1	150,000
						16,150,000
II. Vehicles and Motorcycles						
Vehicles						
Debi		2			2	1,600,000
Lampsar			1		1	800,000
Dagana	5	3	2		10	8,000,000
	5	5	3		13	10,400,000
Motorcycles						
Debi		5			5	250,000
Lampsar			10		10	500,000
Dagana		16	22		38	1,900,000
Training Center	6	1	1	1	9	450,000
	6	22	33	1	62	3,100,000

SENEGAL

SENEGAL RIVER POLDERS PROJECT

POLDER CONSTRUCTION SCHEDULE



ANNEX 9

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Project Staff Requirements

	1973	1974	1975	1976	1977	1978	1979	1980	1985 etc.	Project Cost 1973-1976 Wages	Vehicle Maintenance	Total
										CFAF '000		
Debi												
Expatriates		1	½	½	½					6,300	750	7,050
Senior Local Staff		1	1	1	1	1	1	1	1	1,140	1,000	2,140
Field Assistants		5	5	5	5	4	4	4	4	3,400	400	3,800
										10,840	2,150	12,990
Lampsar												
Expatriates			½	½	½					2,100	250	2,350
Senior Local Staff			1	1	1	1	1	1	1	570	500	1,070
Field Assistants			10	10	7	7	6	6	6	3,400	400	3,800
										6,070	1,150	7,220
Dagana												
Extension Services to Farmers												
Expatriates		2	3	3	2	2	2			21,000	2,500	23,500
Senior Local Staff		1	2	3	2	2	2	2	2	1,710	1,500	3,210
Field Assistants		16	38	61	61	61	58	52	27	18,360	2,160	20,520
Ditch Riders 1/			6	7	8	8	8	8	8	-	-	-
										41,070	6,160	47,230
Training Center										-	-	-
Senior Local Staff	1	1	1	1						2,280	2,000	4,280
Administrative Clerks	2	2	2	2						3,000		3,000
										5,280	2,000	7,280
Evaluation												
Field Assistants	6	6	6	6						8,000	2,000	10,000
Research												
Senior Local Staff	1	1	1	1						2,000	2,000	4,000
Field Assistants	2	2	2	2						2,720	1,120	3,840
	13	48	80	105	88	86	82	73	49	4,720	3,120	7,840
										75,980	16,580	92,560

Costs (CFAF)	Annual Salaries	Annual Vehicle Maintenance	Total
Expatriates	4,200,000	500,000	4,700,000
Senior Local Staff	570,000	500,000	1,070,000
Field Assistants	340,000	40,000	380,000

1/ Not included in maintenance costs provisions.

2/ Does not include part time French technical assistance support.

August 11, 1977

ANNEX 9
Table 4

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SENEGAL RIVER POLDERS PROJECT

SAED Cash Flow

CFAF '000

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Inflows													
1. Project implementation													
IDA disbursement 65%	224,070	344,950	387,150	189,440	5,445								
Government financing	322,453	381,835	221,872	(168,621)	(5,445)								
	546,523	726,785	609,022	20,819									
2. Farmers' Payment													
Consolidated fee													
Lampsar			2,700	2,700	5,400	8,100	10,800	10,800	10,800	10,800	10,800	10,800	
Debi		2,562	2,562	5,125	7,688	10,250	10,250	10,250	10,250	10,250	10,250	10,250	
Dagana		2,896	9,152	23,794	49,752	64,320	73,800	77,520	80,720	80,720	80,720	80,720	
Mechanical services													
Lampsar			5,640	8,340	8,340	8,340	8,340	8,340	8,340	8,340	8,340	8,340	
Debi		5,356	7,919	7,919	7,919	7,919	7,919	7,919	7,919	7,919	7,919	7,919	
Dagana		7,099	21,484	42,825	56,114	66,006	70,950	72,800	74,650	76,500	76,500	76,500	
3. Rice Processing byproducts		1,844	4,395	5,213	5,991	6,626	7,454	8,122	8,788	9,391	9,469	9,469	
4. Government subsidies													
Extension services													
Mechanical plowing		4,195	4,503	228									
	546,523	750,737	667,377	116,963	141,204	171,561	189,513	195,751	201,467	203,920	203,998	203,998	
Outflows													
1. Project cost	546,523	726,785	609,022	20,819									
2. Material renewal				23,935	17,225	12,475	23,880	22,855	11,945	20,405	49,940	37,095	
3. SAED services to farm													
Extension services				53,920	46,120	45,740	44,220	27,840	26,800	22,520	19,480	19,480	
Mechanical service		11,831	27,812	43,749	52,773	60,261	63,815	64,999	66,179	67,359	67,359	67,359	
Water pumping cost		1,050	3,765	7,356	9,633	10,496	11,579	12,254	12,809	13,260	13,260	13,260	
Maintenance			10,700	18,366	22,816	22,816	22,816	22,816	22,816	22,816	22,816	22,816	
Overheads		4,650	5,350	5,350	5,350	5,350	5,350	5,350	5,350	5,350	5,350	5,350	
	546,523	744,316	656,649	173,495	153,917	157,288	181,660	156,114	145,899	151,710	178,205	156,360	
Surplus (deficit) (1)	--	6,421	10,728	(56,532)	(12,713)	14,273	7,853	39,637	55,568	52,210	25,793	47,638	
Government repayment						10,000	10,000	35,000	45,000	45,000	45,000	45,000	
Net surplus						4,273	(2,147)	4,637	10,568	7,210	(19,207)	2,638	
Capitalized interest on Government Loan	1,120	3,976	7,678	10,408	11,232								

(1) Deficit would be met by government as per Annex 19.

ANNEX 10

SENEGAL

SENEGAL RIVER POLDERS PROJECT

IDA CREDIT DISBURSEMENT
CFAF '000

IDA Financial Year	1972/73	1973/74				1974/75				1975/76				1976/77				
	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Category I																		
Imported hydraulic and agricultural equipment		65,800				56,370				59,030								181,280
vehicles		4,050				3,380				2,780				90				10,300
Category II																		
Land development works		41,660	41,660	41,660	41,630	59,910	59,910	59,910	59,150	48,850	48,850	48,850	48,110					600,150
Construction		4,150	4,150	4,150	4,120	3,130	3,130	3,130	3,300	1,300	1,290	1,290	1,400					34,540
Category III																		
Engineering services	18,000	15,000	15,000	16,000	8,000	8,000	8,000	7,500	4,800	4,800	4,800	4,700						114,600
Category IV																		
Operating costs		2,410	2,410	2,410	2,410	2,870	2,870	2,870	2,870	3,210	3,210	3,210	3,210	1,790	1,790	1,790	1,780	41,110
	18,000	133,150	63,220	64,220	56,160	133,660	73,910	73,410	70,120	119,970	58,150	58,050	52,720	1,880	1,790	1,790	1,780	981,980
Category V																		
Contingencies		9,700		10,000		7,000		48,000		17,500		58,000	17,000				1,875	169,075
	18,000	142,850	63,220	74,220	56,160	140,660	73,910	121,410	70,120	137,470	58,150	116,050	69,720	1,880	1,790	1,790	3,655	1,151,055
US$ equivalent US$ '000	70	558	247	290	220	550	289	475	274	537	227	454	272	7	7	7	16	4,500
Accumulated disbursement US$ '000	70	628	875	1,165	1,385	1,935	2,224	2,699	2,973	3,510	3,737	4,191	4,463	4,470	4,477	4,484	4,500	
Undrawn balance US$ '000	4,430	3,872	3,625	3,335	3,115	2,565	2,276	1,801	1,527	990	763	399	37	30	23	16	-	

November 13, 1972

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Estimated Schedule of Disbursements

IDA Fiscal Year and Quarter	Cumulative Disbursements at US$ '000
1972/73	
4th June 30, 1972	70
1973/74	
1st September 30, 1973	628
2nd December 31, 1973	875
3rd March 31, 1974	1,165
4th June 30, 1974	1,385
1974/75	
1st September 30, 1974	1,935
2nd December 31, 1974	2,224
3rd March 31, 1975	2,699
4th June 30, 1975	2,973
1975/76	
1st September 30, 1975	3,510
2nd December 31, 1975	3,737
3rd March 31, 1976	4,191
4th June 30, 1976	4,463
1976/77	
1st September 30, 1976	4,470
2nd December 31, 1976	4,477
3rd March 31, 1977	4,484
4th June 30, 1977	4,500

It is estimated that the Credit Agreement would be signed in December, 1972 and that the credit would become effective on January 1, 1973. The closing date is expected to be December, 1977.

October 11, 1972

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Societe d'Amenagement et d'Exploitation des Terres du Delta (SAED)

Background

SAED (Societe de'Amenagement et d'exploitation des Terres du Delta) was established as a public corporation in 1965. 1/ Its objective is to develop agricultural production in the Senegal River Delta region and to provide extension, water control, land cultivation, credit and marketing services to farmers.

Several organizations aimed at studying and developing the Delta region, such as the Mission d'Amenagement du Fleuve Senegal (MAS) created in 1938 and the Organisation Autonome du Delta (OAD) created in 1960, preceded the establishment of SAED.

Management

SAED has been created as a public autonomous entity managed by a Board of Directors including representatives of various ministries: Rural Development (Chairman), Finance, Planning and Water Development. The general director is nominated by the Ministry of Rural Development and appointed by the Board.

From 1966 to 1970 the Government appointed SATEC representatives to manage SAED. A Senegalese General Manager was appointed in 1970 but SAED continues to receive strong technical support from SATEC which still provides 7 expatriates to SAED. The General Manager prepares budgets which are submitted to the Board and the Ministries of Rural Development and Finance for approval.

Financing

SAED financial autonomy has been considerably restricted by a law published in 1965 which submits all public corporations to direct control by the Ministry of Finance through the Centre Comptable which authorizes any payment or receipt made by or to the General Treasury in Dakar. Day to day operations are submitted for the approval of a "comptable particulier" appointed by and responsible to the Ministry of Finance. This tedious control of day to day operations impairs budgetary control and increases SAED's costs and administrative expenses. SAED should open and operate an account in a commercial bank, and finance required for project implementation should be paid into this account three months in advance. Working capital requirements

---

1/ Law number 65.001 dated January 20, 1965.

should be made available in advance and such funds should be under the direct control of SAED's financial controller.

SAED financing has been until now provided by FAC grants and loans and Government subsidies to balance operating accounts since farmers are unable to pay in full for the services supplied to them by SAED. The average subsidy paid by the Government amounts to $90 million per year.

Accounting

SAED accounts are processed by the Centre Comptable in Dakar, which are partly computerized and reliable accounts are prepared promptly each month. However, some additional accounts classification and analysis would be required to record investment and operating costs separately by sub-projects and project functions.

SAED also keeps accounts of cooperatives to record credit and services provided to members.

Recovery of farmers debts is carried out each year after harvesting and the recovery rate is now about 85% at the end of March. The Fonds Mutuel de Developpement Rural (FMDA) only intervenes in the case of drought or total loss of production.

SAED audited balance sheets as at June 30, 1970 and September 30, 1971 are summarized in Table 1.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Audited SAED Balance Sheet
(CFAF Million)

ASSETS	1969/70	1970/71 /1
Fixed Assets		
Building	29.2	176.6
Material	13.5	42.3
Furniture	5.9	4.2
	48.6	223.1
Inventories	157.3	15.9
Receivable		
Cooperatives	197.5	144.6
Government	101.4	250.4
Other	215.6	363.8
	514.5	758.8
Accumulated losses	27.2	12.1
Total	747.6	1,009.9
Government subsidy	90.0	90.0
Yearly depreciation of assets	33.4	25.9

LIABILITIES	1969/70	1970/71
Government equity	284.8	461.6
Provisions		8.9
Short term debts		
Suppliers	46.3	45.5
Government	390.6	493.9
Profit	25.9	-
	747.6	1,000.9

/1 Fiscal year extended from June 30, to September 30 in 1971.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Outline Terms of Reference for Consultants

A. Terms of Reference for Consultants

1. The consulting engineers would work under the general direction of the project authority SAED. The consultants would accept full responsibility for the technical adequacy and quality of engineering and other services as described hereinafter. This responsibility would cover all investigations and designs, both those already performed and those to be performed.

