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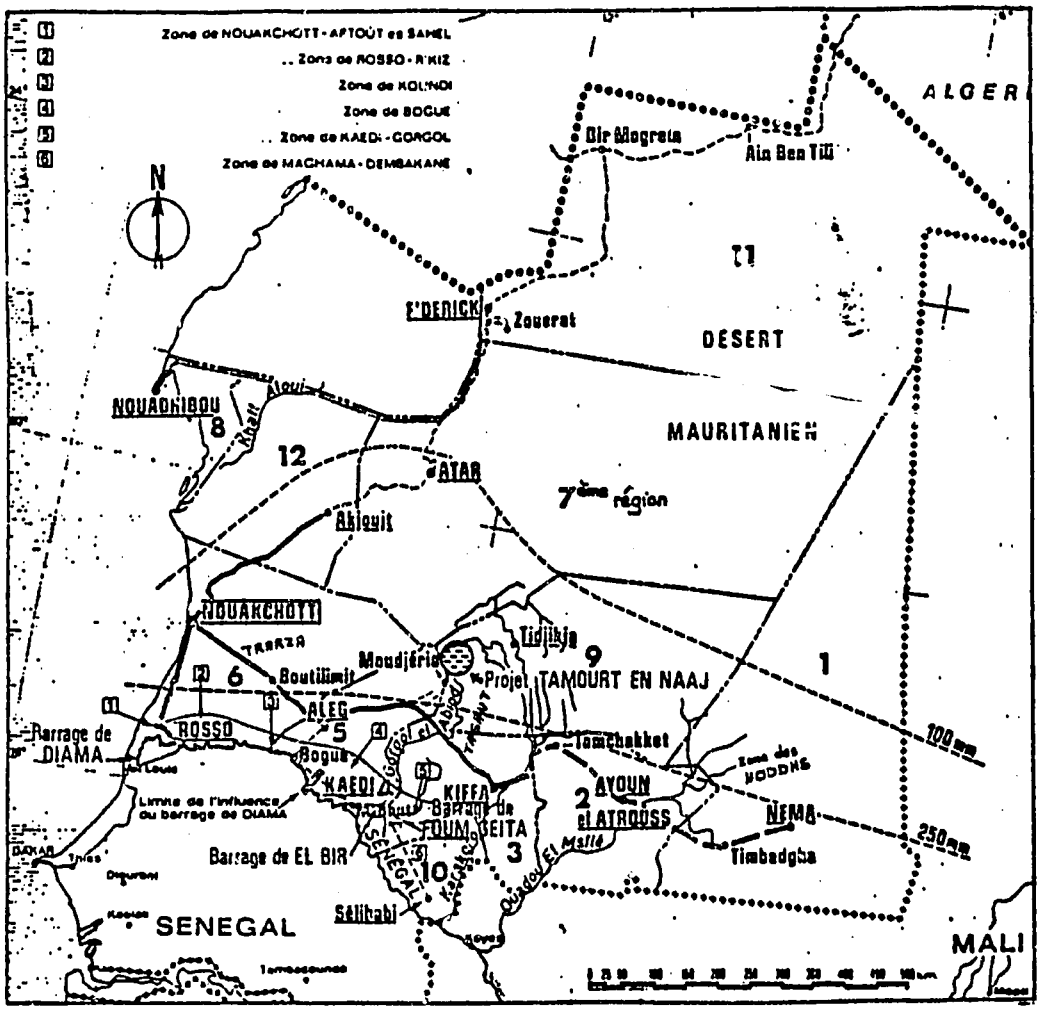
DEVELOPMENT OF IRRIGATED AGRICULTURE IN MAURITANIA

GENERAL OVERVIEW AND PROSPECTS,
- PROPOSALS FOR A SECOND PROGRAMME 1980-1985 -



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PREFACE

At the third Conference of the Club du Sahel in Amsterdam in November 1978, it was recalled that the main objective of the Sahel development strategy is to increase crop production - whence the dominating position in the 1979 work programme of the first generation rainfed and irrigated farming projects. The Conference placed particular emphasis on the need to prepare a programme in 1979 for the second generation of irrigated farming projects to be executed over the period 1980-1985.

A mission of Club du Sahel (FAC, USAID) and CILSS experts visited Mauritania between July 12th and 22nd, 1979. Together with the Mauritanian authorities concerned, they reviewed the current state of irrigation and the status of irrigated farming projects, undertook an appraisal of the first CILSS programme, examined prospects and gathered the information and materials required to work out a second programme for the period 1980-1985.

More specifically, the mission undertook the following assignments:

- to analyse, on the basis of experience with existing perimeters, the main difficulties encountered, and to bring to light the impediments hindering irrigation at the level of new farmers and the management of perimeters, and at national level;

- to make concrete proposals for overcoming these impediments or to remedy shortcomings hindering the pursuit of a true irrigation policy;

- to identify the studies and projects available or in progress;

- to assemble information, to be used in conjunction with the general planning already carried out by CILSS (especially the reports by the "Irrigated Farming" groups) and the multi-year plan drawn up by the Mauritanian administration, to identify a set of new projects, which together with the projects already available or under consideration, can, subject to approval by the national authorities, constitute the second generation programme;

- to specify the needs for executive personnel at all levels (managers, accountants, agronomists, technicians of various kinds, advisory personnel etc.) required for the programme, and to identify the corresponding training needs;

- to sketch out a calendar for the studies to be performed to bring each project envisaged up to the stage of completion of the feasibility study.

These elements are supplemented by an overview of the main economic and human characteristics of Mauritania, and its agricultural and food policy over the Third Plan, 1976-1980, now in course. Stress was laid on the role of irrigated farm products in the economy and in national planning.

In the light of the various studies carried out since 1976/77, it has seemed necessary to recall Mauritania's possibilities in the field of irrigation, both as regards the Senegal River Valley, where the OMVS plays an important role as promoter and coordinator, and the interior, where the scope for operating small dams and for drilling is much better known.

Crop production, whether irrigated (mainly rice (1) or traditional, is far from high enough to meet food requirements. In this report, the main obstacles to the rapid development of irrigation are analysed and a review is made of the research and activity programme of the SONADER, the national Mauritanian company responsible for studying, developing and managing irrigated perimeters.

Proposals are made for activities/work programme and technical assistance studies, to be carried out in the short term over the period 1980-1985 - broadly the span covered by the next Mauritanian Plan now being prepared. Proposals are also made for short expert missions which should help bring forward the start-up of certain projects or studies or their presentation to financing sources.

The document, as far as possible, is a faithful reflection of the information and the opinions of the Mauritanian officials consulted, and of the contents of the official documents placed at our disposal; certain passages and tables have been reproduced directly from them.

Finally, as regards the production of wheat on irrigated land, a proposal for a regional experimental and research project was made in the report on Senegal(2), setting out its national components, including Mauritania; the reader is invited to refer to it. Their proposal would enable the objectives for irrigated wheat production set out in 1977 by the Working Group on "Irrigated Farming" to be met. It is recalled that for Mauritania, these objectives are an output of 28,000 tons on 9,300 hectares in 1982 and 38,000 tons on 12,000 hectares in 1990.

(1) Sugar is not yet produced in Mauritania. The sugar complex project at Koundi, covering 4,400 hectares net, could come into production towards the end of the IVth Plan. This project is included in the Second Generation Programme.

(2) Development of Irrigated Farming in Senegal. Proposals for a second programme 1980-1985, CILSS/Club du Sahel, October 1979, para. 3.40 and Annex F. At present, output of wheat using traditional methods is very low indeed, practically insignificant.

SUMMARY AND CONCLUSIONS

1. Mauritania's food situation as regards cereals is precarious, as was highlighted dramatically during the drought years of the 1970's. Minimum overall needs are estimated at 180,000 tons (120 kg. per capita annually, total population, 1.5 million), against an average output in recent years of 30,000 tons i.e. a chronic deficit of 150,000 tons a year. In these circumstances, the country has no option other than to rely on the international community, which provided food aid grants of 95,000 tons in 1972, 35,000 tons in 1975, 50,000 tons in 1977 and 57,000 tons in 1978. The problems are aggravated by the rural exodus.

2. Rainfed crops in 1979, a year of average to good rainfall, accounted for between 70% and 90% of total agricultural output. As rainfed crops are tributary essentially to climatic uncertainties, the precariousness of cereal production, i.e., of the food situation, can not be mitigated unless and until irrigated crops are grown, and in particular not before the hydro-agricultural development projects in the Senegal Valley have been completed.

3. Recent studies have inventoried 350,000 hectares of potentially irrigable land in the Senegal Valley, the Gorgol Valley and the Aftout es Sahel - more than half of it particularly suitable for rice production. Elsewhere, in the interior of the country, the prospects opened by small dams or the use of boreholes to exploit underground water are far from negligible. Agronomic research in the Senegal Valley has shown that a yield can be obtained of up to 10 tons of paddy rice per hectare per harvest with two or even three harvests per year. For sorghum, corn and wheat, yields of 6 to 8 tons per hectare can be envisaged. In practice, the average yield of paddy rice over the past five years has stabilised at about 4 tons per hectare in the Senegal Valley, while some 5 tons are obtained in village perimeters. Lastly, there are prospects for livestock breeding by production of forage crops under irrigation, or for subsidence-period cultivation.

4. Aggregate rice production was very low in 1979, less than 8,000 tons of paddy rice on 2,700 hectares of developed land, of which 1,850 hectares were effectively sown in 1978/79. Total cereal production in 1978 is estimated to have been 60,000 tons of rice, millet, sorghum and corn. Wheat, cultivated using traditional methods, is produced in negligible quantities. Sugarcane is not yet grown, but is envisaged in the Koundi project.

5. There is a considerable lag vis-à-vis the objectives of the Third Plan, 1976-80, which provided for the availability of 9,600 hectares of developed land by end 1979, with reasonable expectations of an output of 40,000 to 50,000 tons of paddy rice a year, assuming a single harvest. The three projects completed add up to 2,700 hectares: 1,100 hectares for the M'Pourié perimeter, 900 hectares of small village perimeters, and 900 hectares for the Gorgol. To this may be added some 500 hectares of small private perimeters, developed and managed without State assistance.

6. SONADER, the national corporation, has been responsible since its creation in 1975 for the study, development and management of hydro-agricultural developments. It has achieved good results and is now over its teething troubles; its present needs are for strengthened technical assistance to enable it to cope with the import programme which must be expedited in the short term (and for which finance has already been secured): 2,650 million MU (this abbreviation will be used for the Mauritanian currency unit - the ougiya). SONADER should be in a position to have developed and be managing almost 5,000 hectares towards 1985.

7. This experience of the last few years reveals farmers' remarkable capacity to adapt to the development and exploitation of small perimeters. By contrast, the large perimeters are having difficulties stemming from such causes as management problems, the "mechanised" services provided by SONADER, the centralisation of procedures, the isolation of perimeters, and a shortage of motivated and seasoned advisory personnel. Current producer prices for paddy rice do not favour intensification given the heavy operating costs to be borne by farmers, a problem aggravated by imports and food and grants. The transition from the traditional farming system to modern irrigation will call for the revision and adaptation of land tenure legislation. Practical training in irrigation, at all levels from the farmer to the advisor is cruelly deficient by comparison with needs in 1979: particularly substantial efforts are required in this matter.

8. The cost of hydroagricultural development, often running at above 0.5 million MU per hectare, is a constraint whose effect will have to be attenuated by promoting the execution of work by parastatal enterprises ("Régies"), increasing participation by farmers and also by rigourous programming enabling invitations to tender to be distributed more widely. Important actions to be carried out urgently include the creation of an agricultural credit system, the development of village cooperatives, the construction of rice mills near the location of production, and the ending of the isolation of production areas by the construction of permanent roads, especially in the valley of the river Senegal. The maintenance of infrastructures is another requirement, and should be organised now.

9. The status of the first generation irrigated farming programme can be defined by the projects underway or being started up by SONADER as of 1979. The finance secured amounts to 7,057 million MU (i.e., about $ 150 million), of which 6,722 million for implementation work and 335 million for project studies.

10. Proposals are made for a second generation CILSS/Club du Sahel programme for the period 1980-1985 i.e. 6 years. The aim is to achieve a rate of development of 4,500 hectares a year by 1985, and an intensification of production, with progressive generalisation of two-harvest cultivation. An effort will be made to improve the geographical distribution of projects, to preserve the environment, and to imbue the population - especially youth - with the feeling of being involved. However, the pole of irrigation development will remain the Senegal Valley, with an additional 14,000 hectares of developed land by 1985 (estimated cost: 7 billion MU). A considerable portion of the programme is devoted to studies which at present are very much lagging behind: feasibility studies (300 million MU), implementation studies (100 million MU) and studies of overall development schemes for inland regions. The strengthening of technical assistance to SONADER is envisaged for a period going beyond 1985 (420 million MU). The estimate for the sugar project at Koundi, covering 4,400 hectares net, for which the feasibility study is now in progress, is of the order of 5 billion MU.

In total, the Second Generation Programme amounts to 14,685 million MU - about $ 347 million - for the period 1980-1985.

CHAPTER I

I. AN OVERVIEW OF MAURITANIA

1.1 NATURAL CONDITIONS

Mauritania has a surface area of 1,100,000 sq. kilometers, extending from 16° to 27° of latitude north, and from 6° to 16° of longitude west.

More than three-quarters of the country lies in the Saharan region and receives less than 100 mm. of rainfall annually. The climate of the southern portion between Senegal and a line joining Nouakchott to Nema ranges from sub-Sahelian to Sahelian, with an average, but annually very variable, rainfall ranging from 150 mm. at Nouakchott to 500-600mm. in the extreme south in the Selibabi region. The climate of the coastal region is tempered by the influence of the ocean and the trade winds.

The rainy season extends from June to October, with the heaviest rainfall in July, August and September. There is marked annual variability: the rainfall over eight years of a ten-year period accounts for only some 40% to 60% of the total. Between 1968 and 1977, the region suffered its worst drought in 50 years, and 1976 and especially 1977 were also exceptionally dry. However, it cannot be concluded that there is a discernable downward trend in rainfall: the process of desertification seems to have been caused mainly by human activity (deforestation) and excessive livestock density. Relative humidity is low, with daily minima of 15% to 20% during the January-April dry season; this is aggravated by the warm dry east wind, the Harmattan.

Surface water is available mainly from the Senegal river and its main right bank tributaries, the Gorgol, the Karakoro and the Wadi el Msile, which becomes the Kolombiné at the Malian frontier. A separate description is given below and in an annex of these hydraulic resources, and the developments projected in the framework of the OMVS.

Apart from the Senegal, there are a number of wadis whose intermittent flow feeds temporary lake and surface sheets. Particular examples are Lake Gabon and the Tagant plateau, and the many small wadis in the Hodho region, some of whose flood-waters are diverted by small submersible dams.

1.2 THE POPULATION

Total population enumerated in the general census of the first quarter of 1977 was 1.48 million, with an annual rate of increase of about 2.3%. Average density is 1.3 persons per sq. kilometer varying from 0.2 in the North to 35-40 in the Senegal river valley. Approximately 80% of the population is concentrated in less than 15% of the country's land.

The urban population already amounts to 20% of total, and is forecast to exceed one-third by 1985. The nomadic population, at one time the largest single group, numbered no more than 400,000 in 1975, and with sedentarisation continuing by reason (in particular) of the drought, is expected to have fallen to some 220,000 by 1985.

The main ethnic groups are the white Maurs (54%), the black Maurs (27%), the Toucouleurs (9%), the Sarrakolés and the Ouolofs (5%) and the Peuls. Islam is the dominant religion, and Arabic the official language, although French is commonly used in the modern sector. The Maurs and the black population are organised in a fairly rigid tribal and caste system.

1.3 THE ECONOMIC SITUATION

Gross domestic product per capita is some 10,000 MU (about $230) annually, a relatively high figure for a Sahel country. However, in real terms, GDP has been stagnant since 1973 and actually fell in 1977.

TRENDS IN GDP, IN 1973 PRICES

(million MU)

Year	1973	1974	1975	1976	1977
GDP	13.043	15.278	14.158	14.970	13.900
GDP per capita	10.352	11.843	10.726	10.950	9.789

Source: IMF

Nine-tenth of the economically active population works in the traditional sector, mainly in agricultural and livestock production. This sector's share is declining: 50% of GDP in 1968, under 20% in 1977.
The monetary unit (MU) is the Ouguiya:

1 MU = 0.1 French franc = $ 0.023 U.S.

Cereal output is estimated to reach 120,000 to 130,000 tons in a year of high rainfall and 80,000 to 100,000 tons in an average year, but was probably below 30,000 tons in 1973, 1976, 1977 and 1978, of which 6,000 tons of paddy rice. In a normal year, domestic crops cover 60% of needs, and imports amount to 80,000 to 100,000 tons (over 150,000 tons in 1978). Other crops include niébé (10,000 tons), corn (4,000 tons), dates (10,000 tons) and some groundnuts and vegetables.

REGIONAL DISTRIBUTION OF THE POPULATION

Region and capital city	Inhabitants (in thousands)								
	1965	1975				1985			
		Nomads	Rural Settlers	Urban	Total	Nomads	Rural Settlers	Urban	Total
1. Hodh Oriental - Nema -	144	82	51	9	142	53	73	13	139
2. Hodh Occidental Aïoun el Atroussa	97	45	55	13	113	29	79	21	129
3. Assaba - Kiffa	116	56	75	17	148	34	122	27	183
4. Gorgol - Kaedi	102	7	103	20	130	3	119	37	159
5. Brakna - Aleg	124	31	93	17	143	15	112	38	165
6. Trarza - Rosso	196	81	100	27	208	40	132	48	220
7. Adrar - Aleg	68	20	33	19	72	10	38	26	74
8. Baie du Lévrier Nouadhibou	13	2	4	23	29	1	5	42	48
9. Tagant - Tidjikja	75	43	22	8	73	30	28	11	69
10. Guidimaka - Selibaby	76	8	82	6	96	4	104	8	116
11. Tiris Zemmour F'Derick	18	4	2	23	29	1	5	34	40
12. Inchiri - Akjoujt	14	4	3	13	20	1	4	23	28
Nouakchott	18	-	-	102	102	-	-	237	237
TOTAL	1,061	383	625	297	1,305	221	820	565	1,606

Livestock raising of the pasturage type based on continued relocation, is the main activity of 70% of the population. Numbers have diminished enormously by reason of the drought, and include 1.3 million zebu (down from 2.5 million), 4 million sheep, 3 million goats and 0.7 million camels. Annual output is estimated at 56,000 tons of meat and 250,000 tons of milk.

The main other known resources comprise fishing, out of Nouadhibou (an annual catch of 60,000 tons), iron ore and copper almost all exported.

TRENDS IN MINING OUTPUT

Year	1973	1974	1975	1976	1977	1978
Iron ore (000 tons)	10,371	11,741	8,677	9,920	7,767	7,434
Value (million MU)	3,844	5,864	6,194	6,919	5,715	4,202
Copper (tons of metal)	21,780	20,080	6,580	9,622	7,790	2,859*
Gypsum (tons)	-	-	8,752	10,969	10,168	13,505

Source: BCM

The SOMIMA was taken out of production on 31st May 1978. A project is under consideration for the exploitation of the Guelb deposits in the Zouerate region, with an annual output of 14 million tons from 1981 on. The estimated cost of this project is $ 430 million.

1.4 INFRASTRUCTURE AND EQUIPMENT

There are 7,000 kilometers of roads of various grades, of which over 1,000 kilometers are paved (NOUAKCHOTT-AKJOUJT, NOUAKCHOTT-ROSSO, AND NOUAKCHOTT-KIFFA). The second section of the 486 kilometers long transmauritanian highway (Kiffa - Afoun-el-Altrouss - Néma), costing an estimated 6 billion MU ($ 132 million) should have been paved by 1981.

Communications are difficult in the Senegal river valley, and in the rainy season, there is a link only with Senegal.

The rated capacity of electrical power installations is 66,000 KW. Consumption rose from 8 million kwh. in 1966 to 45 million in 1978. The main consumption centres are NOUAKCHOTT, NOUADHIBOU and ZOUERATE.

1.5 PUBLIC FINANCE

The money supply rose from 2.025 billion MU in 1973 to 5.179 billion in December 1978.

Between 1973 and 1978, budgetary expenditure rose from 3.150 billion MU to 12.790 billion and the budget deficit rose from over 0.363 billion to 8.5 billion. Foreign debt has also risen substantially: it was 4.5 times higher in 1978 than in 1973, at 28 billion MU. Debt service absorbs almost 30% of export proceeds and 50% of Government revenue.

Mineral ores account for almost 80% of total exports, which have been falling (8.390 billion MU in 1976, 6.024 billion in 1978) and the import coverage ratio has fallen below unity (133% in 1973, 72% in 1978).

1.6 FOOD NEEDS

Cereal requirements, presently 200,000 tons a year, will rise to over 300,000 tons by 1990, and almost 400,000 tons by 2000, at which date the demand for sugar (of which Mauritania is a major consumer - over 25 kg. annually per capita in 1976) will stand at some 60,000 tons. Current cereal production is below 100,000 tons a year.

Cereal output will have to rise by 7,000 tons a year to keep imports at their present level, and by 15,000 tons a year if self-sufficiency is to be achieved by the year 2000.

In view of rainfall variability, even in the most southerly parts of the country, such needs can only be met through the large scale development of irrigated farming in the Senegal Valley. Other water resources are sparse (the Wadi diversion dam, and a little groundwater).

CHAPTER II

II. STATUS OF IRRIGATED FARMING PRODUCTION AND NEEDS

2.1 The Rural Sector

The rural sector is prey to climatic vagaries, and was hit particularly hard by the droughts of these last few years - in 1972 to 1974 and again from 1976 to 1978.

In an average year, if rainfall is reasonably well distributed, the value added by the rural sector is estimated at 6 billion MU (of which only 0.8 billion in agriculture) and contributes only 25% of GDP. The annual per capita income of the rural population is estimated to be below 3,000 MU ($ 70).

On the livestock side, meat production is estimated at 56,000 tons, milk at 250,000 tons. This suffices to meet needs and allows some export of livestock on the hoof. Crop output is composed of 60,000 to 80,000 tons of cereals (including 5,000 to 6,000 tons of paddy rice cultivated under irrigation, with a further 10,000 tons of dates. This is altogether too low compared to needs, which are of the order of 200,000 tons of cereals and 30,000 tons of sugar.

In a bad year, the position deteriorates further. In 1972-1974, forced slaughtering reduced the number of heads of livestock by 50%, and many nomads were obliged to settle. Output of cereals was less than 20,000 to 30,000 tons in 1973, 1977 and 1978.

2.2 The Country's Food Needs

A recent survey of Mauritania's food situation revealed a major change in the pattern of consumption, with a rapid shift from demand for millet and sorghum, in favour of rice, which is cheaper (16 MU per kilogram), easier to cook, and whose supply is better organised (SONIMEX). This tendency was accentuated by the settlement and urbanisation which have been characteristic of recent years.

CEREAL REQUIREMENTS (1978 SURVEY)

Kg. per capita annually

Cereal	Nomads	Settled rural dwellers	Urban dwellers
Rice	30	80	130
Millet-sorghum	100	100	-
Wheat	30	-	55
TOTAL	160	180	185

Source: Plan

A demographic projection has been established on the basis of the 1977 census. It takes account of the progressive sedentarisation of nomads and the very fast growth of urban centres (10% a year on average, 20% a year for Nouakchott in the past few years), and indicates an annual average increase in population of 2.1%.

DEMOGRAPHIC TRENDS FROM 1977 TO 2000

Year	Total (resident) Population	Nomads	Settled Rural Dwellers	Urban
1977	1 420 000	514 000	595 000	311 000
1980	1 511 000	490 000	633 000	388 000
1990	1 829 000	400 000	823 000	606 000
2000	2 213 000	350 000	1 106 000	757 000

Source: Plan

This can be used to make a projection of Mauritania's cereal needs from 1980 to 2000 which differs considerably from earlier forecasts, which made no allowance for trends in consumption patterns.

PROJECTED CEREAL REQUIREMENTS OF MAURITANIA
1980-2000 (tons)

Year	Total Requirements	Rice	Millet & Sorghum	Wheat
1980	265 000	117 000	112 000	36 000
1990	323 000	157 000	122 000	44 000
2000	400 000	199 000	146 000	55 000

Source: Plan

2.3 Present Cereal Production

Cereal output at present includes the traditional cereals, millet and sorghum(1) grown in the subsidence season ("Oualo" cultivation in the Senegal Valley), as a rainfed crop to the South of the 250 mm. guaranteed rainfall isohyet, and protected by small dams; and rice, mainly grown in the Senegal valley.

(1) Output of corn is very low, that of wheat negligible for practical purposes.

2.3.1 Total production of millet and sorghum is estimated at about 90,000 tons in a good year. The regional distribution of the various traditionally grown cereal crops is given in Annex Table A1.

In practice, this potential figure of 90,000 tons of food cereals reduces to an average real output of 20,000 to 60,000 tons after rats, locusts and drought have taken their toll.

2.32 Rice farming has been developed since 1970. Production is as yet below 8,000 tons a year, obtained as follows in 1978:

	(tons of paddy rice)
(a) Large perimeters	
M. POURIE (State farm)	2,073
M. POURIE (individual farmers)	1,720
GORGOL	540
TOTAL	4,333
(b) Small perimeters	
FED and SONADER	1,800
Sundry private	1,000
TOTAL	2,800
TOTAL (a) + (b)	7,133

2.3.3 Total cereal crop production in 1978 has been estimated at 60,000 tons.

2.4 The Cereal Deficit

In 1969-1971, before the drought, annual production of cereals in Mauritania was some 90,000 tons, and a further 75,000 tons were imported.

2.5 Planned Directions

The objectives of the Third Plan 1976-1980 were designed as part of a strategy aiming at food self-sufficiency by about the turn of the century, while consolidating the income of the rural sector and ensuring that projects are compatible with environmental requirements.

Given that climatic factors make it impossible substantially to raise the yields of rainfed crops except in the extreme South (Guidimaka), reliance is to be placed on irrigation with full water control for intensive cultivation of cereals, forage crops and various other crops, to obtain two harvests annually.

Irrigated farming is viewed as complementary to livestock raising and nearby rainfed cultivation, and the assumption was made that if each male worker farms 0.5 hectares, or the equivalent under irrigated farming, with a crop intensity coefficient of 1.6 per annum, the average income of each farmer would be doubled while guaranteeing his food self-sufficiency and a minimum monetary income.

2.6 Necessary Area of Irrigated Land and the Pace of Development

If the shortfall in cereal output is to be made up, the area under irrigation must be extended very rapidly. It is assumed that development can be conducted with an average crop intensity coefficient of 1.6 (e.g. on a 1,000 hectare tract, 950 will be farmed in the rainy season, and 650 in the off-season).