2. The scope of the consultants work would include, inter alia:

(a) Preparing topographic maps, design drawings, and contract documents for/and clearing, earthwork, land levelling, and the civil works described in the feasibility study prepared by SCET as modified by the present IDA appraisal report, including such additional studies and investigations as may be required;

(b) Preparing invitations to bid for all work described in paragraph (a) above, including prequalification of bidders if necessary; the analysis of resulting bids and the preparation of recommendations for SAED on the award of contracts in line with the "Guidelines for Procurement under World Bank Loans and IDA Credits";

(c) Supervising all construction with the exception of houses, offices, and stores, including the preparation of recommendations for SAED regarding the acceptance of completed works;

(d) Preparing specifications, bidding documents, and contract forms for two alternative systems of generating and supplying electric power to the three Dagana pumping stations. One system would be that recommended in the SCET Feasibility Report dated December 1971, which provides for electric generator installation at each station. (The elements of that system are described in Annex 2 of this report.) The other system would be one with a single central electricity-generating station, with power carried to the three pumping stations by means of transmission lines. Following receipt of bids, the consultant would prepare and submit to IDA an economic and operating analysis of the two systems, which would

include details of capital, operational, and maintenance expenses over the life of the project, personnel requirements, etc.;

(e) Preparing with the assistance of SAED, specifications, bidding documents, and contract forms for all pumps, hydraulic equipment, electrical equipment, and spare parts to be purchased under the project; the analysis of bids and preparation of recommendations concerning the award of contract in line with the "Guidelines for Procurement" as above;

(f) Assisting SAED in the preparation of reports and documents related to the progress of construction and financing of all works supervised by the Consultants; and

(g) Certifying all withdrawal applications for the IDA credit account for work under their cognizance.

B. Engineering Work to be Performed by SAED

3. Engineering work which would be the responsibility of SAED, rather than of the Consultants, would include the following:

(a) Preparation of maps, design drawings, and contract documents for houses, offices, training center, and stores;

(b) Technical supervision of the construction of houses, offices, training center, and stores for which contracts would be let locally.

4. Prequalification of bidders, if necessary, bid analyses, and award of contracts for SAED-supervised work would, insofar as possible, follow the "Guidelines for Procurement under World Bank Loans and IDA Credits", even if procurement were limited to local competitive bidding.

C. Time Schedule

5. The consultant services described above would be completed in about four years (1972-1975). Design drawings and contract documents for the main civil works contract should be completed in late 1972 in time to permit commencement of works in early 1973. Early preparation of the specifications and bidding documents for on-farm works conducted by SAED is also required since, according to the proposed work schedule, this should start in 1973.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Evaluation Unit for the Dagana Polder

General

1. Evaluation of the economic impact of carrying out the Debi and Lampsar subprojects would be relatively simple and part of SAED's routine operations. Dagana, however, with its proposed variety of crops and different sizes of farms would pose more difficult evaluation problems. In view of the importance of Dagana experience for further schemes in the Delta and Valley, a special evaluation unit would be established for this polder.

Objectives and Organization

2. The unit would collect the following data on the situation of families in villages near Dagana from which project participants would be drawn:

- family composition;
- farm size;
- crops;
- use of various inputs;
- revenues from agriculture; and
- revenues from other sources.

This data would be used by SAED in selecting project participants. Criteria would be that participants should:

- have a family with at least two active persons;
- be over 25 years of age but not more than 45 years;
- derive their main revenue from agriculture;
- live in the area;
- have a satisfactory agricultural credit rating; and
- be willing to sign a land use and cropping contract with SAED.

3. As from the first year of cropping at Dagana data would be collected on a regular basis from 5% of the rice farmers and 15% of farmers growing other crops. The basic data collected would be:

- mandays available;
- mandays required by crops and activities;
- irrigation procedures;
- inputs used;
- yields;
- revenues from agriculture;
- revenues from other sources;
- marketing procedures; and
- disposition of income.

Data so collected would be used by SAED to analyze the progression of farmers' revenues, to compare revenues from various cropping patterns and farm types, and to examine farmers' responses to the advice and services provided by SAED.

4. Statistics collected would be subject to statistical analysis. Under FAC's technical assistance programs experts from SATEC and SCET headquarters in Paris would provide guidance to SAED in procedures and data collection and analysis. SATEC would provide computer services for data processing.

COSTS

5. The costs of the evaluation unit for the four-year project development period is estimated at CFAF 14 million, or about US$55,000 equivalent net of contingencies. The evaluation unit would use office facilities at the Dagana training center (see Annex 5). Details of the cost estimates are given in Table 1.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Costs of Dagana Evaluation Unit
(CFAF '000)

	Year 1	2	3	4	TOTAL
Salaries Evaluation Officers (6)	2,000	2,000	2,000	2,000	8,000
Motorcycles (6)	300	50	50	50	450
Operating Costs	500	500	500	500	2,000
Computer Processing Costs:					
- Cultivation Method Analyses	250	250	250	250	1,000
- Yield Analyses	250	250	250	250	1,000
Material (measuring tapes, weighing scales, containers, etc.)	400	550	600	100	1,650
TOTAL	3,700	3,600	3,650	3,150	14,100

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Yields Assumed in Project Calculations

Tons/ha

	Cultivation starting in 1974								Cultivation starting in 1975								Cultivation starting in 1976						
	Year of cultivation								Year of cultivation								Year of cultivation						
	1974	1975	1976	1977	1978	1979	1980	1981	1975	1976	1977	1978	1979	1980	1981	1982	1976	1977	1978	1979	1980	1981	1982
Tomatoes	25	27.5	30	32.5	35	35	35	35	26	28.6	31	33.5	35	35	35	35	27	29.5	32	34.5	35	35	35
Onions	8	9	10	10	10	10	10	10	8.5	9.5	10	10	10	10	10	10	9	9.6	10	10	10	10	10
Potatoes	10	11	12	13	13	13	13	13	10.5	11.5	13	13	13	13	13	13	11	11.5	13	13	13	13	13
Various vegetables 1/																	10	12	15	15	15	3	3
Maize 1/ and sorghum	2.2	2.5	2.7	2.9	3	3	3.0	3.0	2.4	2.6	2.8	3	3	3	3	3	2.5	22.7	2.9	3	3	3.0	3.0
Wheat 1/	2	2.2	2.4	2.5	2.5	2.5	2.5	2.5	2.1	2.2	2.4	2.5	2.5	2.5	2.5	2.5	2.2	2.3	2.5	2.5	2.5	2.5	2.5
Rice	1.8	2.1	2.4	2.6	2.8	3	3.1	3.2	2	2.2	2.5	2.7	2.9	3	3.1	3.2	2.1	2.3	2.6	2.8	3	3.1	3.2
Cowpeas 1/	1	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.1	1.3	1.4	1.5	1.5	1.5	1.5	1.5	1.2	1.4	1.5	1.5	1.5	1.5	1.5
II. DEBI																							
Rice	1.5	1.8	2.0	2.2	2.4	2.5	2.6	2.7															
III. LAMPSAR																							
Rice									1.5	1.8	2	2.2	2.4	2.5	2.5	2.5							

1/ Alternative crops

November 21, 1972

ANNEX 15
Table 1

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Area Cultivated and Production

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982 etc.
A. AREA CULTIVATED (ha)											
Rice											
Debi	260	260	1,025	1,025	1,025	1,025	1,025	1,025	1,025	1,025	1,025
Lampsar	880	880		1,078	1,078	1,078	1,078	1,078	1,078	1,078	1,078
Dagana - 1st crop	160	160	770	1,330	1,420	1,420	1,420	1,420	1,420	1,420	1,420
- 2nd crop				50	100	200	300	500	700	970	1,100
Total Dagana			770	1,380	1,520	1,620	1,720	1,920	2,120	2,390	2,520
Total rice			1,795	3,483	3,623	3,723	3,823	4,023	4,223	4,493	4,623
Other Crops (Dagana)											
Tomatoes			30	70	146	254	334	334			
Onions				30	60	120	170	228			
Potatoes				30	60	120	170	228			
Sorghum	481		84	302	1,040	1,228	1,348	1,336			
Effective area			114	432	1,306	1,722	2,022	2,126	2,126	2,126	2,126
Physical area (Dagana)			114	394	1,230	1,230	1,230	1,230	1,230	1,230	1,230
Total Cultivated			1,802	3,915	4,929	5,445	5,845	6,149	6,349	6,619	6,749
Available for various citrus or other tree crops					80	80	80	80	80	80	80
B. PRODUCTION (tons)											
Paddy											
Debi	260	260	1,537	1,845	2,050	2,255	2,460	2,565	2,665	2,768	2,768
Lampsar	576	576		1,617	1,940	2,156	2,372	2,587	2,695	2,695	2,695
Dagana	240	240	1,098	2,816	3,457	4,148	4,634	5,497	6,243	7,092	7,939
	1,076	1,076	2,635	6,278	7,447	8,559	9,466	10,649	11,603	12,555	13,402
Rice 65%			1,713	4,081	4,841	5,563	6,153	6,987	7,603	8,161	8,711
Other Crops											
Tomatoes			750	1,865	4,092	7,643	10,838	11,553	11,680	11,680	11,680
Onions				255	555	1,155	1,700	2,280	2,280	2,280	2,280
Potatoes				315	675	1,515	2,210	2,964	2,964	2,964	2,964
Sorghum			185	736	2,702	3,433	4,017	4,008	4,008	4,008	4,008

Annex 15
Table 2

ANNEX 15
Table 3

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SENEGAL RIVER POLDERS PROJECT

Growing Cycles of Project Crops

Crops	M	J	J	A	S	O	N	D	J	F	M	A	Tractor Hours	Thresher Hours	Man days	Power Sprayer Hours	Duration of Growing Cycle incl. Nursery (days)	Irrigation (m^3 at field inlet 70% efficiency)	Irrigation Period
Rice																			
Debi and Lampsar	S							H					4	3	56		130-150		
Dagana - 1st crop		S				H							5	2	50		110-130	10,000	July-Aug.
2nd crop						S						H	3	2	52		110-130	10,000	Nov.-Jan.
Other Crops																			
Tomatoes					P					H			9		190	28	180-200	11,500	Sept.-March
Onions - early							P			H			10		121	2	120-130	4,000	Nov. - Jan.
- very early						P			H				10		121	4		5,000	Oct.-Dec.
Potatoes - early							P			H			11		112	10	75-90	4,300	Nov.-Jan.
- very early					P				H				11		112	10		4,800	Oct.-Dec.
Maize - rainy season			S				H						9		58		100-120	8,300 1/	July-Oct.
Sorghum - rainy season		S				H							9		58		100-120	8,400 1/	July-Oct.
- dry season							S				H		9		58			6,700	Nov.-Feb.
Wheat							S				H		6		61		110-120	6,700	Nov.-Feb.
Cowpeas										S		H	3		38		50-60	2,000	Feb.-March
Evapotranspiration Potential 1/	260	240	220	190	180	190	150	150	150	160	230	250							

S = Sowing

P = Planting

H = Harvesting

1/High consumptive use during rainy season due to higher E.P.T. and crop growth cycle.

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SENEGAL RIVER POLDERS PROJECT

Annual Operation and Maintenance Costs of Pumping Stations, and Irrigation and Drainage Networks

Pumping Costs

1. Operating costs of the pumping stations which would be constructed under the project to serve the Debi and Dagana polders have been allocated to these sub-project areas. In the case of Lampsar 32% of the costs of the existing Ronq pumping station have been allocated, this being the proportion of Ronq capacity utilized by the Lampsar polder.

2. Cost estimates are based on power and pumping hour requirements as shown at Table 1. Diesel oil for SAED pumping stations is exempt from taxes.

Maintenance Costs

3. The consulting engineers arrived at estimates of maintenance cost by applying percentages to various elements of capital investments; these are shown in Table 1. This approach appears justified in the light of SAED's actual experience. In general, contracts provide for the contractor to make any needed repairs on earth works for at least the first year, therefore, no maintenance costs are included for the first year after construction of such works. Major maintenance works for canals, drains, and dikes would usually be let by SAED to contractors.

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SENEGAL RIVER POLDERS PROJECT

Estimated Annual Pump Operation and Maintenance Costs

Pumping Costs		Pumping Hours	Total Cost CFAF '000	Cost/ha CFAF
Debi		250 hours	300	290
Lampsar		115 hours	954	883
Dagana	Sector A	4,850 hours)		
	Sector B	5,550 hours)	12,006	2,584
	Sector C	3,870 hours)		
			13,260	

Maintenance Costs CFAF '000

	% of investment	Debi	Lampsar	Dagana	Total
Pumping Stations and Power Station					
Civil Work	1%	320		1,450	1,770
Equipment - Pumps and Generators	5%	1,140		7,300	8,440
Irrigation Investment					
Earth Works	2%	490	1,800	5,500	7,790
Civil Works	1%	-	166	150	316
Gates and Controls	5%	-	-	550	550
Drainage Networks					
Earth Works	2%	/1	/1	2,850	2,850
Civil Works	1%	/1	/1	150	150
Roads	4%	-	-	1,500	1,500
Total		1,950	1,966	19,450	23,366
Cost per ha CFAF		1,900	1,820	7,125	
US$		7.4	7.0	28.5	

/1 Drainage included in irrigation system, canals serve dual purpose

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SENEGAL RIVER POLDERS PROJECT

Recovery of Costs

CFAF'000

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1. DEBI													
a) Farmers' repayment consolidated fee		2,562	2,562	5,125	7,688	10,250	10,250	10,250	10,250	10,250	10,250	10,250	
b) Costs													
- Investments	3,000	89,695											
- Contingencies		17,430											
- Maintenance		,300	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	
- Management		700	700	700	700	700	700	700	700	700	700	700	
	3,000	108,125	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	
Surplus (deficit)	(3,000)	(105,563)	162	2,725	5,288	7,850	7,850	7,850	7,850	7,850	7,850	7,850	
2. LAMPSAR													
a) Farmers' repayment consolidated fee			2,700	2,700	5,400	8,100	10,800	10,800	10,800	10,800	10,800	10,800	
b) Costs													
- Investments			102,026										
- Contingencies			33,302										
- Maintenance			954	2,920	2,920	2,920	2,920	2,920	2,920	2,920	2,920	2,920	
- Management			700	700	700	700	700	700	700	700	700	700	
			136,982	3,620	620	3,620	3,620	3,620	3,620	3,620	3,620	3,620	
Surplus (deficit)			(134,282)	(920)	1,780	4,480	7,180	7,180	7,180	7,180	7,180	7,180	
DAGANA													
Farmers' repayment		2,896	9,152	23,794	49,752	64,320	73,800	77,520	80,720	80,720	80,720	80,720	
Costs													
- Investments	352,103	370,619	242,535										
- Contingencies	60,407	113,545	75,606										
- Maintenance		750	2,511	6,102	8,369	9,394	10,325	11,000	11,555	12,006	12,006	12,006	
			9,300	15,000	19,450	19,450	19,450	19,450	19,450	19,450	19,450	19,450	
- Management		3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950	
	412,510	488,864	333,902	25,052	31,769	32,794	33,725	34,400	34,955	35,406	35,406	35,406	
Surplus (deficit)	(412,510)	(485,968)	(324,750)	(1,259)	17,983	31,526	40,075	43,120	45,765	45,314	45,314	45,314	
Project surplus (deficit)	(415,510)	(591,531)	(458,870)	547	25,051	43,856	55,105	58,150	60,795	60,344	60,344	60,344	

Recovery Rate

Debi	5.2 %
Lampsar	3.1 %
Dagana	0.6 %

Project 1%

Annex 16
Table 2

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SENEGAL RIVER POLDERS PROJECT

Marketing and Price Policies

Rice

1. Rice marketed in Senegal is channeled through ONCAD which purchases the domestic rice production and imports additional market requirements, mainly from S.E. Asia and Brazil. All prices are fixed by Government. ONCAD purchases domestic rice from millers at CFAF 39,500/ton which is equivalent to a farmgate price of CFAF 21,000/ton of paddy and then sells it to wholesalers at CFAF 37,000/ton (Dakar). The difference between wholesale and producer price (CFAF 2,500/ton) is paid out of the Stabilization Fund, see Table 1. The retail price is fixed at CFAF 40,000/ton. The import price is lower than the domestic price. In 1971/72 the average price of imported low quality rice (over 50% broken grain) was CFAF 23,500/ton (US$92.00) cif Dakar. 1/ Allowing for handling costs, duties, etc., the cost price to ONCAD of this imported rice was CFAF 29,000/ton (US$113/ton). The difference of CFAF 8,000/ton between the ONCAD cost and the wholesale price is paid into the Stabilization Fund.

2. The Bank's Economic Department forecasts a 1980 rice price of US$80/ton fob Bangkok, equivalent to US$97.00 (CFAF 24,800/ton) cif Dakar, at constant 1972 price levels and current exchange rates. The projected price would be equivalent to a paddy price rounded to CFAF 15,300/ton at constant 1972 price levels. The economic rate of return analysis is based on this price with adjustments for the intermediate years (Table 1). Government has stated that it intends to maintain the current producer price for paddy at CFAF 21,000/ton and this price is used in the farm budgets. This policy implies continuing produce price support by Government.

Tomatoes

3. By 1980, the project would produce about 11,690 tons of fresh tomatoes or about 1,650 tons of tomato paste at 28% concentration. Tomato paste is used in many traditional Senegalese dishes; consumption has increased from some 7,000 tons in 1963 to about 8,000 tons in 1971 and is expected to rise to about 10,000 tons by 1980. So far tomato paste has been imported mainly from Italy (90%) at an average price of CFAF 80 per kg cif Dakar. Imported tomato paste is purchased by wholesalers at an average price of CFAF 175 per kg, including CFAF 38/kg for import duties and taxes. In April 1969, Government agreed to set up the Societe de Conserves Alimentaires du Senegal (SOCAS) as a pilot private company for the development of domestic

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1/ Corresponds to CFAF 19,100/ton (US$75.000) fob Bangkok.

production of tomato paste. SOCAS has installed a factory at Ross-Bethio. Financing plans have been agreed with CCCE to increase the actual output of 2,600 tons of fresh tomatoes in 1971 to 21,000 tons (3,500 tons tomato paste equivalent) in 1977/78 (9,000 tons at Savoigne and 12,000 tons at Dagana) or 40% of present tomato paste consumption. SOCAS has agreed with Government to sell its production at a wholesale price of CFAF 150 per 820-gram can, and to purchase tomatoes at a producer price of CFAF 7 per kilo. SOCAS estimates that the wholesale price is competitive with world market price including duties and taxes. Excluding duties and taxes would still keep the price competitive (see Table 2). Hence the farmgate price on which it is based has been used in economic evaluation. On the other hand, the possibility of farmers selling some of their fresh tomato production directly in local markets at Saint-Louis, Dakar and Nouakchott at prices as high as CFAF 28/kg, has not been taken into account.

Other Crops

4. Senegal currently imports a range of vegetables and cereals which will also be produced by the project. However, project output will only account for about 25% of import volume as is indicated below (in tons):

Crops	Annual Project Output at Maturity	Range of 1965-1961 Annual Production in Senegal	Range of 1965-71 Annual Import Volume
Onions	2,280	/1	7,000 - 12,000
Potatoes	2,964	/1	10,000 - 12,000
Sorghum /2	4,008	400,000 - 650,000	3,000 - 38,000
Rice	8,416	60,000 - 160,000	145,000 - 180,000
Tomatoes	11,680	/1	48,000 /3

/1 Individual data not available. Total vegetable output varied from 27,000-41,000 tons annually.
/2 Part of the sorghum area may be substituted by maize and wheat.
/3 Imported as tomato paste. Figure represents fresh tomato equivalent.

Since domestic demand for these products is expected to maintain at least at present per capita consumption levels there is a ready market for these products in Senegal. Potatoes and onions from the project area would be available in January and February, three months before the marketing of produce from the Cap Vert area - the main Senegal producer - and thus would not compete with this production. Sorghum produced at Dagana would be used partly for on-farm consumption (15%) and partly marketed in deficit areas such as Dakar.

5. Individually, project farmers would be unable to market their production satisfactorily. It is assumed that SAED would assist farmers in establishing annual market contracts on a group basis with wholesalers as has already been done successfully in marketing vegetables produced at Savoigne in 1971. Such agreements would also assure SAED repayment for its services. Table 3 gives prices for individual crops applied in the farm budgets and economic analysis.

6. The economic analysis is based on a cropping pattern involving rice, tomatoes, onions, potatoes and sorghum. Economic prices for potatoes and onions are the average 1965-71 import prices with adjustment for transport charges from the project area to Dakar which would be the main market. Although the project is expected to produce maize and wheat besides sorghum, the relative share of these crops is difficult to determine at this stage. The Bank's Economics Department forecasts a 1980 sorghum price of US$56/ton fob US port, equivalent to US$79.9 (CFAF 20,410) cif Dakar at constant 1972 price levels and current exchange rates. This 1980 sorghum price is equivalent to a farm gate price of CFAF 19,910. The economic rate of return analysis is based on this price with adjustments for the intermediate years.

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SENEGAL RIVER POLDERS PROJECT

Paddy and Rice Prices Per Ton

Imported Rice	1972-75	1976	1977	1978	1979	1980
A. Rice						
FOB Price Burma (US$)	75	76	77	78	79	80
Freight	14.5	14.5	14.5	14.5	14.5	14.5
Insurance	2.5	2.5	2.5	2.5	2.5	2.5
CIF Dakar (US$)	92	93	94	95	96	97
CIF Dakar (CFAF)	23,500	23,700	24,000	24,200	24,500	24,800
Harbor & Handling charges	750	750	750	750	750	750
Import Commission	2,000	2,000	2,000	2,000	2,000	2,000
Transport to Project Area	1,200	1,200	1,200	1,200	1,200	1,200
	27,450	27,650	27,950	28,150	28,450	28,750
B. Paddy Equivalent-65%	17,850	18,000	18,150	18,300	18,500	18,700
Milling Costs)net of	1,900	1,900	1,900	1,900	1,900	1,900
Transport to mill) taxes	2,150	2,150	2,150	2,150	2,150	2,150
Net Value	13,800	13,950	14,100	14,250	14,450	14,650
By-Products	700	700	700	700	700	700
Economic Farmgate Price	14,600	14,650	14,800	14,950	15,150	15,350
C. Price to ONCAD (CFAF)						
Dakar Price	23,500	23,700	24,000	24,200	24,500	24,800
Import Taxes	1,000	1,000	1,000	1,000	1,000	1,000
ONCAD Costs and margin	4,600	4,600	4,600	4,600	4,600	4,600
Total Cost to ONCAD	29,100	29,300	29,600	29,800	30,100	30,400
Stabilization Fund	7,900	7,700	7,400	7,200	6,900	6,600
Wholesale Price	37,000	37,000	37,000	37,000	37,000	37,000

Domestic Price Structure	
Per Ton of Paddy	CFAF
Paddy	21,000
Transport to Mill (1)	2,475
Mill Costs (1)	2,200
Total	25,675
Equivalent in Ton of Rice	39,500
ONCAD Purchase Price	39,500
Stabilization Fund Subsidy	2,500
Wholesale Price	37,000

(1) Including taxes on Fuel.

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SENEGAL RIVER POLDERS PROJECT

Prices of Imported and Local Tomato Paste
(Per Ton)

TOMATO PASTE	Including Duties and Taxes		Excluding Duties and Taxes	
	SOCAS CFAF	IMPORT CFAF	SOCAS CFAF	IMPORT CFAF
Import Price		80,000/1		
Import Taxes and Duties		38,000		
Cost Price Dakar	126,060	118,000	99,560	80,000
Gross Margin	40,440/3	57,000/2	40,440/3	57,000/2
Selling Price without Taxes	166,500	175,000	140,000	137,000
Value added tax 13.5%	22,500	23,600		
	189,000	198,000		
Wholesale Cost per 820 g Can	150	160	114	112

The above SOCAS "selling price" is close to the world market price, even when all taxes and duties are excluded (21% taxes component in SOCAS costs estimates).

FRESH TOMATOES

The farmgate price of fresh tomatoes is CFAF 7/kg and is considered to be a good estimate of the economic price on the basis of the above prices.

/1 Net average import price in 1970-71.
/2 Including harbor and unloading charges.
/3 Including financial charges.