As regards rice, assuming a stabilised yield of 3.5 tons of paddy per hectare per harvest and a milling yield of 65%, the irrigated land area required is :

- 32,000 hectares in 1980
- 43,000 hectares in 1990
- 61,000 hectares in 2000

As regards millet and sorghum, traditionally grown crops can be taken to yield 60,000 tons of output, taking the good years with the bad(1). The share of irrigated crops, with an assumed yield of 3 tons per hectare per crop, would then be :

Year	Irrigated crops (tons)	Area Irrigated (hectares)
1980	52,000	11 000
1990	62 000	13 000
2000	86 000	18 000

Wheat yields are lower(2), 2.5 tons per hectare per harvest, and would require a land area of :

(1) In the long term, the "Oualo" lands in the Senegal valley, which produce 30,000 to 40,000 tons a year, will progressively be taken up by irrigated perimeters, and traditional cultivation will be possible only by rainfed or dam-protected crops.

(2) Experiments are in progress, and a yield of over 6 tons per hectare has been obtained on small plots. However, this type of farming is very sensitive to weather conditions and irrigation techniques. Until these techniques have been perfected, it seems preferable to use a conservative figure of 2.5 tons/hectare.

- 9,000 hectares in 1980
- 11,000 hectares in 1990
- 14,000 hectares in 2000

Hence, by the year 2000, 93,000 hectares of land would have to be devoted to cereal production, with a further :

- 4,000 hectares of sugar cane perimeters (10 tons of sugar per hectare for total sugar output of 40,000 tons), and
- 10,000 to 15,000 hectares for forage and other crops.

This is a total of some 115,000 hectares. To achieve it calls for the development of 5,000 hectares a year; on the basis of 0.5 million MU per hectare(1), the annual investment outlays involved amount to 2.5 billion MU.

2.7 The Objectives for Irrigation in the Third Plan, 1976-80

The 1976-1980 Plan includes a hydro-agricultural development programme for the decade 1974-1984 covering 35,000 hectares, with a rate of development to be stepped up from 1,000 to almost 6,000 hectares a year by 1984. The detailed breakdown of these projects is presented in the following table(2).

(1) This is the average estimated cost on the basis of evaluation of the following projects :

- Boghé pilot tract, 1,000 ha. (including the infrastructure for 4,000 ha.): 1.2 billion MU, or 1.2 million MU per hectare
- The Gorgol perimeter, including the Foum el Geita dam: $ 84 million for 3,600 ha.: $ 21,000 per ha., equal to 900,000 Mu
- Village perimeters costing from 100,000 to 250,000 MU per ha.

(2) For the location of these perimeters, see the annexed map.

LAND TO BE BROUGHT UNDER IRRIGATION DURING THE 1974-1984 DECADE

(Ready for cultivation as of July 1st of .... year)

PERIMETER \ YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Small perimeters	283	350	740	1,000	1,000	1,100	1,100	1,200	1,300	1,400	1,500
M'Pourié	716	750	1,000	1,500	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Boghé			200	1,000	1,000	1,000	2,000	3,000	4,000	4,000	4,000
Gorgol, pilot			700	700	700	700	700	700	700	700	700
Gorgol, cereals			700	1,700	700	1,700	2,700	3,700	4,700	5,700	6,700
Gorgol, sugar cane					200	1,000	2,000	3,000	3,000	3,000	3,000
Lake R'Kiz, cereals							100	500	1,000	1,000	1,000
Lake R'Kiz, forage crops										500	1,000
Garak								200	1,000	2,000	3,000
Naghama										200	1,000
Kaedi, fattening			400	400	400	400	400	400	400	400	400
Rosso, livestock breeding			200	200	200	400	400	400	400	400	400
Koundi 3							200	1,000	2,000	3,000	4,000
Koundi 5						500	1,000	1,500	2,000	2,500	3,000
Tamourt en Naaj				200	400	600	800	1,000	1,200	1,500	1,500
Achram Diouk						200	400	600	800	1,000	1,200
M'Bagne 2											200
Aftout es Sahel											800
Total area	999	1,100	3,240	5,000	6,600	9,600	13,800	19,260	24,500	29,300	35,400
Annual increase		100	2,140	1,760	1,600	3,000	4,200	5,400	5,300	4,800	6,100

Source: Third Plan 1976-1980

2.8 Hydro-Agricultural Development Projects Completed by end 1979 (see Map B2)

In 1979, completed projects covered an area of 2,701 hectares against a target figure of 9,600. They were:

- the 1,100 hectare M'Pourié project near Rosso, implemented with Chinese technical assistance from 1971 to 1979, and whose extension is continuing;
- the 700 hectare pilot perimeter of the Gorgol, near Kaedi, at the confluence of the Gorgol and Senegal rivers, financed by the FED;
- 1,800 hectares of small village perimeters financed by the FED, IBRD and the FAC;
- a few hundred hectares of small, independent perimeters.

There is thus a serious lag against schedule. The annual rates of development foreseen in the Plan and actually achieved are compared in the following table:

COMPLETION OF SMALL PERIMETERS AND THE FORECASTS OF THE THIRD PLAN

	1974	1975	1976	1977	1978	1979*	1980*
1. Third Plan: envisaged (ha. developed)	-	-	3,240	5,000	6,600	9,600	13,800
2. Effectively completed (ha. cumulative)							
i) M'Pourié	716	750	843	986	986	1,100	1,200
ii) SIP (FED)	283	350	379	483	541	541	600
iii) SVP (FAC)	-	-	-	59	230	360	1,200
iv) Gorgol				148	570	700	700
v) Independent*			(200)	(300)	(400)	(500)	(600)
TOTAL (ha.)	999	1,100	1,222	1,676	2,327	2,701	3,700
3. Third Plan: expected annual rate of increase (ha.)		100	2,140	1,760	1,600	3,000	4,200
4. Completion: annual additions (ha.)		100	122	454	651	374**	1,000
5. Shortfall 1 - 2			2,018	3,324	4,273	6,899	10,100

* Irrigated by private enterprises organising small perimeters without State aid. They are omitted from the computation.

** Decrease.

Source: SONADER

2.9 Production Yields and Trends

The area being farmed is smaller that the area developed. In 1978/79, excluding private perimeters, 1,848 ha. were planted (of which 1,790 harvested) and produced 6,953 tons of paddy rice, with a few more hundred tons of corn and wheat produced on certain perimeters outside the rainy season.

In five years, between 1973/74 and 1978/79, paddy rice output has risen from 3,830 tons to 6,953 tons - an annual average increase of only 800 tons, which is about 5% of the increase required to make up the national cereal deficit by 2000(1).

The individual perimeter results for the 1978/79 crop year and the trend of total output in the Senegal river valley (omitting independent perimeters) are shown in the table on the following page.

It can be seen that:

- yields, which reached 4.4 tons per hectare in 1973/74 have since stabilised at rather below 4 tons;
- village perimeters account for one-third of total production.

2.10 Analysis of Existing Developments

The review here is limited to projects in the general area of the valley and delta of the Senegal river for which statistical data are available.

Before 1970, experiments were carried out on the combined use of water from the Senegal river, using pumping when floodwater heights were inadequate, and the floodwater spread from the adjacent wadis (the Dar el Barka perimeters). This attempt using controlled submersion produced unsatisfactory results, and led to the introduction of irrigation with full water control of two types of perimeters:

- large centrally-managed perimeters constructed after dykes had been built to protect areas liable to flooding which had previously been farmed in the subsidence months ("Oualo"). There are the m'Pouri perimeter developed over 1,100 hectares between 1970 and 1979, and the Gorgol pilot tract (1975-1978) covering 700 hectares;
- small village perimeters created on rises on the banks of the Senegal, a few score hectares in size, executed by peasants and irrigated using mobile pumping sets.

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(1) By 2000, 340,000 tons of cereals will have to be produced on irrigated land i.e. an average annual increase of 16,000 tons during the period 1980-2000 (see 2.2 above).

INDIVIDUAL PERIMETER RESULTS FOR THE 1978/79 CROP YEAR AND TREND OF TOTAL OUTPUT IN THE SENEGAL RIVER VALLEY

CEREALS (rice, corn, wheat)	Land Area (hectares)			Yield (in tons per hectare)	Output (tons)
	Cultivated	Damaged	Harvested		
Growth of production in the Senegal Valley					
Crop year : 1970/71	325	-	325	2.5	829
71/72	585	-	585	3.4	1,990
72/73	667	57	610	3.8	2,288
73/74	843	-	843	4.6	3,839
74/75	994	-	994	3.9	3,830
75/76	1,039	-	1,039	3.9	4,066
76/77	1,104	-	1,104	3.3	3,644
77/78	1,507	-	1,507	4.0	6,066
78/79	1,933	58	1,857	3.8	7,098
Distribution among perimeters, 1978/79 crop year:					
M'Pourié (State)	624	11	613	3.0	1,852
M'Pourié (farmers)	362	23	339	3.4	1,165
Small village perimeters (FED)	382	-	382	5.1	1,972
SONADER perimeters	195	10	185	2.8	520
Gorgol	370	14	356	4,4	1,589

Source: OMVS Socio-economic project, June 1979.

2.10.1 The M'POURIE perimeter (see Annex Map B2)

This perimeter is located downstream from Rosso, and is exposed to the rising of the salt tongue of the Senegal river between January/February to end July/August until such time as the OMVS projects have not been executed. It was established and is being exploited with the aid of the People's Republic of China and is in course of extension.

It is protected by a dyke which is levelled off at an elevation of 4.25 meters, and should be raised by about 60 cm. to withstand exceptional floods. The dyke encloses a basin of 4,000 hectares, of which 1,100 hectares have been developed. Extension is progressing at a pace of about 100 hectares a year.

Mechanical farming techniques are used (ploughing, seedling transplantation, harvesting) on plots of about 1 hectare constituting a State farm of rather over 600 hectares, and by farmers working on allotments of 1-2 hectares, whose total area is expanding year by year.

The main operating results are given in the following table:

EXPLOITATION OF THE M'POURIE PERIMETER 1970-1979

Perimeter	Crop Year	Total area cultivated (ha.)	Area damaged	Area harvested	Yield (tons per hectare	Production (tons)
State Farm	70/71	266		266	2.5	736
	71/72	530		530	3.5	1,865
	72/73	530		530	4.1	2,255
	73/74	550		550	5.0	2,767
	74/75	572		572	4.3	2,471
	75/76	590		590	4.3	2,557
	76/77	609		609	4.0	1,484
	77/78	609		609	3.3	2,073
	78/79	624	11	613	3.0	1,852
Farmers	73/74	59		59	7.5	423
	74/75	145		145	2.3	349
	75/76	202		202	3.7	895
	76/77	277		277	4.3	1,113
	77/78	361		361	4.7	1,720
	78/79	362	24	339	3.4	1,165

The yields obtained in 1973/74 - 5 tons per hectare on the State farm and 7.5 tons on farmers' allotments - have since fallen below 4 tons due to several problems encountered, including:

- soil salinity, which is increasing on some plots and casts doubt on the prospects for extensions;
- a delay in planting by reason of the lateness of the Senegal floodwaters (after 5th August in 1977 and 1978);
- an invasion of red rice which forced 320 hectares to be allowed to lie fallow in 1978;
- maintenance of mechanical equipment (some plots had not yet been harvested as of 20th April 1978 !).

2.10.2 The Gorgol Pilot project

This development(surface area of 700 hectares) carried out between 1975 and 1977 under the control of the Rural Engineering Department, and financed by FED funds, represents an investment of over $ 5 million (191.2 million MU). It is exploited in plots of 0.5 hectares, with a few score hectares as a single State-controlled unit ("régie"); technical advisory services are provided by SONADER. The results obtained are as follows:

Crop year	Area Cultivated	Yield (tons per ha.)	Production (tons)
1977/78	147	3.6	542
1978/79	370	4.4	1,589
1979/80	573		

The following remarks may be made:

- In order to make savings, some structures were built too small (dyke too low to protect against exceptional floods; seating of the dam-bridge too limited to allow more than partial operation, etc.).
- Changes in the main contractor (first the Rural Engineering Department, then SONADER, led to defective control of the work done, whose quality is often sub-standard; renovation work is necessary even at this early stage.

- Despite extremely difficult operating conditions (poor smoothing), interruptions in irrigation due to "breakages", tensions arising from demands for payments of fees, etc.) average yields have been reasonable - from 6 to 7 tons per hectare for those who observed the farming calendar.

- The replanting of rice was mastered on most of the perimeter in 1978/79, despite some gloomy predictions that it could not be done.

- In July 1979, the farmers of the perimeter accepted the principle of payment of a fixed annual fee of 9,000 MU per 0.5 hectare plot, together with a share of current costs proportional to dressing.

2.10.3 Small village perimeters

The unit size of these perimeters varies from 15 to 40 hectares. The first were developed in 1966, and the many that followed were financed by :

- the FED, 14 from 1972 to 1976;

- the World Bank: 170 hectares of new perimeters and the redevelopment of 288 hectares;

- the FAC: 18 perimeters in 1977 and 1978;

- many additional projects are in progress, financed by the FAC and the CCCE (20), IBRD (30), Netherlands (30) etc..

In 1978/79, rainy season cultivation was carried out on 482 hectares and produced 2,347 tons of paddy rice - an average yield of almost 5 tons per hectare. Outside the rainy season, 30% of the area is cultivated: the crops grown are rice (yield 4 to 5 tons/hectare), corn (3 tons/hectare) and occasionally wheat.

Crop year	72/73	73/74	74/75	75/76	76/77	77/78
Number of perimeters developed	7	10	10	10	14	14
Area developed (hectares)	390	455	455	455	568	568
RAINY SEASON						
Area cultivated (hectares)	136	174	204	198	196	276
Yield (tons per hectare)	2.4	2.7	3.7	2.1	5.0	4.7
Production (tons)	333	469	763	418	973	1260
OUT OF SEASON						
Area cultivated (hectares)	59	72	48	21	97	148
Yield (t/ha.)	3.0	3.0	4.1	3.5	5.0	4.0
Production (tons)	179	217	197	74	487	592

Source: FED Reports

It may be remarked that:

- the area cultivated in the rainy season is well below the area developed (40% in 1976);
- yields are rising over time, but with interruptions. Farmer motivation is indispensable;
- cultivation outside the rainy season is increasing only gradually and hardly covers more than 50% of the area planted in the rainy season;
- an analysis of costs in the 1974/75 crop year showed that average consumption of gas oil in the winter season was 170 litres per hectare, and 392 litres per hectare outside the rainy season. The total operating costs per hectare amounted to 18,500 MU per hectare.

2.10.4 Small independent perimeters

In the vicinity of Rosso, the zone from Keur-Macène to Tiékane is dotted with a fairly large number of small perimeters of a unit size of a few hectares fed by pumping water from the Senegal river or an adjacent tributary, and developed wholly by local private initiative, apart from the motor pump unit, supplied in a few instances by an NGO.

It is estimated that some 500 hectares had been developed by 1979, producing paddy rice (2 to 3 tons per hectare), wheat and truck gardening products (tomatoes, pimentos, etc.).

Development of these perimeters is currently hampered by:

- the presence of the salt tongue in the Senegal river;
- the cost of inputs (fertilisers, gasoil);
- a scarcity of high quality advisory services;
- variable seed quality.

CHAPTER III

III. POSSIBILITIES AND CONSTRAINTS TO THE DEVELOPMENT OF IRRIGATED FARMING IN MAURITANIA

In Mauritania, probably to a greater extent than elsewhere in the Sahel, the constraints affecting the development of irrigated farming are intimately linked to the very specific nature of the possibilities: it has therefore seemed necessary to deal with both in a single chapter.

3.1 General Potential

Apart from a very narrow strip in the South, nowhere in Mauritania does annual rainfall exceed 500 mm. annually, so that there is little point seeking for a long-term increase in rainfed crop production. As was noted in the preceding chapter, it will be necessary to look to irrigated farming to make up the deficit in natural food production; and in the long term, this means devoting 100,000 hectares to growing irrigated crops.

There are considerable possibilities in the Senegal Valley - a potential of 200,000 hectares - but less scope elsewhere. This raises the problem of balanced national development.

Before going into detail on the conditions for developing irrigation - and corresponding constraints - we will review the general possibilities offered by water and irrigable soil resources, the results of experimental agronomic research and the production obtained.

3.1.1 Water and soil resources

The average flow of the Senegal river is 23 billion cu. meters (15 billion in a dry year) and the OMVS projects should regulate it to a continuous average flow of 300 cu. meters per second, with the possibility of using a number of artificial (the Diama dam) or natural (Aftout es Sahel, the Lake R'Kiz depression) reservoirs.

More than 350,000 hectares of land suitable for irrigation have been inventoried in the valley and delta of the Senegal river, the Gorgol valley and Aftout es Sahel (see maps B2, B3 and B4 in annex), and more than half of this is particularly suitable for rice.

3.1.2 Agronomic possibilities

The latest results of agronomic research and experiments(1) show that potential rice yields can be as high as 10 tons per harvest, and three harvests have been obtained in experimental stations. For other crops (sorghum, corn, wheat) yields of 6 to 8 tons per hectare may be envisaged once certain constraints - scorching, birds, pests - have been removed.

There has been considerable progress in recent years in the acquisition of knowledge of new varieties that are well adapted to local conditions, and it is believed that cold-resistant varieties will soon be available, making it possible to de-seasonalise growing, and to abolish the most serious handicaps stemming from agricultural calendars that are too packed for successive crop dressings to be executed in time.

Thus it seems not unreasonable to envisage a production potential of 6 to 8 tons of cereals in two harvests with careful family farming(2), which should represent an average production of 5 tons per crop harvested making due allowance for various contingencies. If a coefficient of intensity of 1.6 is assumed (see chapter II), average annual output per hectare developed would be of the order of 8 tons of cereals.

3.1.3 Fodder crops and the possibilities of livestock breeding

It will be recalled that the average Mauritanian is a heavy consumer of milk and meat, and that agricultural development calls for robust, and therefore well nourished-draft animals.

An experimental fattening operation was begun in 1976, using FAC credits to test, in full scale operation, the scope for producing green fodder crops (pennisetum purpureum (elephant grass), stylosanthis gracilis, etc.), and feeding gobra zebru. Interesting results were achieved. Thus:

- fodder crop output, cut six times a year, can reach 120 to 180 tons, representing 15 to 20,000 forage units;

- considerable weight gains are available from fattening - 970 grams per head daily for a batch of animals fed on rice bran and green fodder, and 590 grams for a batch fed on green fodder alone(3).

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(1) These results apply to the rises on the banks of the Fondi and the Hollabré basins, but more water is required in the former by reason of the fairly substantial percolation through the soil. See Annex C "Note on the Possibilities for Agricultural Production in the Senegal Valley".

(2) Worth citing is the example of M. Omar Racki Fall of Guédé on the opposite bank of the river. On a 2.5 ha. irrigated plot, harvested twice annually, he has been producing 40 tons of paddy rice a year for the past four years.

(3) These interesting experiments should be pursued, for the optimum ration has still not been defined. Further, after a few weeks of a green fodder diet, there is a process of adaptation to the new feed which results in a loss of weight.

These results can be reproduced in actual farm operation; thus there is scope for the development of fattening on irrigated developments as a complement to pasturage on "Dieri" (unfloodable) land, and the creation of a stock of draft animals - impossible hitherto, as the beasts were famished after the heavy work in preparing the earth at the end of each dry season.

3.2 Mobilisation of Water Resources

One may distinguish :

- the flow of the Senegal river and its tributaries;
- the intermittent flow of the Sahel Wadis;
- the underground water table.

3.2.1 The possibilities of the Senegal River(1)

The Senegal river flows along 800 kilometers of the Mauritanian border, and several of its divergent channels penetrate quite deeply into the country (Koundi, Lake R'Kiz, Aftout es Sahel).

At present, however, the flow in the low water period from February to June is very limited - a few cubic meters per second - and in the delta and the lower valley, a salt tongue reaches as far as 200 kilometers upriver. It is therefore impossible to envisage full-scale tow-harvest farming(2) until the hydraulic regulation structures of the OMVS - the Diama and Manantali dams - have been installed (see Annex A).

The main features of these structures are described in Annex. The important points are that the Diama dam - which should enter service in 1983/84 - influences the delta and the lower and middle valley as far as Boghé - and possibly also M'Bagne if its operating height is carried to 2,5 meters, and that the Manantali dam will regulate the low-water flow along the length of the valley, and also slightly diminish the floodwater crest level.

Even if the OMVS structures are built, the Senegal river will still be liable to sharp variations in its flow, with differences between flood and low water levels of the order of 2 to 3 meters in the delta, 4 to 5 meters in the lower valley (in the Rosso and Gani regions), and 9 to 10 meters in the middle and upper valley (Boghé and Kaedi). Most of the irrigable land is at a level between low and high water, and

(1) See Annex C - Note on the Agricultural Production Potential of the Senegal Valley.

(2) Palliatives have been found in a few instances. The Gorgol pilot tract can usually be irrigated outside the rainy season over 700 hectares using the reservoir formed behind the Gorgol bridge-dam. Projects are under review similarly to use the water which could be stored in Lake R'Kiz.

cannot be irrigated with full water control (although this was recognised as essential after the failure of controlled submersion) unless dykes are built and the water pumped - apart from a few short spells during floodtime when gravity feed is possible.

Large hydraulic structures have thus to be installed, and to make them worthwhile, calls for immediate and intensive development.

In the case of small perimeters on rarely-submerged rises on the bank ("fondé" lands), dykes are not usually necessary, so that a major portion of the basic investment can be dispensed with. By contrast, water must be pumped to a greater height, up to 10 meters, entailing considerable use of energy (see para. 2.10.3).

This method of mobilising water resources thus involves heavy charges for irrigation, so high that farmers can meet them only with difficulty. This will be returned to in detail in para. 3.4.2.1.

3.2.2 Possibilities of the intermittent Wadis in the Sahel

Precipitation is rare and irregular throughout the Sahelian and Saharan parts of Mauritania, but when it does rain, it can do so very intensely, with heavy torrents streaming down drainage basins with marked relief, flooding the wadis, which are dry the rest of the year. The resultant overflows can sometimes moisten the earth enough for post-flood cultivation (sorghum, barley, wheat) to be carried out on tracts of a few hectares. In addition, there are a few cases (the Atar region) in which surface ponds are restocked by these flows and an an attempt is made to store as much of them as possible.

This has led to construction of a large number of dams, which have yet to be brought into service, to improve the spreading of floodwaters and increase their infiltration. The work is costly, and the results sometimes(1) very variable, but in many regions, there is no other water. SONADER has inventoried the sites that could be developed (see map annexed); the results for each region are recapitulated on the following page.

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(1) A dam in the Hodhs region allowing 50 to 100 hectares to be brought under post-flood cultivations costs from 20 to 40 million MU. The yield of cereals in a year of heavy flow can be between 1,000 and 1,500 kilograms.

		Number of sites recorded
Hodh al Chargui	(Néma)	13
Hodh al Gherbi	(Afoun el Atrouss)	20
Assaba	(Kiffa)	47
Gorgol	(Kaédi)	4
Brakna	(Aleg)	34
Trarza	(Rosso)	4
Adrar	(Atar)	26
Tagant	(Tidjikja)	16
Guidimaka	(Sélibabi)	1
TOTAL		168

The Gorgol is an important special case. It is a Sahelian wadi whose annual discharge from a drainage basin of 8,950 sq. km. is estimated at 350 million cubic meters. A remarkable site at Foum Gleita can be harnessed for the construction of a 500 million cubic meter reservoir dam dominating a 28,000 hectare plain, on which a 3,600 hectare perimeter has been traced out as being suitable for gravity - fed irrigation. This project - the only major irrigation project whose water resources are entirely Mauritanian - is estimated to cost $ 84 million of which $ 15 million for the dam proper. It should be implemented between 1980 and 1985 (see para 4.3.4)

3.2.3 Possibilities using ground water for irrigation

Up to now, water has been used only as drinking water for people and livestock, but it could in some cases be pressed into service for irrigation (see the note in Annex D on "Ground Water Resources in Mauritania").

A sedimentary basin of over 100,000 sq. km. covers the whole of the region bounded by Nouakchott, Kiffa and the Senegal river, with a number of water-bearing stratas including in particular:

- the extreme continental sheet of Trarza,
- the Amachtil limestone sheet,
- the Brackna eocene sands.

Total reserves have been assessed at over 100 billion cubic meters - 100 years supply for a regular flow of 30 cubic meters per second. These reserves may be fed in part by infiltrations from the Senegal river.

Many shafts have been sunk (see annexed note and schematic map), in particular along the Nouakchott-Kiffa road. Over 50 boreholes produce a flow high enough for agricultural purposes - from 20 to 50 cubic meters per hour from a depth of a few dozen meters.

These installations could produce useful make-up supplies, providing a source of fresh water in areas where none exists, or in which needs have become more pressing through the acceleration of settlement and urbanisation, the consequences of demographic growth and drought.

3.3 Irrigable Land : Possibilities and Constraints

3.3.1 Pedology and suitability for irrigation

Surveys carried out in the delta and valley of the Senegal river using 1: 50,000 maps covering 1,200,000 hectares have enabled the identification of 800,000 hectares of land suitable for irrigation, of which over 300,000 hectares on the Mauritanian right bank.

The soils are mainly of the Hollaldé type - very clayey vertisoils located in submersible basins, making them particularly suitable for rice cultivation; the "fondé" soils on rises immune from flooding; and intermediate "false Hollaldé" soils. The experiments carried out to date (see para. 3.1.2) have established that, using appropriate growing techniques and the correct fertilizers, all these soils can bear rice and other cereal crops. However, in the delta and the lower valley upriver to about Boghé, problems are frequently met stemming from salinity of fossil salt water (the Nouakchott transgression) and the rising of the salt current. Leaching these salty soils is proving more difficult than had been thought some years ago (unfavourable soil structure, calcium-deficient water). In practice, even for rice which can tolerate salt fairly well, and despite a considerable investment in drainage, it is difficult to make these soils productive, and many problems have been encountered at such locations as M'Pourie and on the left bank at Richard Toll, the Great Tellel dam, etc.

Three regions adjacent to the Senegal valley offer substantial land areas which could be irrigated with advantage:

- Aftout-es-Sahel, almost 20,000 hectares of land have been identified as irrigable, with appropriate precautions;
- the 28,000 hectare plain of the Gorgol valley;
- the Great R'Kiz Depression, presently used for low-flow pasturage.

3.3.2 Constraints stemming from Land Rights

Most of the irrigable land in the Senegal valley is subject to flooding, and used for crops grown in the low water season such as sorghum, corn and niébé. When development projects were put in hand, the property rights of those owning or working the land, based on custom and unwritten agreement, were not always taken fully into consideration, and the resulting quarrel led to heavy delays in production in the Dar el Barka perimeter and the Gorgol pilot tract.

The difficulties are occasionally compounded by the intertwining of property and usage rights on tracts straddling national borders. For example, in the upper valley, near Selibabi, most of the irrigable land is owned by Senegalese residents, while conversely, the Demet perimeters opposite Boghé, on Amorphil Island, belong to Mauritanian nationals.