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SENEGAL RIVER POLDERS PROJECT

Other Crops
(prices per ton in constant 1972 dollars)

	Sorghum 1971	Sorghum 1980	Potatoes 1971-80	Onions 1971-80
Prices Used in Calculating Economic Rates of Return				
Fob US$	56.9	56.0		
Freight, Insurance US$	23.8	23.9		
Cif US$ (Dakar)	80.7	79.9		
Cif CFAF	20,540	20,410		
Handling charges	700	700		
Economic value warehouse Dakar	21,340	21,110	19,450	28,150
Transport and handling charges from project area to Dakar	1,200	1,200	1,950	3,150
Economic farm gate price /1	20,140	19,910 /2	17,500	25,000
Actual Farm Gate Price 1972	18,000		20,000	20,000

/1 Used in economic rates of return analysis.

/2 In economic calculation, retain in 1974: 20,040
1975: 20,020
1976: 20,000
1977: 19,980
1978: 19,960
1979: 19,940
1980: 19,910

SENEGAL RIVER POLDERS PROJECT AND PER FARM

BENEFITS AND COSTS PER HECTARE AT FULL DEVELOPMENT

			DEBI/LAMPSAR		DAGANA									
	Units	Costs per unit	Rice		Rice		Sorghum		Tomatoes		Onions		Potatoes	
			Unit	Value	Unit	Value	Unit	Value	Unit	Value	Unit	Value	Unit	Value
yield per ha in tons		CFAF		2.7		3.2		3		35		10		13
unit price per kilo CFAF				21		21		18		7		20		20
A. Revenue per ha CFAF			Lampsar	52,500		67,200		54,000		245,000		200,000		260,000
			Debi	56,700										
B. Costs per Hectare CFAF														
1. Inputs														
Seeds														
Paddy	kg.	26.5	120	3,200		3,200								
Tomatoes	kg.	5,500							0.5	2,750				
Sorghum	kg.	80					12	1,000						
Onions	kg.	4,800									4	19,200		
Potatoes	kg.	40											1,500	60,000
Fertilizers														
12.20.20	kg.	26							1,000	26,000	0.5	13,000	0.5	13,000
Super	kg.	19	100	1,900	100	1,900					0.1	1,900	0.2	3,800
S.A.	k	17	300	5,100	300	5,100	400	6,800					0.1	1,700
				7,000		7,000		6,800		26,000		14,900		18,500
Pesticides										30,000		4,000		14,000
2. Mechanical Services (1)														
Plowing	Hour	1,435	0.7	1,000	1 1/3	2,200	3	4,300	3	4,300	3	4,300	3	4,300
Harrowing	Hour	1,490	2 2/3	4,000	2 1/3	3,200	2	3,000	3	4,500	5	7,500	3	4,500
Ridging	Hour	1,530					3	4,600	3	4,600			3	4,600
Spraying	Hour	900					1		28	25,200	4	3,600	10	9,000
Brushcutting	Hour	1,600							1	1,600				
Transport	Hour	1,500									2	3,000	2	3,000
Threshing	T	240	2	500	2	500								
				5,500		5,900		11,900		40,200		18,400		25,400
3. Consolidated Fee	Ha	10,000		10,000										
		16,000				16,000		16,000		16,000				
		30,000										30,000		30,000
4. Amortization (2)														
Farmers Equip.	Farm	25,000		1,915		930								
		5,000						250		250		250		250
Tractors & Tools				2,225		3,350		5,650		9,980		5,520		7,620
TOTAL COST				29,840		36,380		41,600		125,180		92,270		155,770
C. Net Revenue per ha			Debi	26,860		30,820		12,400		119,820		107,730		104,230
			Lampsar	22,660										
Labor day per ha				56		52		58		190		121		112
Net Revenue per labor day per crop			Debi	480		593		213		630		890		930
			Lampsar	404										

(1) Services repaid by farmers include a provision of 15% to cover financial charges and SAED overheads.

(2) Farm equipment provided under credit by BNDS is repaid with 5% interest over 5 years.

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SENEGAL RIVER POLDERS PROJECT

BENEFITS AND COSTS PER FARM AT FULL DEVELOPMENT

	Rice Farm			Other Crops	
				DAGANA	
	DEBI	LAMPSAR	DAGANA	Areas A/C	Area B
1. Farm size 1st crop	3	3	3.5	3	2
2nd crop	-	-	2.75	2	1.5
	3	3	6.25	5	3.5
2. Number of Farm	342	372	406	58	456
3. Cropping pattern: Ha cultivated per Farm					
Rice	3	3	6.25		
Tomatoes				1	0.5
Onion					0.5
Potatoes					0.5
Sorghum				4	2.0
4. Net Revenue per Farm	80,580	67,980	192,930	169,420	190,690
Subsistence Food	21,000	21,000	21,000	21,000	21,000
5. Cash Revenue	59,580	46,980	171,930	148,420	169,690
Working Days	168	168	325	422	320
Revenue per working Day	480	404	593	401	595
% consolidated Fee on net Revenue	27.1	30.1	34.2	32	26.8

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RIVER POLDERS PROJECT

DEBI POLDER

Total Farmers' Revenue and Net Revenue per Family

(CFAF'000)

	1974	1975	1976	1977	1978	1979	1980	1981
No. of Farms	342							
Paddy production in T.	1,537	1,845	2,050	2,555	2,460	2,565	2,665	2,768
A. Revenues								
Paddy at CFAF 21/T	32,277	38,745	43,050	47,355	51,660	53,865	55,965	58,128
B. Costs								
a) Inputs:								
Seeds	3,280							
Fertilizers	7,175							
b) Land preparation	7,919							
c) Credit repayment	2,030							
Subtotal	20,404	20,404	20,404	20,404	20,404	20,404	20,404	20,404
Less subsidies								
Fertilizers	2,870							
Plowing	2,563							
	5,433							
Net cost	14,971	20,404	20,404	20,404	20,404	20,404	20,404	20,404
Gross revenue	17,306	17,741	22,646	26,951	31,256	33,461	35,561	37,724
d) Consolidated fee	2,562	2,562	5,125	7,688	10,250	10,250	10,250	10,250
C. Net Revenue	14,744	15,179	17,521	19,263	21,006	23,211	25,311	27,479
Net revenue per farm	43.1	44.4	51.2	56.3	61.4	67.9	74.0	80.3
Subsistence food	21.5							
Cash revenue	21.6	22.9	29.7	34.8	39.9	46.4	52.5	58.8
Net revenue per working day (CFAF)	257	264	305	336	366	404	441	479

October 5, 1972

SENEGAL

RIVER POLDERS PROJECT

LAMPSAR POLDER

Total Farmers' Revenue and net Revenue per Family

(CFAF'000)

	1975	1976	1977	1978	1979	1980
No. of Farmers	372					
Paddy Production in Tons	1,616	1,940	2,156	2,372	2,587	2,695
A. Revenues						
Paddy at CFAF 21/k	33,957	40,740	45,276	49,812	54,327	56,595
B. Costs						
a) Input						
Seeds	3,456					
Fertilizers	7,560					
b) Land preparation	8,340					
c) Credit repayment	2,139					
Subtotal	21,495	21,495	21,495	21,495	21,495	21,495
Less subsidies						
Fertilizers	3,024					
Plowing	2,700					
	5,724					
Net cost	15,771	21,495	21,495	21,495	21,495	21,495
Gross revenue	18,186	19,245	23,781	28,317	32,832	35,100
d) Consolidated fee	2,700	2,700	5,400	8,100	10,800	10,800
C. Net Revenue	15,486	16,545	18,381	20,217	22,032	24,300
D. Revenue Per Farm	41.6	44.5	49.4	54.3	59.2	65.3
Subsistence food						
Cash revenue	20.1	22	27.9	22.8	37.7	43.8
Revenue per working day CFAF	256	246	305	336	366	402

October 6, 1972

Annex 18
Table 3

SENEGAL

SENEGAL RIVER POLDERS PROJECT
DAGANA

Total Farmers Revenue and Revenue per Farm from Rice
(CFAF '000)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Farms	174	380	406								
Ha cultivated	610	1,380	1,520	1,620	1,720	1,920	2,120	2,320	2,520		
Paddy production	1,098	2,816	3,457	4,148	4,634	5,497	6,243	7,092	7,939	8,064	8,064
Revenue											
Paddy Sales	23,058	59,136	72,597	87,108	97,314	115,437	131,102	148,932	166,719	169,344	169,344
Costs											
a) Inputs											
-Seeds	1,952	4,416	4,864	5,184	5,504	6,144	6,784	7,424	8,064	8,064	8,064
-Fertilizers	4,270	9,660	10,640	11,340	12,040	13,440	14,840	16,240	17,640	17,640	17,640
b) Land Preparation	5,642	12,765	14,060	14,985	15,910	17,760	19,610	21,460	23,310	23,310	23,310
c) Credit repayment	1,000	2,185	2,335	2,335	2,335	2,335	2,335	2,335	2,335	2,335	2,335
Total	12,864	29,026	31,899	33,844	35,789	39,679	43,569	47,459	51,349	51,349	51,349
Subsidies											
- Fertilizers	1,096	1,298	164								
- Ploughing	1,522	1,803	228								
Net Costs	10,246	25,925	31,507	33,844	35,789	39,679	43,569	47,459	51,349	51,349	51,349
Gross Revenues	12,812	33,211	41,090	53,264	61,525	75,758	87,533	101,473	115,370	117,995	117,995
d) Consolidated Fee	2,440	5,520	8,720	12,520	17,160	26,000	33,400	37,120	40,320	40,320	40,320
Net Revenue	10,372	27,691	32,370	40,744	44,365	49,758	54,133	64,353	75,050	77,675	77,675
Net revenue per farm	59.6	73.4	79.7	100.3	109.3	122.6	133.3	158.5	184.8	191.3	191.3
Cash revenue per farm	38.1	51.9	58.2	78.8	87.8	101.1	111.8	137.0	163.5	169.8	169.8
Revenue per working day (CFAF)	327	386	410	484	496	498	491	533	572	592	592

October 5, 1972

Annex 18
Table 4

SENEGAL

SENEGAL RIVER POLDERS PROJECT

DAGANA POLDER - ZONE B - FARM SIZE 2 HA

Total Farmers' Revenue and Revenue per Farm from Crops other than Rice
(CFAF '000)

	1975	1976	1977	1978	1979	1980
Farmers	140	456	456	456	456	456
Area Cultivated ha						
Tomatoes	32	78	148	228	228	228
Onions	30	60	120	170	228	228
Potatoes	30	60	120	170	228	228
Sorghum	188	714	872	924	912	912
Sub-total	280	912	1,260	1,492	1,596	1,596
Production tons						
Tomatoes	832	2,154	4,414	7,344	7,882	7,980
Onions	225	555	1,155	1,700	2,280	2,280
Potatoes	315	675	1,515	2,210	2,964	2,964
Sorghum	451	1,856	2,442	2,772	2,736	2,736
Sub-total	1,823	5,240	9,526	14,026	15,862	15,960
Revenue						
Tomatoes	5,824	15,078	30,898	51,408	55,174	55,860
Onions	4,500	11,100	23,100	34,000	45,600	45,600
Potatoes	6,300	13,500	30,300	44,200	59,280	59,280
Sorghum	8,118	33,408	43,956	49,896	49,248	49,248
Sub-total	24,742	73,086	128,254	179,504	209,302	209,988
Subsidy on consolidated fee	4,200	9,480				
Total revenues	28,942	82,566	128,254	179,504	209,302	209,988
Production Costs						
Inputs						
- Tomatoes	1,880	4,583	8,695	13,395	13,395	13,395
- Onions	1,143	2,286	4,572	6,477	8,687	8,687
- Potatoes	2,775	5,550	11,100	15,725	21,090	21,090
- Sorghum	1,466	5,569	6,802	7,207	7,114	7,114
Sub-total	7,264	17,988	31,169	42,804	50,286	50,286
Mechanical Services						
Tomatoes	1,605	3,914	7,426	11,441	11,441	11,441
Onions	718	1,435	2,870	4,066	5,454	5,454
Potatoes	991	1,981	3,962	5,613	7,529	7,529
Sorghum	3,299	12,530	15,304	16,216	16,006	16,006
Sub-total	6,613	19,860	29,562	37,336	40,430	40,430
Credit Repayment	513	513	513	513	513	513
Consolidated fee	5,600	18,240	25,200	29,840	31,920	31,920
Total costs of production	19,990	53,601	86,444	110,493	123,149	123,149
Net return	8,952	28,965	41,810	69,011	86,153	86,839
Net return per farm	65.9	63.5	91.7	151.3	188.9	190
Cash return per farm	42.4	41.0	70.2	149.8	167.4	168.5

August 16, 1972

ANNEX 18
Table 5

SENEGAL

SENEGAL RIVER POLDERS PROJECT

DAGANA POLDER - ZONE A AND C - FARM SIZE 3 HA

Total Farmers' Revenue and Revenue per Farm from Crops other than Rice
(CFAF '000)

	1974		1975		1976		1977		1978		1979		1980	
Areas Cultivated	A	C	A	C	A	C	A	C	A	C	A	C	A	C
- Tomatoes	30		38		38	30	38	68	38	68	38	68	38	68
- Sorghum	84		114		152	174	152	204	152	272	190	340	152	272
Sub-total Ha	114		152		190	204	190	272	190	340	190	340	100	340
Production Tons														
- Tomatoes	750		1,033		1,128	8,810	1,223	2,006	1,318	2,176	1,318	2,346	1,330	2,380
- Sorghum	185		285		410	435	441	551	456	789	456	816	456	816
Production sales														
- Tomatoes	5,250		7,231		13,566		22,603		24,458		25,648		25,970	
- Sorghum	3,330		5,130		20,340		17,856		22,410		22,896		22,896	
Sub-total	8,580		12,361		33,906		40,459		46,868		48,544		48,866	
Production costs														
Inputs														
- Tomatoes	1,763		2,332		3,995		6,228		6,228		6,228		6,228	
- Sorghum	638		866		2,478		2,705		3,222		3,222		3,222	
Mechanical services														
- Tomatoes	1,505		1,909		3,412		5,319		5,319		5,319		5,319	
- Sorghum	1,474		2,000		5,721		6,248		7,441		7,441		7,441	
Credit repayment	44		44		122		122		122		122		122	
Consolidated fee	456		2,432		6,304		7,392		8,480		8,480		8,480	
Total Production Costs	5,880		9,583		22,032		28,014		30,812		30,810		30,810	
Net revenue	2,700		2,778		11,874		12,445		16,056		17,734		18,056	
Net revenue per farm	75.0		76.9		112.0		117.4		154.9		167.9		170.3	
Cash revenue	53.5		55.4		90.5		95.9		133.5		146.5		149.1	

ANNEX 18
Table 6

SENEGAL
SENEGAL RIVER POLDERS PROJECT

FARM LABOR AND TRACTOR REQUIREMENTS PER FARM
Debi and Lampsar Polders

	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	TOTAL
Mandays per Ha													
Manuring		1	1										
Sowing					2								
Weeding						5	15	10	5				
Harvesting										10	5		
Threshing											2		
Total Mandays		1	1		2	5	15	10	5	10	7		56
Plowing Hours	2	1		1									4
3 Ha Farm													
Mandays		3	3		6	15	45	30	15	30	21		168
Tractor Hours	6	3		3									12

SENEGAL
SENEGAL RIVER POLDERS PROJECT

FARM LABOR AND TRACTOR REQUIREMENTS PER FARM
Dagana Rice

Man-days	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	TOTAL
Rice- 1st Crop 3.5 ha													
Manuring		3.5											
Sowing				14									
Water Control				3.5	3.5	3.5	3.5						
Weeding				10.5	35	24.5							
Harvesting							10.5	63					
Total Man-days		3.5		28.0	38.5	28.0	14.0	63					175
Second crop-2.7ha													
Manuring								3					
Sowing									11				
Water Control									3	3	3	5	
Weeding									13	27	16		
Harvesting	14	16											
Total Man-days	14	43						3	27	30	19	5	141
Total per farm	14	46.5		28	38.5	28	14	66	27	30	19	5	316
Tractor Requirement (Hours)													
1st crop		7	7	3.5									
2nd crop								5.4	2.7				8.1
Combine (Hours)		2.7	2.7					3.5	3.5				12.4

SENEGAL
SENEGAL RIVER POLDERS PROJECT

LABOR AND TRACTOR REQUIREMENTS PER FARM
Dagana - Area A and C (3 Ha per Farm)

	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar	TOTAL
Tomatoes-1 ha													
Manuring					2								
Land Preparation					4	4							
Planting						15							
Irrigation Maintenance						4	4						
Pest Control							8	8	8	8	8	4	
Hoeing							10	8	5				
Harvesting										30	30	30	
Total Mandays					6	23	22	16	13	38	38	34	190
Tractor Hours	2	2		1	2	2							9
Sprayers Hours						2	7	7	6	4	2		28
Sorghum 1st Season 3ha													
Land Preparation													
Sowing								10					
Manuring								10					
Weeding									12	24	14		
Water Control								4	6	6	6		
Harvesting	12											12	
Total Mandays	12							24	18	30	30	12	116
Sorghum 2nd Season													
Land Preparation													
Sowing				10									
Manuring				10									
Weeding					24	20	6						
Water Control				6	6	6	4						
Harvesting							24						
Total Mandays				26	30	26	34						116
Total Manday/Farm	12			26	36	59	56	40	31	68	58	48	422
Tractor Hours													
Tractor 1st season	6	4	6						2				18
2nd season	2							16					18

SENEGAL
SENEGAL RIVER POLDERS PROJECT

LABOR AND TRACTOR REQUIREMENT PER FARM
Dagana - Area B (2 Ha Farm)

	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	TOTAL
Tomatoes-½Ha													
Manuring					1								
Land Preparation					2	2							
Planting						7.5							
Irrigation Maintenance						2	2						
Pest Control							4	4	4	4	4	2	
Hoeing							5	4	2.5				
Harvesting										15	15	15	
Total Mandays					3	11.5	11	8	6.5	19	19	17	85
Sorghum/Onion-½Ha													
Nursery							4	1					
Land Preparation				2.5				1.5					
Planting/Sowing				2.5				10					
Irrigation and Pest Control				1.5	1.5	1.5	1	1.5	2.5	2.5			
Weeding					6	5	1.5		8.5	4			
Harvesting							6				20	5	
Total Mandays				6.5	7.5	6.5	12.5	14	11	6.5	20	5	89.5
Sorghum/Potatoes-½Ha													
Nursery													
Land Preparation				2.5									
Planting/Sowing				2.5				12.5					
Irrigation and Pest Control				1.5	1.5	1.5	1	1					
Weeding					6	5	1.5		20	10			
Harvesting							6				7.5	5	
Total Mandays				6.5	7.5	6.5	8.5	13.5	20	10	7.5	5	85
Sorghum/Sorghum-½Ha													
Land Preparation													
Sowing				2.5				2.5					
Manuring				2.5				2.5					
Weeding					6	5	1.5		3	6	3.5		
Maintenance				1.5	1.5	1.5	1	1	1.5	1.5	1.5		
Harvesting	3						6					3	
Total Mandays	3			6.5	7.5	6.5	8.5	6	4.5	7.5	5	3	58
Total Manday/Farm	3			19.5	25.5	31.0	40.5	41.5	42	43	51.5	20	317.5
Tractor Hours	6	4	4.5	0.5	1	1		10			1	1	29
Sprayer Hours							3.5	3.5	6	5	1		20

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Government Cash Flow
(CFAF '000)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
I. Direct and Indirect Expenditure													
A. Direct Project Expenditure													
a) Project cost	546,523	726,785	609,022	20,819									
b) Farmers' subsidies													
-Mechanical ploughing		4,195	4,503	228									
-Rice fertilizers		4,120	4,168	164									
c) SAED deficit				56,532	12,713								
d) IDA credit charges													
-Interest	840	2,983	5,714	7,882	8,632	8,632	8,632	8,632	8,632	8,632	8,589	8,503	8,417
-Repayment											11,510	11,510	11,510
Sub-total A	547,363	738,083	623,407	85,625	21,345	8,632	8,632	8,632	8,632	8,632	20,099	20,013	19,927
B. Indirect Project Exependiture													
ONCAD subsidies 1/		3,963	9,522	11,394	13,182	14,636	16,519	18,031	19,526	20,876	21,079	21,079	21,079
TOTAL	547,363	742,046	632,929	97,019	34,527	23,268	25,151	26,663	28,158	29,508	41,178	41,092	41,006
II. Direct Revenues													
IDA contribution	224,070	344,950	387,150	189,440	5,445								
SAED repayment						10,000	10,000	35,000	45,000	45,000	45,000	45,000	45,000
SAED surplus		6,421	10,728			4,273	(2,147)	4,637	10,568	7,210	(19,207)	2,638	2,638
TOTAL	224,070	351,371	397,878	189,440	5,445	14,273	7,853	39,637	55,568	52,210	25,793	47,638	47,638
Surplus (Deficit)	(323,293)	(390,675)	(235,051)	92,421	(29,082)	(8,995)	17,298	12,974	27,410	22,702	(15,385)	6,546	6,632
III. Tax Revenues	132,817	193,941	129,099	25,465	19,861	26,958	30,634	26,958	25,602	25,833	32,802	32,802	32,802

1/ Difference between the price at which ONCAD sells rice to wholesalers, (CFAF 37.000), and purchases it from SAED, (CFAF 39.500).

SENEGAL

SENEGAL RIVER POLDERS PROJECT

Economic Rate of Return Calculation

1. Annual costs and returns used in calculating the economic rates of return are shown in Tables 1, 2, 3, and 4. Economic rate of return calculations have been made for each sub-projects and for the project overall.

2. In the calculation of the economic rate of return the following principle assumptions have been used:

(a) an economic life for the project of 35 years;

(b) an eight-year period in which yields would increase gradually and reach those forecast at appraisal; consequently farms of the last group of project participants would reach full development in year 12 after project commencement;

(c) a zero opportunity cost for farm family labor, project farmers are not expected to hire labor, and to the large majority of project families participation in the project would mean an intensification of family effort and consequently a greater use of family labor. This additional use of family labor would entail no additional cost to the economy since at the time such labor would be required no alternative employment opportunities would exist in which such labor could be employed productively;

(d) an economic cost for labor employed in project construction equivalent to its cash cost. It is probable that the economic cost of such labor is lower than its cash cost; however a shadow rate is difficult to establish and its impact on the rate of return would be insignificant;

(e) inclusion in project costs of a physical contingency equivalent to 15% of irrigation works costs;

(f) treatment of past investments in flood control from which the Debi and Lampsar sub-projects will benefit as sunk-costs. This is justified since only incremental production at Debi and Lampsar is treated as a project benefit;

(g) a shadow rate for foreign exchange of US$1 = CFAF 320 instead of the official rate of US$1 = CFAF 255.79;

(h) deduction from benefits of the value of production of farmers now farming in the sub-project areas and who would continue to grow crops in the area where the project is not implemented.