There are , it seems, two necessary conditions for dealing with this situation:

- preliminary but thorough investigations to determine the losses occasioned by projects and the form of the corresponding indemnification;

- the promulgation of legislation on land tenure specifying the rights and limits to sue of owners, farmers and those having a claim on lands that have been developed using public moneys. It is understood that such legislation is presently under consideration.

3.4 The Socio-Economic Environment : Possibilities and Constraints

Apart from the issue of property rights just discussed, special attention should be given to the receptiveness of the community's members to the processes involved in making land productive by irrigation, as regards in particular:

- the availability of labour, its motivation and its productivity;

- operating costs and producer prices;

- the transition from the traditional system to irrigated farming.

These points were studied recently in the OMVS socio-economic project.

3.4.1 Labour availability, motivation and productivity

3.4.1.1 Availability of Labour in the Senegal Valley

The delta and lower valley of the Senegal river are sparsely populated, but density is high in the upper and middle valley, especially around Boghé and Kaédi, where rainfed "Diéri" crops and "Oualo" crops are grown on both banks of the river. On the left bank, the over-hasty installation of some perimeters, with use of imported labour led to difficulties, and the OMVS has drawn up an outline general development scheme which attempts to match prospection for new sites with the manpower resources available in the immediate vicinity.

3.4.1.2 Farmers' Motivation

The remarkable adaptability of farmers to the techniques which render land productive has already been referred to: a few harvests suffice for them fully to absorb the first technological "dose" (selected seeds, fertilizers, dressing, replanting, etc.). This is particularly true of the small perimeters, where the farmer's technical agronomic skills have rapidly outpaced those of the advisory personnel whose suggestions they then challenge.

By contrast, in the large perimeters, many activities are mechanised and undertaken by the managing entity with a centralisation of procedures that hinders rapid and appropriately flexible action when breakdown or unforeseen events occur. The result is to instil a passive attitude in farmers vis-à-vis irrigated farming, and to stultify initiative in intensifying production or performing maintenance.

3.4.1.3 Productivity Problems

Bottlenecks exist as regards soil preparation, transport, harvesting and threshing, especially on the small perimeters developed by the farmers themselves. It is difficult to prepare more than 1,000 to 1,500 sq. kilometers a year, and wholly manual farming "à ladaba" is carried out on plots not exceeding 0.5 hectares, which is too small an area to secure an adequate income for a family(1).

Consequently, some mechanisation of ploughing, threshing and storage(2) of paddy rice is essential, and this involves :

- adaptation of plot size to the type of machinery used (or the converse),

(1) "In a 15 hectare perimeter, the farmers put everything they have into the development of 4 or 5 hectares in the first year. By the second year, they are tired out !" (a village perimeter organiser).

(2) Animal-drawn farming is not very widespread and it will take years before the stock of draft animals can be built up to the number required (see para 3.1.3.)

- a decentralised approach to the management of agricultural equipment very similar to that taken in certain CUMA (Agricultural Machinery User Cooperatives) on the left bank of the Senegal river.

3.4.2 Operating Costs and Prices Realised

3.4.2.1 Operating costs

The figures below are for the 1979-80 crop year for the Gorgol pilot perimeter, per hectare for two harvests in the year(1):

- Irrigation charges	22,200 MU
- Farming costs (seeds, dressings, fertilizers)	17,160 MU
TOTAL	39,360 MU

(for details of rates for supplies and services, see Annex A2).

At current prices, this is the equivalent of 4 tons of paddy rice, of which 2 tons are absorbed by fixed fees. These very high charges are difficult for farmers to meet in present circumstances. Their payment presupposes irreproachable quality of the services of the National Corporation which performs the management function, intensification of development so as to produce more than one harvest a year, and sufficiently rewarding sale prices. This last is examined below.

3.4.2.2 The Price of Paddy Rice

The cost of a kilogram of imported broken rice was 14 MU in 1979 at Nouakchott, and, allowing for transport costs, 17 MU in the regions. The purchase price of rice is fixed at 13 MU which puts a kilogram of paddy rice at 7.8 MU after allowing for expenses and milling losses - almost 3 MU below its cost of production.

An upward revision of the price of rice is necessary to incite farmers to raise output. The National Cereals Bureau should be endowed with the resources needed to pursue this policy.

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(1) See Annex for the 1979/80 SONADER rates for services and supplies of means of production for an 0.5 hectare plot in the Gorgol pilot perimeter.

3.4.3 Constraints Related to the Transition from the traditional to the modern system

According to the OMVS Socio-Economic Survey, the traditional farm unit on the Senegal valley consists of 10 persons, of whom 4 are active and devote 50% of their time (400 to 500 working days per year) to cultivating 2.7 hectares of "oualo" crops (subsidence period crops, sorghum, corn, niébé) and 1.7 hectares "diéri" (dry season) crops, mainly small millet, for an output in a reasonably fruitful year of 2 to 3 tons of cereals. The opportunity cost of a day's work can thus be put at 5 kg. of cereals, which would retail for 60 to 80 MU.

As was noted above, the transition to irrigated farming of large tracts will entail upheaval of the land rights system. because of the withdrawal after enclosure by dykes, of a vast acreage of submersible "oualo" lands on which subsidence-period crops had been grown, as well as the use of new techniques of cultivation requiring machines (smoothing, ploughing), the consumption of inputs (fertilizers, plant hygiene products etc.), high fees for irrigation water, and major requirements for manpower (replanting, weeding, harvesting, threshing, etc.).

In the fairly densely populated middle and upper valleys, it seems that the transition from the traditional system to irrigated farming on large perimeters can go forward without undue upheaval, by preliminary installation of village perimeters of 20/50 hectares, to the extent that:

- these perimeters are preferentially located on "fondé" rises at a sufficient elevation not to withdraw "oualo" soil from use for subsidence-period crops, and are protected against floods of a height observed once a decade, if necessary by low dykes;

- the farming systems used are sufficiently simple - one or two new techniques at most in the first few years, e.g. a rice-rice or rice-corn system;

- developments begun on plots of 1,000 to 2,000 sq. meters per family are quite rapidly extended to about 1 hectare implying the possible enlargement of the perimeter;

- working farmers devote the bulk of their effort to cultivation techniques - which requires a degree of mechanisation for maintenance of the hydraulic system as well as for smoothing and ploughing (which do not have to be performed every year), with one medium-power tractor for about 50 hectares and the corresponding associated machinery;

- during the transitional period of installation of the perimeters, farmers should be subsidised. This could be done via the price of inputs;

- in the long-term, measures should be taken to integrate small village perimeters into large perimeters;

- the population, especially the young, should be closely associated with the design and implementation of projects.

3.4.4 Advisor training : a necessity and a priority

Needs for advisory services, the capabilities of monitors and the methods for training them are being determined in the frame of the general scheme for the hydro-agricultural development of the Senegal valley. It is expected that precise information will be available towards end 1979.

Initial estimates are that one advisor is required per 100 hectares. If the Plan's development targets are achieved, this implies 50 further advisors a year. The only training facilities at present are the ENFVA - the National School of Agricultural Training and Extension - at Kaédi, which graduates a total of 75 advisors in all disciplines each year. Only a few of these are specialised in hydroagricultural development and the management of irrigated farming, further, only 40% of graduates remain in the agricultural sector.

Rural activity and extension should be promoted, with the particular aim of retaining the best elements of the youth on the land.

To meet these needs, the creation is projected (see para 5.6 below) of a training centre at Boghé for the upkeep and maintenance of heavy machinery used in the construction and maintenance of projects, a training centre for pump mechanics, also at Boghé, and a training centre for "pilot farmers". The options chosen thus place considerable emphasis on basic training.

There might, incidentally, be scope for collaboration with the Senegalese SAED for the use of the N'Diayes Centre for more specialised training in irrigation techniques.

3.5 Constraints to the Implementation of Hydro-Agricultural Development Programmes

New programmes are normally put in hand by SONADER working with enterprises, but there are many other constraints pertaining to the circuits of production organisation, advisory services to farmers, the collection, transformation and storage of products, and the shortage of basic equipment.

3.5.1 SONADER - a National Development and Management Corporation

SONADER ("Société Nationale pour le Développement Rural") was set up in 1975 to"identify, study, control, supervise, and as necessary advise and manage all state actions in the agricultural sector and more specifically as regards their hydro-agricultural aspects".

As of 30th June 1979, its staff totalled 255, including 32 national executives and 26 expatriates. It presently manages 21 projects, with a 1979 budget allocation of 733 million MU.

The projects to be carried out in the short term, and for which financing arrangements have already been made add up to 2,650 million MU. The projects to be put in hand in the short and medium term will cost some 23100 MU (Annex A3 contains the full list of SONADER projects).

Despite remarkable efforts - to which the number of projects in hand and the prospects bear testimony - SONADER has not yet reached the rate of 5,000 to 6,000 hectares annually indicated in the Plan, and its human and material resources need to be strengthened (see the technical assistance project described in para 4.5 below).

3.5.2 The Cost of Hydro-Agricultural Developments

As was noted in para. 2.6, the cost of projects is extremely high, and exceeds 500,000 MU per hectare for the irrigation and drainage structures in large perimeters. From the several analyses of these costs that have been made, the following conclusions emerge:

- Mauritanian firms are at most marginally interested in rural development. Further, the restricted size of the national market, together with various obstacles to the repatriation of equipment and funds are a disincentive to investment by foreign enterprises;

- the location of projects in isolated areas considerably increases the costs of bringing in equipment and materials, as well as the cost of site personnel;

- large perimeters involve heavy infrastructural outlays (dykes, pumping stations).

To ease these difficulties in part, SONADER is considering the execution of repetitive work such as plot development and smoothing by parastatal companies ("régie"). Donors should back this policy, which should lead to a reduction in the presently excessive costs per hectare developed.

3.5.3 Production Organisation Problems

The circuits involved in supplying inputs and the off-take of production (collection, transformation, storage etc.) are embryonic, when they exist at all. A major effort is called for in this area, bearing notably on :

- the creation of an agricultural credit system providing equipment or harvest loans at a rate of interest not above 4 or 5%. This would in particular help promote the development of animal-drawn farming;

- the construction of rice mills close to the location of production, to enable rice-growers to collect the proceeds of their deliveries of paddy rice within the region;

- the establishment of village cooperatives for collective acquisition of small machinery, and the construction of workshops and storage depots, whose structure and supply networks would guarantee farmers timely availability of the factors of production, and secure the maintenance of installations.

3.5.4 Enclaves

Apart from the region of Rosso, the Senegal valley lies distant from any asphalted main road. While Boghé will soon be linked to the Trans-Mauritanian Highway by an all-weather road, access to the regions of Kaédi and Selibaby is difficult during several months of the year, when inputs and product deliveries can only be moved using the road which follows the left bank of the Senegal river, in Senegalese territory.

CHAPTER IV

IV. STATUS AND REVIEW OF FIRST GENERATION PROJECTS

4.1 Preliminary observation - General framework

An ambitious programme of hydro-agricultural projects, covering 13,800 hectares in 1980 and 35,400 hectares in 1984, was scheduled in the third Plan (1976-1980).

The real status is well below these estimates (see para. 2.8). As of 1980, less than 3,700 hectares had been equipped; in 1978/79, only 1,938 hectares were developed.

It is thus more realistic to portray first generation projects as embracing only those which have begun, or which have also been assessed by donors. These projects consist of studies, development work and support activities for the main development organisation, the SONADER.

On this basis, the first CILSS programme is a rather heterogeneous list of 16 projects, some of which have remained at the stage of project ideas, others having been studied up to feasibility stage and some others being implemented. The detailed status of this first generation programme is given later in tabular form.

4.2 Studies of Development Schemes

Two studies of this type are under way: the Senegal valley hodro-agricultural development scheme and the Tagant integrated development project.

4.2.1 Senegal valley development scheme (right bank)

Cost: 15 million MU (1.5 million French francs), financed by FAC. This study, started in 1978, should be completed by end 1979 and result in the programming of activities of the SONADER in the Senegal valley, in liaison with the OMVS programme. The services covered include:

- updating of basic data (physical and human environment, existing developments and equipment and production possibilities);
- presentation of general norms, in particular for hydrology, cultivation schemes, hydro-agricultural developments, advisory staff, training and unit prices;
- proposals for a programme of activities, including as well as long term development assumptions and criteria for geographical choice a short term programme of studies (1980-1982) and for work in the medium term (1980-85).

Accordingly, from the beginning of 1980, the SONADER should have available a detailed development programme for the Senegal valley covering the next five years, set in the frame of long-term prospects, and with the definition of the corresponding means.

4.2.2 Tagant integrated development study

Cost: 36 million MU - Financed by the GTZ (Germany).

An overall scheme for rural development of the Tagant region should become available through this project. Phase I began in March 1978 and will finish at the end of 1979. It will include implementation of short-term projects (construction of 14 dams, Tamourt en Naaj and the Ashram Diouk project (see below), which will be the short-term development poles), medium-term developments with the corresponding complementary activities, and the long-term measures to be taken, essentially in the field of physical and social infrastructure.

Feasibility and project implementation studies will be undertaken during 1980.

4.3 Development Project Studies

Some feasibility studies are extended partly to the implementation study stage. There are projects underway at Aftout es Sahel, Lake R'Kiz, Tamourt en Naaj, Black Gorgol, the Koundi sugar perimeter, Ashram Diouk and the implantation of small perimeters.

4.3.1 Evaluation study of Aftout es Sahel (see map B3)

Cost: 2.5 million MU (250,000 French francs) - financed by FAC.

This evaluation study undertaken by SOGREAH is the follow-up of feasibility studies and the execution of infrastructural work and construction of a test station; it was completed in June 1979.

The work programme to follow-up these studies at a cost of 1.12 billion MU is presented in the second generation programme (chapter V).

4.3.2 Hydro-agricultural development study of Lake R'Kiz (see map B3)

Cost: 22 million MU (2.2 million French francs) financed by FAC.

This study was undertaken by BCEOM. It began in 1975 but was stopped through lack of funds. It was resumed in 1979 and should be completed by end 1979.

The study covers the region of lake R'Kiz, which is a wide depression supplied by several tributaries of the Senegal river during the flood season and has good pasture land and a few subsidence season crops are grown (see the sketches in annex).

The study will cover: the results of hydrological and pedological studies as well as topographical measurements of approximately 20,000 hectares, proposals for the development scheme of the Lake R'Kiz zone (scale: 1/20,000), and summary studies of developments covering three 100 hectare zones.

After selection of one of the proposed schemes, additional studies must be allowed for to establish feasibility and implementation study specifications.

4.3.3 Hydro-agricultural development study of Tamourt en Naaj (see Map B3)

Cost: 1.3 million MU (130,000 French francs) - Financed by FAC.

This study undertaken by BCEOM in 1976 and also stopped through lack of funds was taken up again in 1979 and should be completed by end 1979.

It covers the Tamourt en Naaj depression, and involves a 19 million cubic meter reservoir project which should allow gravity irrigation of 1,000 hectares of cereal crops as well as irrigation by pumping of 80 hectares of small perimeters and improvement of subsidence season crops over 800 hectares (see sketch in annex).

The study, which is a complement to the identification carried out by the FADES* in 1977, will provide the feasibility and execution specifications.

Financing :

- has been arranged for 80 hectares of small perimeters - 40 million MU (FAC-CCCE);
- is being sought for the remainder - 410 million MU; IFAD has expressed interest in making 360 million MU available.

4.3.4 Black Gorgol project study (map B4)

Cost: 75 million MU - financed by the IDA 694/MAU (in part) and IDA 5/16 MAU. Studies completed in June 1979.

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* Arab Fund for Economic and Social Development (Kuwait)

The studies taken up again in 1977 by "Il Nuovo Castoro" have enabled the Black Gorgol project to be completed; it includes the Feum Gleita dam(1) and a 3,600 hectare perimeter irrigated by gravity (see map in annex).

Invitations to tender for the work have been issued and funds of 3,804 million MU ($84 million) in aggregate are sought.

4.3.5 Feasibility study of a sugar perimeter at Koundi

Cost: 40 million MU - Financed by the CCCE.

A 7,000 hectare sugar perimeter was identified by the SONADER with the help of a consultant (SODETEG) covering the natural development units of Koundi 6,7,8, with an annual sugar production of 40,000 tons.

The net area is divided into 4,400 hectares for sugar cane and 1,000 hectares for cereal crops.

The terms of reference of the pre-project and feasibility studies were established in June 1979 by the SONADER. Financing of the studies has been arranged (40 million MU), as well as funds for the programme of agronomic research in sugar cane.

4.3.6 "Koundi 3" study

An identification study was performed in 1976/77 by the Arab Organisation for Rural Development (OADA) on the natural development unit of Koundi 3. The project, available in Arabic provides for endyking 15,000 hectares and developing 4,500 hectares net at a cost of 2,245 million MU.

Additional financing of 45 million MU is sought for the establishment of the feasibility and implementation studies for this project.

4.3.7 Ashram Diouk development study

Cost: 44 million MU - Financed by GTZ (Germany).

This study should be integrated in the Tagant Guiding Scheme; it began in 1979, and after the interpretation of the photographs taken by satellite, should be followed by a feasibility study covering a 5,000 to 8,000 hectare zone of agro-pastoral land by end 1979.

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(1) The design of the Feum Gleita dam was completely transformed; it was initially intended to be an earth dam with a 2 billion cubic meters reservoir, the present specifications are for an arch-dam up to a level of 40,2 IGN with an upper outfall and a reservoir of 600 million cubic meters.

4.3.8 Study of a project for the construction of 15 dams in the Brakna, Assaba and Gorgol regions (see map B1 in annex)

Cost: 15 million MU - Financed by USAID.

The study was carried out by the SONADER on behalf of USAID to select 15 reservoir dams for subsidence season crops (approximately 50 hectares per dam) i.e., a total of approximately 750 hectares. It should be completed by end 1979.

USAID would finance the 220 million MU needed for constructing the 15 dams.

4.3.9 Study for the installation of small village perimeters

Cost: 6.5 million MU (650,000 francs) - Financed by FAC.

This study which was started by the SATEC in 1979 will be finished by early 1980. It should result in a general feasibility study of small village perimeters and the determination of the area which can be developed on this basis, detection of the corresponding sites and the definition of methods for the later insertion of these developments in the framework of extended perimeters. The average area of these village perimeters is approximately 20 hectares.

4.3.10 M'Bagne Bababé execution study

Cost: 17 million MU - Financed by WAEC(1).

The implementation study of 20,000 hectares (14,000 hectares net) in the M'Bagne Bababé region between Boghé and Kaedi is underway. It is being performed by the SERIAC office, which is also to find the additional funds for the completion of this study (total estimate: 80 million MU).

4.4 Preparation and Development Projects

These include the M'POURIE perimeter, the Gorgol pilot plot, the Boghé pilot perimeter, the Black Gorgol project, VILLAGE PERIMETERS and the construction of dams in the hodhs, Brakna and Assaba.

4.4.1 The M'Pourie perimeter

This perimeter is directly sponsored by the Ministry of Agriculture. It entered into service in 1970 (see para 2.10.1). In 1979, the surface developed was 1,400 hectares - of which 340 hectares fallow - and its extension is continuing with the assistance of the People's Republic of China. The final objective is to attain 3,000 hectares, i.e., the whole endyked area.

(1) West African Economic Community.

Because of salinity and the invasion of red rice, lower rice yields have been obtained in the last few years and the rate of new development has slowed down.

4.4.2 Gorgol pilot perimeter (see map B2 in the annex)

Cost: 191 million MU - Financed by FED.

This pilot perimeter covering a developed area of 700 hectares has been progressively extended by the SONADER from 1977 to 1979 (147 hectares in 1977, 370 hectares in 1978 and 573 hectares in 1979) (see para. 2.10.2).

Renovation work is already necessary: more than 10 million MU worth of consolidation work had to be carried out in 1978/79 and an estimate of rehabilitation work is to be established by the SONADER. This development proves the need for proper execution of infrastructural work and levelling, together with strict control during the work. Prior studies of geotechnical and topographic qualities are indispensable.

4.4.3 Boghé pilot perimeter

The Boghé plain was surveyed by the SOGREAH in 1973 and the findings updated by the SONADER in 1978/79.

The project comprises: endyking the 400 hectares of the plain and structures for irrigation and drainage of a pilot perimeter, net surface of 975 hectares, to be allotted as 0.5 hectare plots, a pumping station supplied by a thermal power plant, operating buildings, a variety of agricultural equipment and machinery; and technical assistance for the development and exploitation phases.

The work would have to be carried out in part by a parastatal enterprise ("régie") using earthmoving equipment which could also serve later in other projects. The cost of the project is estimated at 1,222 million MU, with financing broken down as follows:

KFW (Germany)	624
Saudi Arabia	281
ADB	247
Mauritania	70
	1222

Invitations to tender were issued in the summer of 1979. Development should begin in 1980 and entry into production in 1981.

4.4.4 The Black Gorgol project

The final specifications of this project (financed by IDA, see para 4.3.4) have just been completed and the corresponding funds are being sought or mobilised.

The project comprises: a dam with a concrete arch (height, 37 m; length, 95 m; 15,000 cubic meters of concrete) with free outfall at the crest, a reservoir capacity: 600 million cubic meters, of which 355 million cubic meters useful, an irrigated perimeter with a gross area of 4,200 hectares (3,600 hectares net area) gravity fed by a 3.6 km. primary canal, which then separates into two branches, as well as stores, warehouses, housing and a rice mill of 5 tons per hectare.

Its cost is evaluated at 3,804 million MU, of which 380 million MU for the dam (total estimate of $ 8.4 million, 52 million in 1978 prices + 15% for physical contingencies and 20% to account for price increases).

It will produce 19,500 tons of paddy, 2,800 tons of corn, 2,100 tons of sorghum, 2,000 tons of vegetables. This output corresponds to the food needs of 4,600 households.

Probable financial participation announced:

FED	9 M UC	i.e.	$ 11 M.
IDA	$ 7 M.		
KFW	16 M. DM		$ 9 M.
IFAD	$ 7 M.		
FAC	10 M. FF.		$ 2.4 M.

i.e. a total of $34.4 million, which would be completed by Saudi Arabia ($ 25 M.), Libya, the Islamic Development Bank and some other donors.

4.4.5 Village perimeters (see para 2.10.3)

Perimeters developed by the department of Agriculture and financed by FED are progressively taken over by the SONADER which also undertakes the development of additional perimeters.

The following projects are presently underway:

	Start-up	Cost in million MU	Donor
Advisory personnel for small irrigated perimeters	1976	48.0	FED
Feasibility and installation studies for small village perimeters (para. 4.3.9)	1979	6.5	FAC
Aid and advisory services for small perimeters from 1978 to 1980	1978	21.0	FAC
Coordination of small perimeters	1979	8.3	FAC
Development of 19 perimeters	1978	46.0	FAC
Survey and development of 15 perimeters	1979	108.4	Netherlands
Survey, development and technical services of 30 perimeters	1979	153.0	IBRD
Development of 15 perimeters	1979	46.3	FAC-CCCE

The results of the feasibility and installation study of village perimeters must be known before any further programming of village perimeters is undertaken. This is because the number of available sites meeting the requisite conditions now seems to be limited.

4.4.6 Construction of dams in Hodhs (map B1)

This project involves the construction of 18 dams in the Hodhs region, which should allow 2,200 hectares to irrigated for subsidence season crops (see map B1 in annex).

The work will be performed "en régie" by the SONADER over 3 years with the technical assistance of "the Il nuovo castoro" office; the SONADER will be equipped with civil engineering machinery for the purpose.

The cost of the project is estimated at 400 million MU, with the financing arranged as follows:

FED	216 M. MU
Germany	116 M. MU
Mauritania	68 M. MU
	400 M. MU

4.4.7 Construction of dams in Brakna, Assaba and Gorgol (Map B1)

This project consists of building 15 dams in Brakna, Assaba and Gorgol to irrigate 700 to 1,000 hectares. They have been studied by the SONADER, financed by USAID (see para. 4.3.8).

The cost of this project which can be implemented by a SONADER para-statal corporation ("en régie") is estimated at 220 million MU. It would be financed by USAID.

4.4.8 Tamourt en Naaj project (map B3)

The implementation study was to be completed in 1979 (see para. 4.3.3). The corresponding sub-projects are expected to be financed as follows:

- 80 hectares of small perimeters at a cost of 40 million MU, financed by the FAC-CCCE;

- the remainder of the project - 1,000 hectares of irrigated perimeters and 800 hectares for subsidence season crops - costing 410 million MU was evaluated by IFAD in 1979 which would envisage a participation of 360 million MU.

4.4.9 Other projects

(a) The Tenesouellem market gardening perimeter: This small perimeter of a few hectares is fed by residual water from Nouakchott (8,000 cubic meters per day, of which 900 cubic meters are purified). An improvement was effected using a CIDA credit of 6.9 million MU. In present circumstances, it does not appear possible to undertake a major extension of this perimeter.

(b) The Garak solar pumps: Specifications being established for the installation of a 3KW. solar pump - Cost: 700,000 francs. Financed by FAC.

4.5 Technical Assistance to the SONADER

Substantial technical assistance has been provided by various donors since 1977 (approximately 40 experts). The status at the end of 1979 is recapitulated in the timetable (annex A4).

Several credits will be used up during 1980. It is important that contracts be renewed and that structures be reinforced in certain fields. The aggregate cost of 40 experts per year can be estimated at $ 5 million, but most of their pay would be met out of project budgets.

Financing of the institutional technical assistance funded by IDA funds will come to an end during 1980, and it is important that bridging finance be available to aid the central departments of the SONADER to implement a programme which is becoming increasingly larger.

As regards only the first generation projects which are still to be implemented in the next five years, the sums to be managed will amount to:

335 million MU ($ 7.9 M.) for studies,

6722 million MU ($ 152.3 M.) for work.

In a note drafted by it, the SONADER sets out the structural technical assistance necessary for the reinforcement of its central departments over the next few years, until enough national executives with appropriate training and experience are available to manage these programmes.

This request is reviewed in paragraph 5.8.