3. On the basis of the above assumption the economic rates of return for the project and its component sub-projects would be as follows:

Project	Debi	Lampsar	Dagana
%			
14	19	17	14

4. Sensitivity tests have been carried out to measure the impact of changes in the assumptions made on project costs and benefits. The results are summarized below:

Change	Project	Debi	Lampsar	Dagana
	%			
(a) Forecast production levels reached in 12 instead of 8 years	12	17	15	12
(b) Forecast production levels reached in 16 instead of 8 years	10	15	12	10
(c) 10% increase in project investment and operating (including on-farm) costs	13	16	14	12
(d) 10% decline in project benefits	13	16	14	12
(e) 10% increase in project costs (as in c.) combined with 10% decline in project benefits (as in d.)	10	12	11	10
(f) 10% increase in project benefits	17	23	20	17

5. In addition to the above for the sake of completeness the rates of return have been calculated (a) using an annual labor cost per farm family equivalent to the value of its subsistence consumption, i.e. CFAF 21,000/year for a family of five persons, and (b) using the current exchange rate of US$1 = CFAF 256.9 rather than a shadow rate. The results are:

	Project	Debi	Lampsar	Dagana
	%			
(a) Subsistence labor cost	13	15	12	13
(b) Current exchange rate	12	15	13	12

SENEGAL

SENEGAL RIVER POLDERS PROJECT

ECONOMIC RATE OF RETURN CALCULATION

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984 /-2008
BENEFITS												
Dagana	(4,810)	24,963	88,473	186,225	285,749	369,965	427,469	443,550	459,379	476,503	477,076	477,569
Debi		21,796	27,080	31,114	35,225	39,712	41,979	44,400	46,375	46,375	46,375	46,375
Lampsar			18,091	24,284	28,528	32,851	37,392	39,957	39,957	39,957	39,957	39,957
TOTAL	(4,810)	46,759	133,644	243,623	249,502	442,528	506,860	527,907	545,711	563,835	563,408	563,901
COSTS												
Dagana	427,935	451,552	371,713	175,140	183,498	192,818	223,583	211,750	204,689	211,676	228,135	211,923
Debi	4,740	115,564	19,537	19,537	19,759	19,169	17,271	22,941	16,671	21,287	22,280	22,280
Lampsar			114,720	17,911	17,911	17,915	16,824	21,689	20,379	14,081	14,081	19,437
TOTAL	432,675	567,116	505,970	212,588	221,168	229,902	257,678	256,380	241,739	247,044	264,496	253,640
Surplus (deficit)	(437,485)	(520,357)	(372,326)	31,035	128,334	212,606	249,162	271,527	303,972	316,791	298,912	310,261

Rate of Return: 14%

Annex 20
Table 1

SENEGAL

SENEGAL RIVER POLDERS PROJECT

DAGANA

ECONOMIC RATE OF RETURN CALCULATION

(CFAF '000)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
BENEFITS												
A. With Project												
Rice		14,860	38,430	47,979	58,520	66,198	79,795	91,931	104,594	118,293	118,752	119,146
Tomatoes		5,250	13,055	28,644	53,501	75,866	80,871	81,760	81,760	81,760	81,760	81,760
Vegetables			11,887	25,687	55,387	81,175	108,870	108,870	108,870	108,870	108,870	108,870
Sorghum		3,708	14,734	54,036	68,595	80,175	79,919	79,799	79,799	79,799	79,799	79,799
TOTAL	----	23,818	78,106	156,346	236,003	303,414	349,455	362,360	375,023	388,722	389,181	389,575
B. Without Project	3,848	3,848	7,328	7,366	7,404	7,442	7,480	7,520	7,520	7,520	7,520	7,520
Incremental benefits	(3,848)	19,970	70,778	148,980	228,599	295,972	341,975	354,840	367,503	381,202	381,661	382,055
Shadow pricing 1,25	(4,810)	24,963	88,473	186,225	285,749	369,965	427,469	443,550	459,379	476,503	477,076	477,569
COSTS (1)												
A. With Project												
Engineering	55,900	28,525	15,412									
Infrastructure	202,252	245,820	165,202									
Construction	15,187	10,125	2,531									
Material and equipment	89,912	78,528	53,928	21,980	14,593	9,242	22,234	16,500	10,951	20,431	39,783	24,671
Extension services	3,722	18,976	32,819	41,152	41,152	33,828	32,153	20,552	17,651	15,471	12,578	11,478
Training	14,440	2,799	2,799	2,799								
Evaluation	3,565	4,609	4,672	3,057								
Operating costs	12,620	24,757	69,634	103,989	125,868	147,269	166,386	171,780	173,061	172,640	172,640	172,640
Contingencies	30,337	37,413	26,246	2,693	3,415	4,009	4,340	4,448	4,556	4,664	4,664	4,664
TOTAL	427,935	451,552	373,243	175,670	185,028	194,348	225,113	213,280	206,219	213,206	229,665	213,453
B. Without Project			1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530
Incremental cost	427,935	451,552	371,713	174,140	183,498	192,818	223,583	211,750	204,689	211,676	228,135	211,923
Surplus (deficit)	(432,745)	(426,589)	(283,240)	12,085	102,251	177,147	203,886	231,800	254,690	264,827	248,941	265,646

Economic Rate of Return: 14%

(1) Foreign exchange costs are increased by 25% for shadow pricing.

Annex 20
Table 2

SENEGAL

SENEGAL RIVER POLDERS PROJECT

LAMPSAR POLDER

ECONOMIC RATE OF RETURN CALCULATION

(CFAF '000)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984/-2008
I. Benefits										
A. With Project	21,572	26,526	29,994	33,527	37,233	39,383	39,383	39,383	39,383	39,383
B. Without Project	7,099	7,099	7,172	7,246	7,319	7,417	7,417	7,417	7,417	7,417
Incremental benefits	14,473	19,427	22,822	26,281	29,914	31,966	31,966	31,966	31,966	31,966
Shadow pricing 1.25	18,091	24,284	28,528	32,851	37,392	39,957	39,957	39,957	39,957	39,957
II. Costs (1)										
A. With Project										
Engineering	4,450									
Infrastructure	72,172									
Construction	4,891									
Materials	1,176			1,091			6,298			3,454
Extension services	6,856	6,856	6,856	5,769	5,769	5,419	3,026	3,026	3,026	3,026
Operating costs	20,942	17,647	17,647	17,647	17,647	22,862	17,647	17,647	17,647	19,549
Contingencies	11,373	548	548	548	548	548	548	548	548	548
TOTAL	121,860	25,051	25,051	25,055	23,964	28,829	27,519	21,221	21,221	26,577
B. Without Project	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140
Incremental cost	114,720	17,911	17,911	17,915	16,824	21,689	20,379	14,081	14,081	19,437
Surplus (deficit)	(96,629)	6,373	10,617	14,936	20,568	18,268	19,578	25,876	25,876	25,876

Economic Rate of Return: 17%

(1) Foreign exchange costs are increased by 25% for shadow pricing.

SENEGAL

SENEGAL RIVER POLDERS PROJECT

DEBI POLDER

ECONOMIC RATE OF RETURN CALCULATION
(CFAF '000)

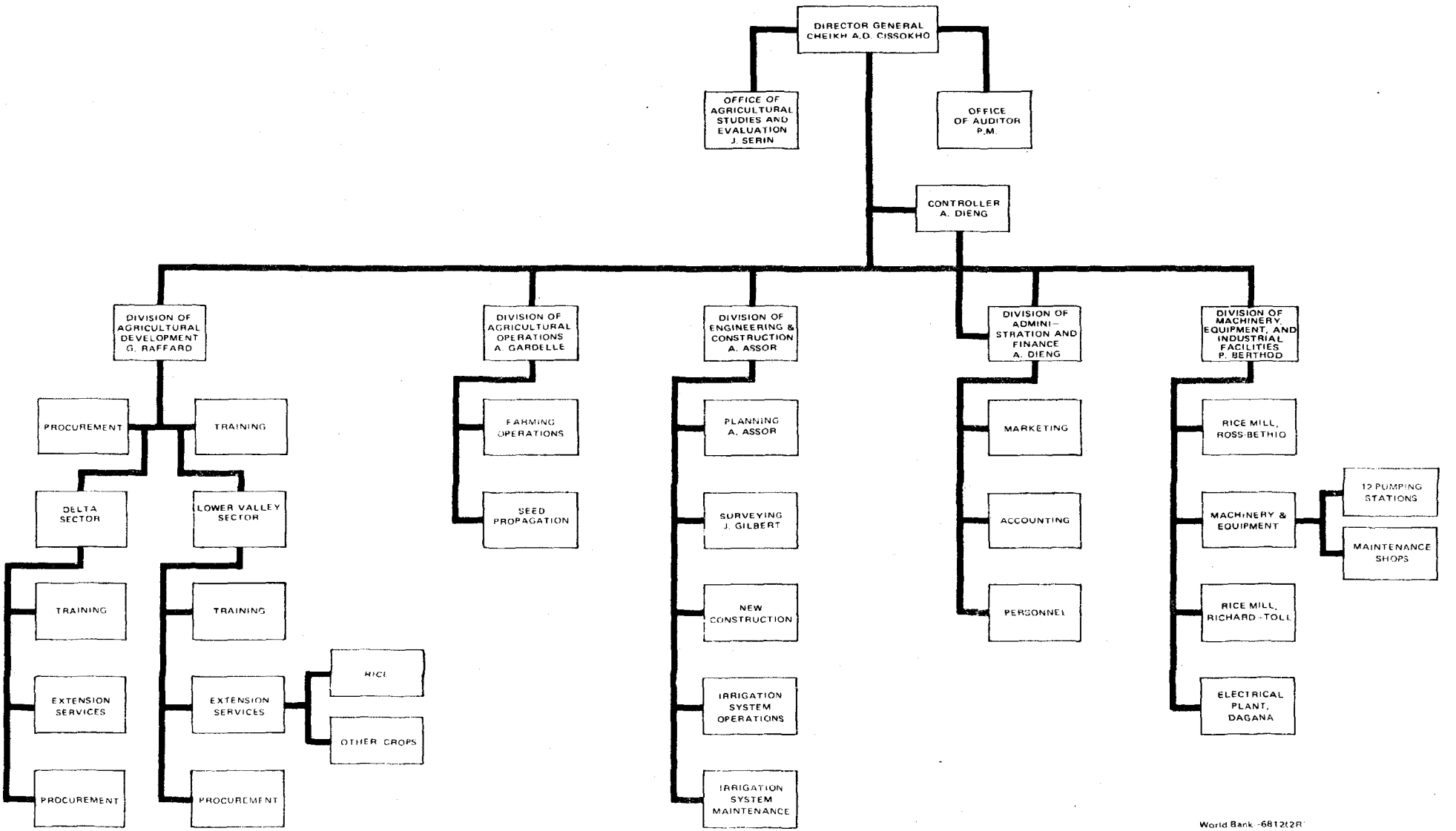
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983 /-2008
I. Benefits											
A. With Project		20,503	24,970	28,231	21,554	34,938	36,997	39,020	40,600	40,600	40,600
B. Without Project		3,306	3,306	3,340	3,374	3,408	3,454	3,500	3,500	3,500	3,500
Incremental Benefits		17,197	21,664	24,891	28,180	31,530	33,543	35,520	37,100	37,100	37,100
Shadow Pricing x 1.25		21,796	27,080	31,114	35,225	39,712	41,979	44,400	46,375	46,375	46,375
II. Costs (1)											
A. With Project											
Engineering	2,940	4,410									
Infrastructure		43,700									
Construction	1,800	7,762									
Material		28,519			590			6,270		4,616	4,616
Extension services		6,670	5,167	5,167	4,799	4,799	2,301	2,301	2,301	2,301	2,301
Operating costs		19,505	15,936	15,936	15,936	15,936	16,536	15,936	15,936	15,936	15,936
Contingencies		7,078	514	514	514	514	514	514	514	514	514
TOTAL	4,790	117,644	21,617	21,617	21,839	21,249	19,351	25,021	18,751	23,367	24,367
B. Without Project		2,080	2,080	2,080	2,080	2,080	2,080	2,080	2,080	2,080	2,080
Incremental costs	4,740	115,564	19,537	19,537	19,759	19,169	17,271	22,941	16,671	21,287	22,287
Surplus (deficit)	(4,740)	(94,068)	7,543	11,577	15,466	20,243	24,708	21,459	29,704	25,088	24,088