4.6 REVIEW OF FIRST GENERATION PROJECTS UNDERWAY OR ABOUT TO BE IMPLEMENTED

(financing obtained except for C)

	Cost in millions		DONORS	Time frame
	MU	US$		
A) Studies				
1. Hydro-agricultural development scheme of the Senegal valley	15	0.35	FAC	1979-80
2. Integrated development study of Tagent	36	0.85	GTZ	1978-80
3. Evaluation of AFTOUT ES SAHEL	2.5	0.06	FAC	1978-79
4. Lake R'Kiz development study	22	0.52	FAC	1979
5. Development of Tamourt en Naaj	17	0.40	FAC	1979
6. Black Gorgol project	75	1.75	IDA	1976-79
7. Feasibility of a sugar perimeter	40	0.95	CCCE	1979-80
8. Koundi 3 development study	45	1.07	?	1980-81
9. Development of Achram Diouk	44	1.03	GTZ	1979-80
10. Study of 15 dams in the Brakna, Assaba and Gorgol zones	15	0.35	USAID	1979-80
11. Implementation study of M'BAGNE-BABABE	17	0.40	CEAO	1979-80
12. Study for the implantation of small village perimeters	6.5	0.17	FAC	1979-80
TOTAL A =	335	7.90		
B) Development and entry into production				
1. M'POURIE perimeter (technical assistance from China)	?	?	China	1980-85
2. Gorgol pilot perimeter	191	4.5	FED	1976-79
3. Boghé pilot perimeter	1,222	28.8	KFW 14.6 Saudi Arabia 6.6 ADB 5.8 IRM 1.8	1980-82
4. Black Gorgol development study	3,804	84	FED 12 IDA 7 KFW 9 IFAD 7 FAC 2.4	1981-85
5. Small village perimeters	435	9.7	FAC/CCCE IBRD/EDF Netherlands	1978-82
6. Construction of dams in the Hodhs region	400	9.5	FER 5.1 Germany 2.7 IRM 1.7	1979-81
7. Construction of dams in Brahna, Assaba and Gorgol	220	5.2	USAID	1979-81
8. Development of Tamourt en Naaj	450	10.6	FAC/CCCE 0.95 IFAD 8.2 + ?	1979-80
TOTAL B =	6.722	152.3		
C) Structural technical assistance to the SONADER (p.m.) (see the second generation programme)	p.m.	p.m.	?	1980-90
GENERAL TOTAL =	7.057	160.2		

CILSS/
CLUB DU SAHEL

- MAURITANIA -

$ 1 = 42 MU

October, 1979

1MU = 0.10FF = 5 CFA francs

4.7 STATUS OF THE CILSS FIRST GENERATION PROGRAMME

- Irrigated Farming -

I : Preliminary interest, under study
II : Marked interest, cofinancing
III : Firm commitment

PROJECT	Estimate of costs		Financing		REMARKS
	Million MU	Million $ US	Source	Type of interest	
1. Irrigated perimeter in the outskirts of Nouakchott: 500 ha. sprayed with residual water		9.524	-	-	At "idea for project" stage - the present cleansing station for used water yields only 900 m3 per day.
2. Development of Aftout es Sahel, Phase I:					
(a) completion of studies	21	-	FAC	III	- studies completed (implementation specifications).
(b) work (part of which performed by the OMVS)	1,125		FAC	II	- commitment for 30 million FF by the FAC (1/3 of total).
			Germany Saudi-Arabia		- requests presented to these two donors.
3. M'Pourie development; extension of 3,200 ha., raising the present area to 4,000 ha.	960	22,857			Financed by Mauritania and Chinese technical assistance. Major problems (soils, salinity and wild rice) delay extension; underway since 1977.
4. and 5. GARAK development. Identification and feasibility studies to be undertaken	20				At "idea for project" stage. The Koreans were interested in these projects.
6. Development of the valley of lake R'Kiz:					
- studies (execution record)	50		FAC	III	- Feasibility studies by the SONADER in progress. Financing to be sought after feasibility.
- execution of work	600				- Preliminary estimate; financing to be sought.
7. Development of Boghé I 1st Phase: complete endykement and development of a pilot plot covering 1,000 ha.	1,222		ADE Germany Saudi-Arabia	III III II	- commitment of 247 million MU - commitment of 550 million MU - 400 million MU expected for the equipment of the SONADER. Work was scheduled to start in October 1979.
8. Development of Boghé II (2,300 ha. net) - studies	10				Feasibility studies: financing to be sought.
9. Development of the Gorgol valley. Phase I : 700 ha. pilot perimeter	191		FED	III	Renovation project to be executed urgently: 5,000 ha. farmed of the 700 developed (dyke, smoothing).
Phase II: Black Gorgol studies	75		IDA FED	III III	The execution project was completed in June 1979.
Development of a perimeter of 3,600 ha.		68	IBRD FED Germany	III III III	$7 million from IBRD $10 million from FED $6 million from Germany (possibly $16 million)
			IFAD FAC Libya-IDB Saudi-Arabia	III III I	$7 million from IFAD $2.7 million from FAC
(10.)* Foum et Gleita dam	-	12	FED	III	Work scheduled to begin end 1979.
10. Phase 3: Development of 3,000 ha. net and construction of the El Bir dam	?	-	-	-	Financing of studies to be sought.

PROJECT	Estimate of costs		Financing		REMARKS
	Million MU	Million $ US	Source	Type of interest	
11. Development of GARLI, 1,600 ha; studies	10	-	-	-	At "idea of project" stage. Feasibility study to be performed and financing to be sought.
12. Development of Maghama-Dembakane; studies; identification and feasibility	150				Studies to be financed urgently with prior identification (10 million MU).
13. Small irrigated perimeters on the right bank of the Senegal river					
- 30 small perimeters	153		IDA	III	- underway
- 15 small perimeters	46		FAC/ CCCE	III	- underway
- 30 small perimeters in 2 phases	108		Netherlands	III	- under study. Commitments amount to $ 2.31 million for small perimeters in the Rosso region.
- coordination, maintenance and renovation of small irrigated perimeters	77.3		FED FAC	III III	- perimeters already developed; 14 by the FED and 13 by FAC.
14. Development of Damourt en Naaj					
(a) Studies (implementation specifications)	17		FAC	III	Specifications available
(b) Execution:	450		IFAD	II	IFAD would finance 360 M. MU.
. reservoir formed by hills with 300 ha. of subsidence season crops					
. perimeter of 1,000 ha/ gravity			Germany FAC	I III	Request for financing of 10 small perimeters, drawing on "Sahel special assistance" funds.
15. Development of Achram-Diouk					
- Preliminary studies, feasibility	44		Germany	III	KFW financing. Studies underway of a development scheme for the Tagant region.
16. Kaedi Training centre for irrigated farming monitors					

CHAPTER V

V. PROPOSALS FOR A SECOND GENERATION PROGRAMME (1980-85)

5.1 Basic Directions and Principles

5.1.1 The last five years must be considered as the initial period of the irrigated crop development policy decided upon by the Mauritanian Government, and more particularly the beginning of the hydro-agricultural development programme in the third plan (1976-80), as well as a running-in period for the SONADER, which was created in 1975.

It should be recalled that in 1976, Mauritania had less than 1,300 hectares of irrigated perimeters; by 1979, 2,700 hectares had been developed. In the last crop year 1,848 hectares were sown of which 1,790 hectares were harvested.

Delay by comparison with the Plan is considerable; it had scheduled the development of 9,600 hectares by 1979, of which 3,000 in that year and a further 5,400 in 1980. The Working Group of the CILSS/Club du Sahel proposed a rate of 2,700 hectares for the latter crop year.

5.1.2 The second CILSS/Club du Sahel programme over the 1980-85 period should aim for an average pace of development of at least 5,000 hectares per year, and, if possible, 5,500 hectares per year, which would yield relative food self-sufficiency toward the turn of the century. In 1985, the rate should increase to 4,500 or 5,000 hectares per year.

This programme must be in line with the national and regional development choices made, and more particularly, permit a suitable spread of action over the whole of the nation's territory and in particular in the Sahel zone. It should also correspond to internal and foreign financial possibilities, be integrated in the OMVS programmes which schedule the entry into service of the Diama dam as of 1983 and of the Manantali dam in the second half of the next decade.

5.1.3 Of the basic options of the first programme, the following should be maintained:

- intensification of production and generalisation of double annual harvesting on perimeters of 0.5 hectares;
- distribution of projects over the whole of the national territory;
- continuation of basic studies.

In the light of the results obtained up to now on hydro-agricultural developments, it seems necessary to establish a general overview in order to define guidelines for the future. In addition, development scheme studies, such as those in progress for the Senegal river valley and Tagant, could then be extended to other large natural zones of the country, to have available an inventory of usable water resources by region, as well as of land development possibilities.

5.1.4 The second generation programme outlined here is an outline that will need to be filled in. The projects correspond to proposals formulated by the Mauritanian authorities, which the mission has tried to quantify. These proposals will have to be analysed and made more specific, and inserted in a programme that is consistent at national and regional levels.

5.2 Proposals for Project Studies

5.2.1 Not many studies are available at present. Approximately 6,600 hectares can be developed up to 1985, for which feasibility studies are available. These are:

- the M'Pourie perimeter	1,000 hectares
- the Boghé pilot plot	1,000 hectares
- the Black Gorgol project	3,600 hectares
- small village perimeters	1,000 hectares
	6,600 hectares

Approximately 2,000 hectares of subsidence season crops, whose variable yield makes this type of cultivation more a social rather than an economic matter should be added to these 6,600 hectares.

Over the 6 years of this period, these developments correspond to a pace of 1,000 to 1,400 hectares per year, whereas the Plan forecasts 5,000 hectares per year.

Mauritania has not enough project dossiers to allow Plan executives to study development alternatives or the SONADER to present to donors a programme of new perimeters whose development would be completed before 1984-85 with implementation beginning 1981-82.

5.2.2 Studies to be undertaken by 1983 (feasibility)

The Plan development forecasts an average of 5,000 hectares per year from 1980 to 1984, which implies that, given present circumstances, feasibility studies be undertaken covering:

- 24,000 hectares from 1980 to 1984,

- 36,000 hectares from 1985 to 1989,

- 36,000 hectares from 1990 to 1994,

taking account of a 30% reduction as between gross and net surfaces.

Since 2 years must elapse between the presentation of the feasibility appraisal to the donors and the opening of the working site, and a further two years are needed for the work, feasibility studies would have to cover:

- 24,000 hectares studied by 1981,

- 36,000 hectares studied by 1983,

i.e. a total of 60,000 hectares which should be studied up to feasibility stage by 1983, assuming that the technical implementation specifications are established progressively.

5.2.3 Estimate of the cost of the studies to be undertaken

The cost per hectare of studies for the Senegal valley where many basic investigations have been carried out is approximately indicated by the following figures:

A - Feasibility

- Basic investigations..... 3,000 MU/hectare:

  Topographical survey (scale 1/5,000 or 1/10,000).
  Pedology; 1 sounding per 4 or 5 hectares.
  Geotechnical survey, taking of samples for infrastructural work.
  Hydrological and socio-economic.

- Engineering ..... ?,000 MU/hectare.

  Preliminary surveys.
  Interpretation of basic investigations.
  Core scheme with variants
  Rough (technical) project summary.
  Economic feasibility.

B - Implementation documentation established for the main infrastructural installations(1)

- Basic investigations..... 2 to 4,000 MU/hectare

  Topography, complements (1/5,000 and 1/2,000 scale)
  Pedology: 1 sounding per hectare.
  Detailed geotechnical study of terrain covered by structures.

(1) Execution projects for developments below approximately 500 hectares should be prepared in advance by the team supervising (leadership and control) sites being developed "en régie" (i.e. by a para-statal enterprise).

- Engineering ..... 2,000 MU/hectare

  Definition and interpretation of site investigations.
  Detailed pre-project.
  Specifications of invitation to tender.

Given these figures, the cost of studies to be undertaken by 1984 can be estimated at:

Feasibility studies: 5,000 x 60,000 = 300 million MU
Implementation studies : 5,000 x 20,000 = 100 million MU

i.e., a total of 400 million MU for studies ($ 9.5 million).

This is an order of magnitude. It can doubtless be confirmed soon by the conclusions of "the hydro-agricultural development scheme for the right bank of the Senegal river", expected by end 1979.

Proposal: A mission of experts of one month's duration including one development engineer, 1 agronomist and 1 economist could assist the SONADER in preparing the terms of reference of phase 1 of these studies and could participate in the identification of the projects to be selected. The cost of this mission is estimated at 12.5 million MU.

5.2.4 Studies of identified projects to be implemented

(a) Funding should cover the amount necessary for the study of projects in the first generation programme which have not yet been financed:

- Study of Koundi 3,

- Feasibility and execution, Lake R'Kiz zone,

- Implementation study of the M'Bagne - Bababé perimeters.

(b) In addition, the following studies should be performed (identification and feasibility):

- Development of Garak - Garak 1 : 5,300 hectares net
  Garak 2 : 7,000 hectares net

- Development of Boghe 1 - Phase 2 : 3,000 hectares
  Boghe 2 : 2,300 hectares

- Gorgol valley, phase 3 : 3,500 hectares

- Development of Maghama-Dembakane 1 : ? hectares

- Development of Dioup-Sokotami : 4,700 hectares.

The following studies should be added:

- a census of oases and their potential,
- project of machinery for farmers,
- dam projects in agro-sylvo-pastoral zones, with the creation of a maintenance team,
- agricultural projects to be undertaken around major drilling locations,
- reinforcement of central departments.

5.3 Senegal Valley Development Projects

5.3.1 If the above programme of studies is respected, the projects for the Senegal valley can be submitted to the donors in 1980-81, and the targeted rates of development could be as follows:

2,000 hectares per year in 1982
3,000 hectares per year in 1983
4,000 hectares per year in 1984
5,000 hectares per year in 1985.

These objectives correspond to 14,000 hectares of new perimeters by end 1985, which would involve aggregate financing of 7 billion MU at 1979 prices, on the basis of an average cost of 500,000 MU per hectare developed.

5.3.2 In the Senegal valley, the sugar project for Koundi (4,400 hectares) covering Koundi 6, 7, 8 could be added; its feasibility study is underway (1). The cost of implementing this sugar project ie estimated at approximately 5 billion MU.