Economic Rate of Return: 14%

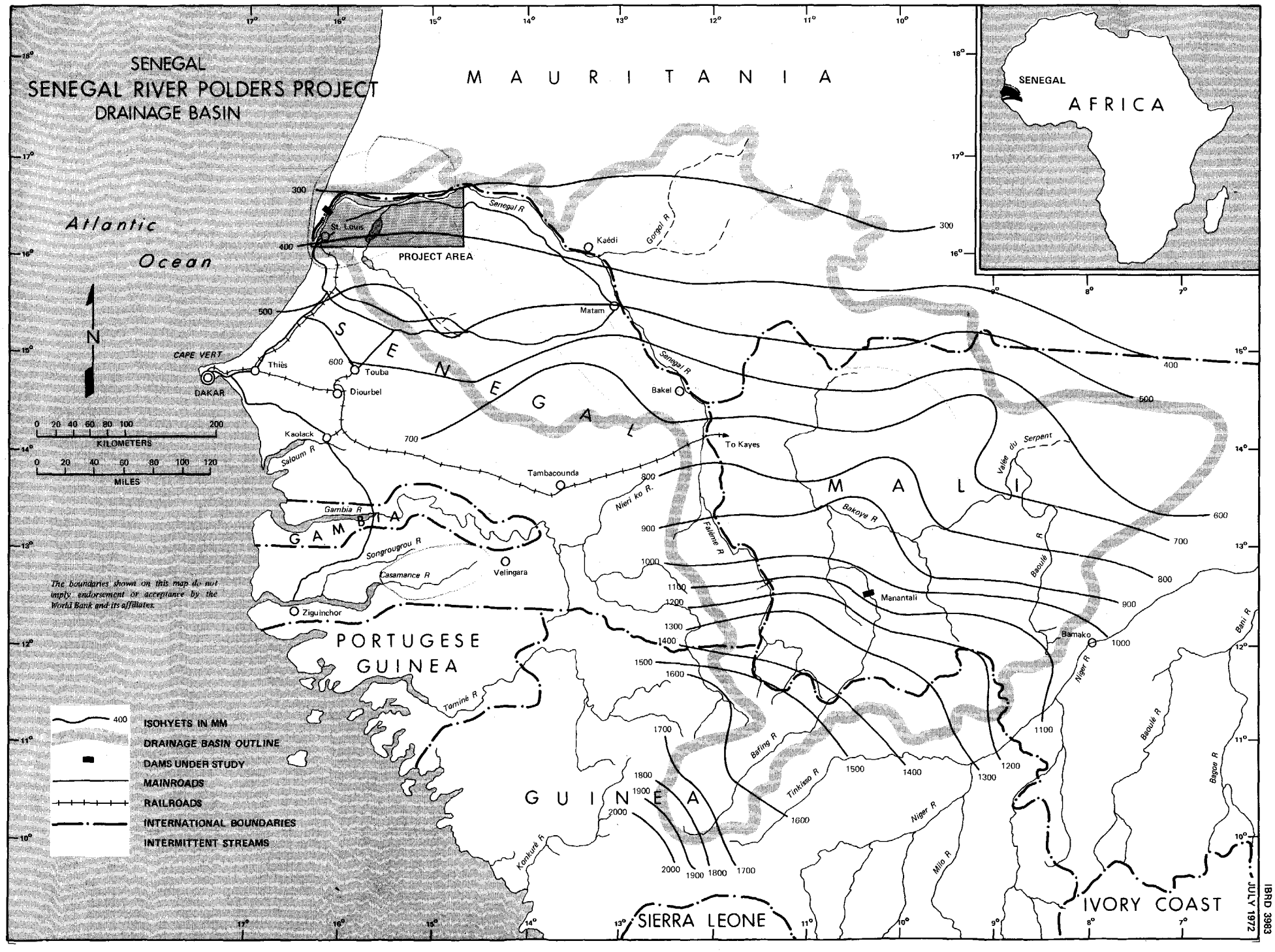
(1) Foreign exchange costs are increased by 25% for shadow pricing.

Annex 20
Table 4

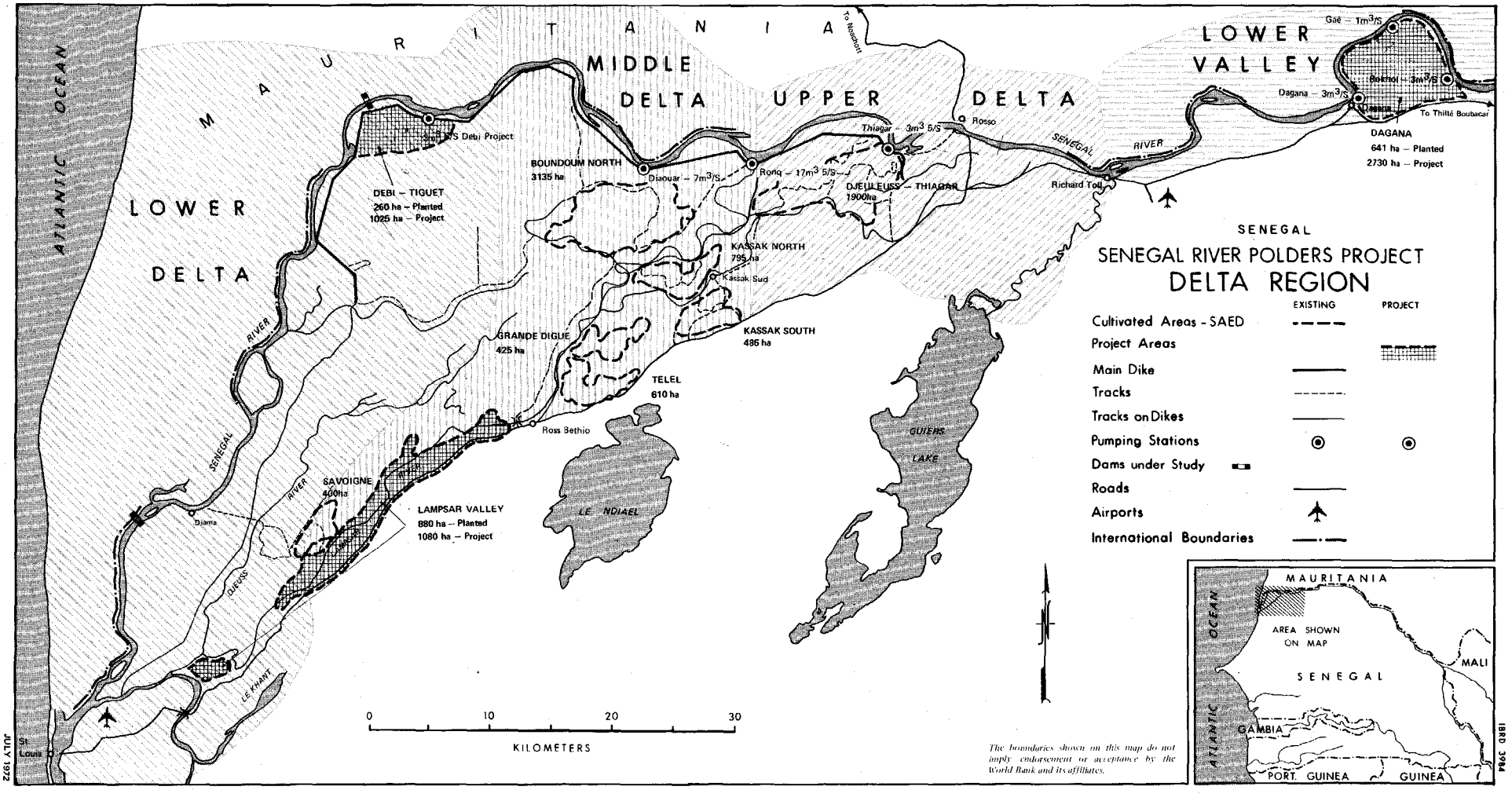
SENEGAL
SENEGAL RIVER POLDERS PROJECT
SAED ORGANIZATION

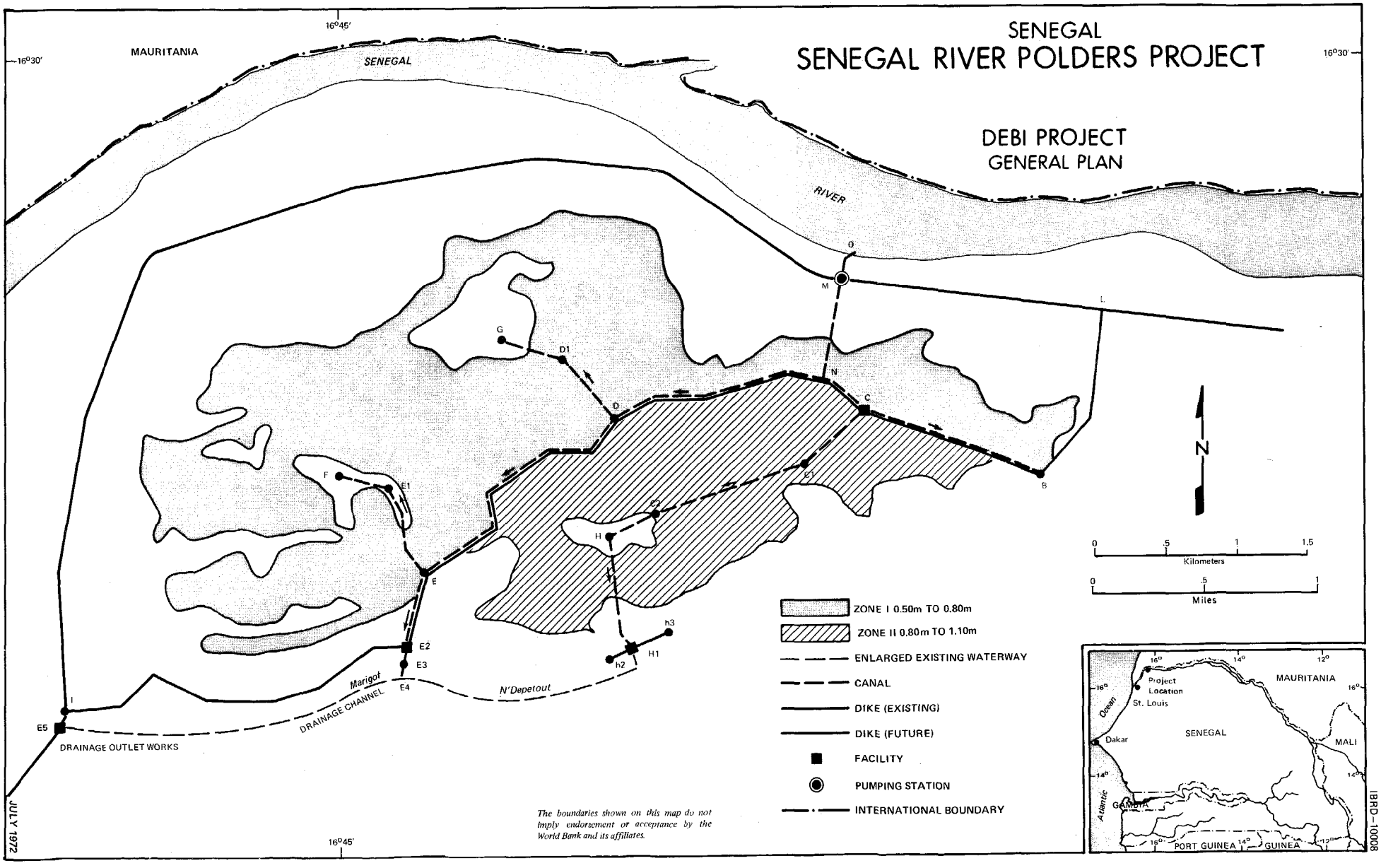


World Bank -6812(2R)



IBRD 3983
JULY 1972

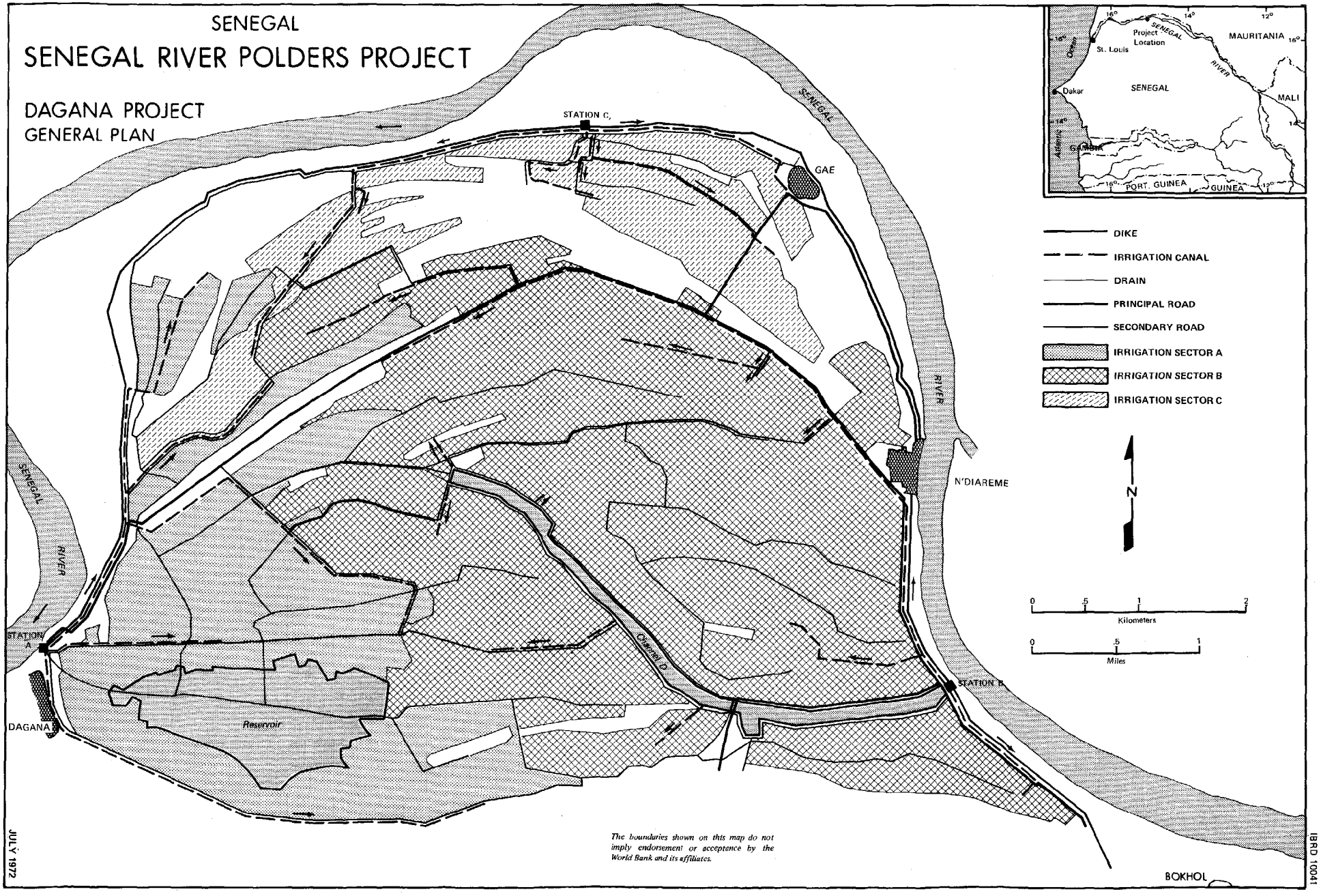

SENEGAL
SENEGAL RIVER POLDERS PROJECT
DELTA REGION
EXISTING
PROJECT
Cultivated Areas - SAED
Project Areas
Main Dike
Tracks
Tracks on Dikes
Pumping Stations
Dams under Study
Roads
Airports
International Boundaries
ATLANTIC OCEAN
MAURITANIA
LOWER DELTA
MIDDLE DELTA
UPPER DELTA
LOWER VALLEY
SENEGAL RIVER
To Nouakchott
To Thiltè Boubacar
DEBI – TIGUET
260 ha – Planted
1025 ha – Project
BOUNDOUM NORTH
3135 ha
Diaouar – 7m³/S
Ronq – 17m³/S
Thiagar – 3m³/S
DJEUL EUSS – THIAGAR
1900ha
Rosso
Richard Toll
Gaé – 1m³/S
Dagana – 3m³/S
DAGANA
641 ha – Planted
2730 ha – Project
KASSAK NORTH
795 ha
Kassak Sud
KASSAK SOUTH
486 ha
GRANDE DIGUE
425 ha
TELEL
610 ha
Ross Bethio
GUIERS LAKE
LE NDIAEL
SAVOIGNE
400ha
LAMPSAR VALLEY
880 ha – Planted
1080 ha – Project
Djama
DIEUSS
LE KHANT
St. Louis
0
10
20
30
KILOMETERS
The boundaries shown on this map do not imply endorsement or acceptance by the World Bank and its affiliates.
MAURITANIA
AREA SHOWN ON MAP
MALI
SENEGAL
GAMBIA
PORT. GUINEA
GUINEA
ATLANTIC OCEAN
JULY 1972
IBRD 3964


SENEGAL
SENEGAL RIVER POLDERS PROJECT
DEBI PROJECT
GENERAL PLAN
MAURITANIA
SENEGAL
RIVER
16°45'
16°30'
16°30'
16°45'
O
M
L
N
C
B
G
D1
D
F
E1
E
C1
C2
H
h3
h2
H1
E2
E3
E4
E5
I
Marigot
DRAINAGE CHANNEL
N'Depetout
DRAINAGE OUTLET WORKS
N
0
.5
1
1.5
Kilometers
0
.5
1
Miles
ZONE I 0.50m TO 0.80m
ZONE II 0.80m TO 1.10m
ENLARGED EXISTING WATERWAY
CANAL
DIKE (EXISTING)
DIKE (FUTURE)
FACILITY
PUMPING STATION
INTERNATIONAL BOUNDARY
The boundaries shown on this map do not imply endorsement or acceptance by the World Bank and its affiliates.
Project Location
St. Louis
Dakar
MAURITANIA
SENEGAL
MALI
GAMBIA
PORT GUINEA
GUINEA
Atlantic Ocean
16°
14°
12°
JULY 1972
IBRD-10008

SENEGAL

SENEGAL RIVER POLDERS PROJECT

DAGANA PROJECT
GENERAL PLAN



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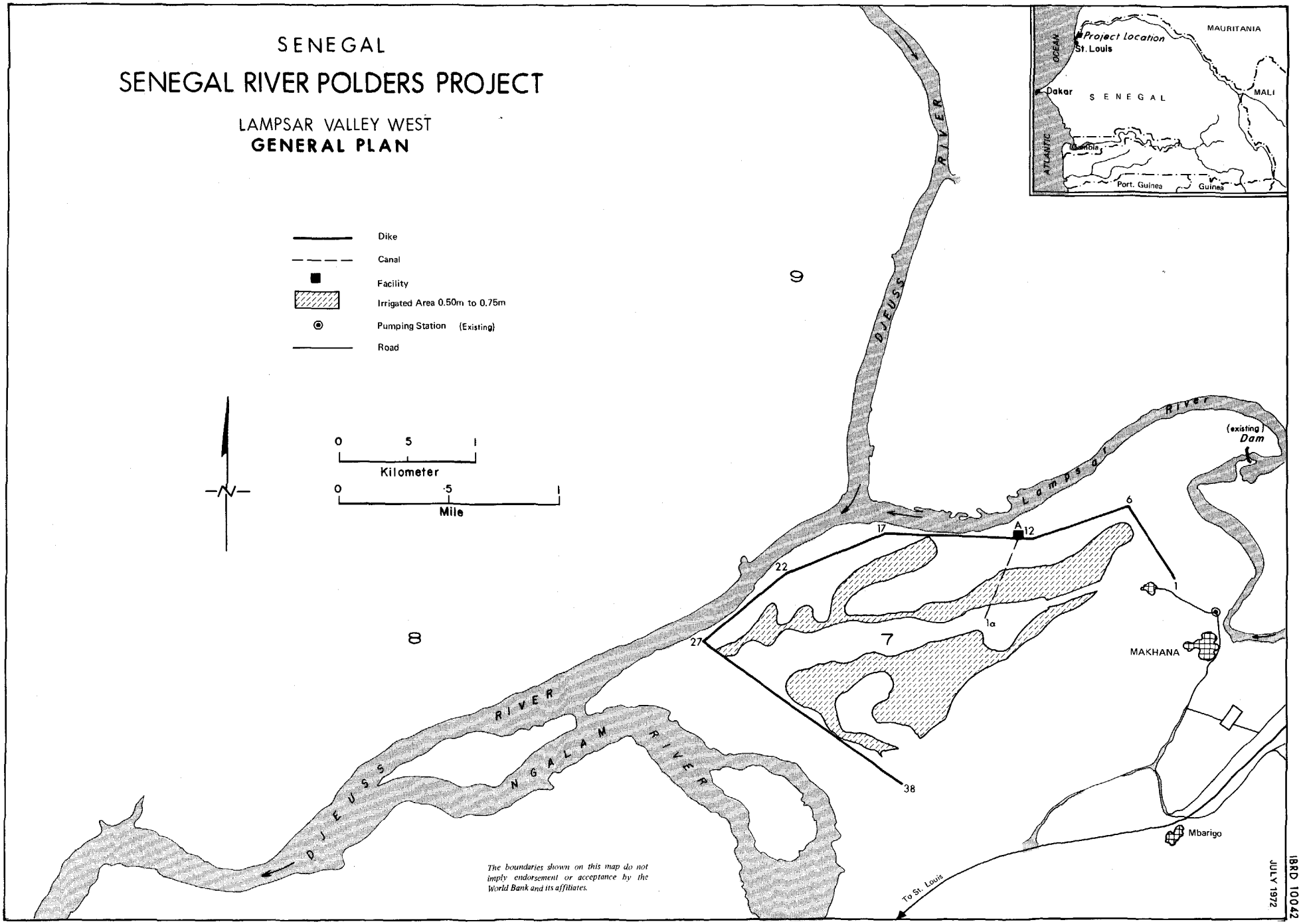
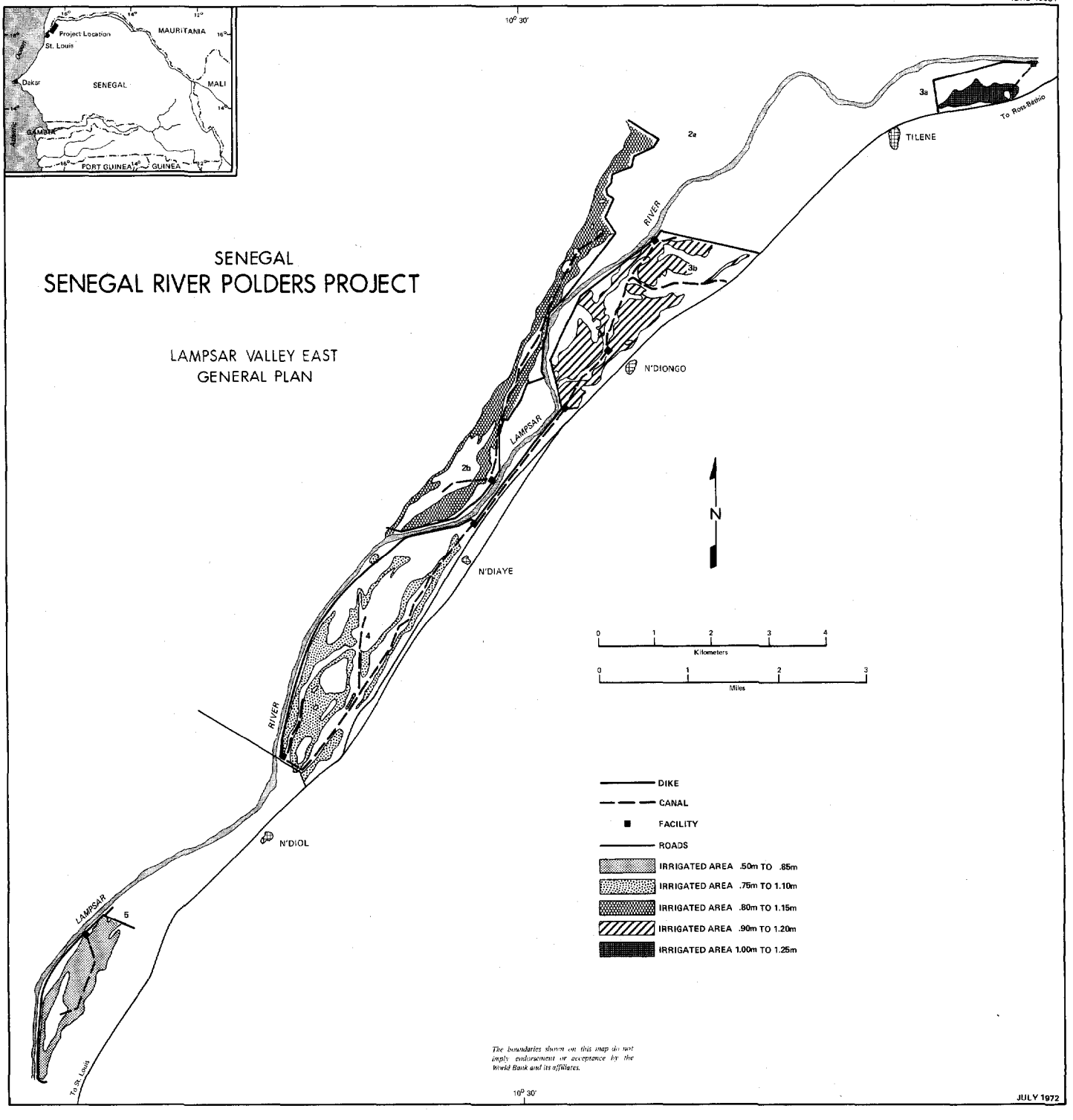
JULY 1972

IBRD 10041



IBRD 10042
JULY 1972

IBRD 10054



JULY 1972