5.3.3 Over the next 6 years (1980-85), the SONADER will centre its activities mainly in the Senegal river valley.

5.4 Development Projects for the Sahel Desert Zone

5.4.1 Necessary basic studies

The possibilities for agricultural production and irrigation of these regions are relatively poorly known.

This statement applies to rainfed crops in the Guidimaka (Selibabi) and Gorgol regions, to surface water resources in the Hodhs , Assaba, Brakna, Tagant, Trarza and Adrar regions; and to ground water resources in the sedimentary basin of the Trarza, Brakna, Assaba, Indimi and Adrar regions.

(1) See para 4.3.6 above. Koundi will be the first sugar plantation project in Mauritania, whose sugar deficit is presently estimated at 30,000 tons.

It is indispensable to devise integrated rural development plans for these regions(1), involving in particular thorough study of ground and surface waters.

A mission of experts could help the SONADER in the definition of the terms of reference of these basic studies; it would include: a development engineer, 1 hydrogeologist, 1 hydrologist, 1 agrostologist and 1 zoo technician. This mission would need to stay approximately 6 weeks and would cost some 6 million MU ($ 150,000).

5.4.2 Tagant dam projects

A team to carry out repairs on existing dams and to build new ones should be created in the Tagant region.

Its first task would consist of building or reparing 14 dams, allowing a further 1,900 hectares of subsidence season crops to be harvested. This programme is estimated at 400 million MU. Provision should be made for the execution of urgent work with these funds, in particular in the Adrar region, where water tables pumped for various uses are at the limit of their capacity and run the risk of being polluted by salination in case of overuse.

Maintenance of hydraulic infrastructures is extremely important. The creation of this team would be a first experiment.

5.4.3 Well-boring projects (see annex D, para III).

There are substantial deposits of ground water between Nouakchott and Kiffa (2), located along the trans-Mauritanian highway linking Nouakchott to Néma via Kiffa.

Several requests were made for the equipment of these boreholes for pastoral hydraulic uses. However, it would be interesting to provide for experimental drip-sprinkling irrigation projects on areas of 1 to 5 hectares, which could be included in an integrated development programme such as the Ashram-Diouk project will be.

For indicative purposes, the cost of the three experiments of this type which should be undertaken is estimated at 50 million MU. They could be defined and the sites located by the mission of experts referred to in para. 5.4.1 above.

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(1) As shown by the integrated rural development study of the Tagant region or by the Ashram Diouk development study.

(2) Well-boring, used for the construction of the Nouakchott - Kiffa - Néma highway.

5.5 Aftout es Sahel Development Project

This project was presented at the donors' meeting in Dakar (September, 1978), and technical specifications were drafted by the CILSS/Club du Sahel. The implementation specifications, whose preparation was financed by FAC are available. Work is estimated to cost 1.1 billion MU; France would be willing to provide 30 million French francs. Additional funds are sought.

Aftout es Sahel is a large depression running along the coast from the delta of the Senegal river to just under 100 km. from Nouakchott. Phase I of the project consists of filling up the depression by flood waters from the Senegal to bring fresh water close to Nouakchott.

The return to the civil engineering work is ensured through the improvement of subsidence season pasture land, and secondarily, fish production. In the long run, it is envisaged that 10,000 hectares of terraces could be developed for irrigation. In the light of this installation, an experimental agronomic station is scheduled in the near term (cost : 125 million MU).

5.6 Transport

These projects, which concern the country's general development, are initially indispensable for the development of irrigated perimeters, especially in the Senegal valley (see para 3.5.4 above).

It should be recalled that the Boghé and Kaedi zones are deprived of usable roads during several months of the year. The development of irrigated crops cannot take place until permanent tarred roads are built.

Boghé will soon be linked to the Trans-Mauritanian Highway. Thus, the sections of permanent road to be built urgently are:

Rosso-Boghé	:	230 km.
Boghé-Kaedi	:	140 km.
Kaedi-Matam	:	70 km.

Road building is extremely expensive in Mauritania, of the order of 10 to 20 million MU per kilometer; consequently the three roads above would cost between 5 and 6 billion MU.

5.7 Training Programmes

The SONADER has established three projects for training centres, for which financing is sought (SONADER specifications available).

5.7.1 The Boghé training centre

This centre will aim to improve the general qualifications of agents in charge of maintenance and of driving earthmoving machinery. It is located near the central workshop of the SONADER, which will allow agents' training to be adapted to the realities of work in the workshop and on site.

Its cost is estimated at:

- buildings and equipment	50 million MU
- operation over three years	100 million MU
TOTAL	150 million MU

5.7.2 Training centre at Boghé for pump operators

This project will meet requirements for the development of autonomous operations of small village perimeters by training pump operators coming from the countryside in 4-month courses.

During the first three years of the project, teacher training services will be given by a foreign mechanic.

Cost of the project:

- investment	2.6 million MU
- operation over three years	27.4 million MU
TOTAL	30 million MU

5.7.3 Training centre for pilot farmers at Kaedi

The objective of this centre will be to train "pilot farmers" by giving them practical experience of irrigated farming, so that the farming methods learned can be referred to by other farmers of a zone who will have to switch rapidly from traditional extensive agriculture (millet, sorghum or niébé) to intensive irrigated farming (mainly rice).

This formula will ease monitors' work, reduce their number and consequently, the cost of advisory services which are at present a heavy burden on farmers (see para 3.4.21 above).

In other words, the objectives of the project are to put an end to the traditional training process such as it is practised now in the institutions created to act as the framework for agricultural production projects. Up to now, these institutes have been training civil-service type wage-earners whose concerns are - with a few exceptions, not very closely related to farmers' needs.

This project would be implemented in the Kaedi pilot plot, and cover 6.5 hectares. Advisory services would be provided for the first three years by an agronomist specialised in training farmers who would train the Mauritanian executives who will be in charge of the training project.

The centre would train 40 "pilot farmers" per year. New centres would be created later in developing zones.

The cost of the project is estimated at 81 million MU over 6 years.

5.7.4 Training project for farmers and sociological follow-up

This project, associated with the training project for pilot farmers at Kaedi should, after the necessary phase of development of the awareness of farmers in small and large perimeters, participate in farmer training at technical level, in management, working out technical themes and defining educational methods, after having convinced farmers in small and large perimeters of the value of the operation; it will establish a frame for evaluating training activities.

The project will last for two years under the direction of an expatriate sociologist.

Its cost is estimated at 14 million MU.

5.8. Project for Technical Assistance to the SONADER

The foreign technical assistance conveyed, at present, to the SONADER was referred to in para 4.5 above. In the light of the size of the programme to be implemented by this corporation over the next five years, we must stress the need for technical assistance to the SONADER to be reinforced.

SONADER has drafted a detailed note on the structural technical assistance which would be required to reinforce central departments until a high enough number of well trained and experienced national executives are available.

The description of the functions with the profile of the required experts is given in table para 5.8.1, with a note on the duration of stay envisaged. These can vary substantially: more than 10 years for the assistant to the head of the works office (a function requiring long practical experience on-site) and only 2 years for the assistant director of the study and works service.

The following services are required:

(a) Study and Works Directorate: 12 posts corresponding to 56 man-years;

(b) Production and Development Directorate: 5 posts corresponding to 26 man-years;

(c) Financial and administrative Directorate: 2 posts corresponding to 10 man-years.

i.e., a total of 92 man-years.

As a first approximation, using an annual cost of $ 100,000 to $ 110,000 for an expert on mission (1979 prices), the aggregate cost is $ 10 million. This apparently high figure corresponds to 7% of the cost of the first generation programme, but the investment could yield a very high return if the savings resulting from improved coordination of projects are taken into consideration.

Furthermore, the presence of experts in the field will be beneficial for the training of the Mauritanian executives teamed with them.

Given the size of this long-term investment, a further note should be requested of the SONADER, setting out precisely:

- the organisation chart of the corporation and the missions delegated to each service, decisions and services, in the light of medium-term projects;

- the possible utility of creating a group for programming hydro-agricultural development projects, so that the SONADER would be the established single opposite number for dealing with financing sources in the field of irrigation;

- the terms of reference of the activity of each expert requested, specifying their responsibilities;

- the training programme for Mauritanian executives with the timetable for their availability;

- the means which will be put at the disposal of the experts (machinery, offices, vehicles, field personnel, etc.) to enable them to perform their task efficiently.

A month's mission, including a rural engineer, an agronomist and a project management expert could help the SONADER to establish this information at a cost of 2.5 million MU.

5.9.1 SONADER - PROJECT FOR THE REINFORCEMENT OF STRUCTURAL TECHNICAL ASSISTANCE

Description of the functions to be performed	Qualification	Period
A - STUDY AND WORK DIRECTORATE		
1. Assistant to the Head of the Studies and Work: execution and coordination of projects; study and work	Senior rural engineer	1980-81
2. Assistant to the Head of the Studies Office: direction of studies and preparation of identification, feasibility and implementation specifications, and of invitations to tender	Senior rural engineer	1980-85
3. Assistant to Topographic Department Head, draughtsman's office	Topographic engineer	1980-82
4. Topographic Department Head Assistant, on-site measurement readings	Topographic engineer, land surveyor	1980-82
5. An engineer to design studies: execution plans, cost estimates	Civil engineer or higher technician	1980-85
6. Assistant to Work Office Head: installation of working sites, supervision of work, administrative supervision	Experiences civil or topographic engineers	1980-90
7. Assistant to Equipment Office Head, responsible for the management of a park exceeding 200 machines, the central workshop and supplies	Senior mechanical engineer with experience of public works	1980-85
8. Assistant to Central Workshop Head: workshop supervision, assistance to field workshops	Mechanical engineer	1980-90
9. Assistant to Central Stores Head: management of spare parts and supplies	Experienced management technician	1980-82
10. Coordination of small village perimeters: implantation, development studies, work, organisation of supply	Rural engineer	1980-81
11. Directorate Assistant: study and implementation of small dams, well-boring and related development activity	Rural engineer	1980-82
12. Engineer in the well-boring and small perimeters service	Civil or rural engineer	1980-81
B - DEVELOPMENT AND PRODUCTION DIRECTORATE		
13. Assistant to the director: agronomic feasibility, programmes for the operation of perimeters	Experienced agronomist	1980-85
14. Evaluation and Sociology: assessment of projects, training	Economic agronomist	1980-83
15. Production Office Head Assistant: crop projections, supplies and marketing of products; advisory and extension services	Field agronomist	1980-85
16. Assistant to Hydraulics Department Head: management and maintenance of networks	Rural engineer	1980-85
17. Assistant to the Head of the Group for Programming and Planning	Senior economist	1980-83
C - ADMINISTRATIVE AND FINANCIAL DIRECTORATE		
18. Assistant to Head of the Accounts Department: accounting organisation, analytical accountancy and management control	Certified accountant	1979-84
19. Head of the supply and storage department: supplies, purchases...	Management institute graduate	1979-84

5.9 Proposals for Short Missions

These missions were outlined below:

	Million MU
1 - Definition of structural technical assistance to SONADER	2.5
2 - Drafting the terms of reference for feasibility and implementation studies to be undertaken in the short-term	2.5
3 - Drafting the terms of reference for integrated rural development studies or regions	6.0
4 - Provision made for additional missions concerning training, agronomic research, marketing and storage, agricultural product processing, improvement of communications, etc.	9.0
i.e. a total of	20 million MU.

5.10 RECAPITULATIVE TABLE OF PROJECTS PROPOSED IN THE SECOND GENERATION PROGRAMME (1980-85)

- Irrigated Farming -

PROJECT TITLE	Estimated cost		Time-table	Technical Specifications
	Million MU	$ Million		
1. Irrigation project studies: - Feasibility studies - Implementation studies	(400) 300 100	9.5	 1980-82 1981-85	-
2. Senegal valley hydro-agricultural development projects (1982-85)	7,000	165	1982-85	-
3. Koundi sugar plantation project (irrigated perimeter and industrial zone)	5,000	119	1982-85	S
4. Basic regional studies (integrated rural development)	p.m.	-	-	-
5. Tagant dam projects (with 1,900 hectares of subsidence season crops)	400	9.5	1980-83	S
6. Equipment of teams for the installation of dams in the Adrar, etc.	p.m.	-	-	-
7. Experimental borehole irrigation projects	50	1.2	1980-85	-
8. Development of Aftout es Sahel. Phase I: Infrastructure and experimental station	1,000	26.2	1981-83	-
9. Boghé Training Centre: (mechanical equipment maintenance)	150	3.5	1980-82	S
10. Training Centre for Pump Operators at Boghé	30	0.7		S
11. Kaédi Centre for pilot farmers	81	1.9	1980-85	S
12. Farmer Training Project and Sociological follow-up	14	0.3		S
13. Project for structural technical assistance to the SONADER	420	10	1980-85	-
14. Short missions	20	0.2	1980-81	-
15. Access routes to zones providing irrigated crops: Rosso-Boghé-Kaedi-Matam roads	p.m.	-	-	-
Total estimated cost of the second generation programme: 14.685 billion MU or $ 347 million	14,685	347		
	Value as of October 1979 $ 1 = 42 MU			

A N N E X E S

A1 - TRADITIONAL CEREAL CROPS (MILLET-SORGHUM) BY REGION

REGION	Floodwater		Rainfed		Dam protected	
	hectares	kg/hectare	hectares	kg/hectare	hectares	kg/hectare
Hodh el Charqui			6,000	200	14,000	350
Hodh ek Gherbi			6,000	200	12,500	350
Assaba			10,000	250	4,000	350
Gorgol	14,000	400	21,000	350	2,500	350
Brakna	20,000	400	13,000	300	3,000	350
Trarza	1,500	400	2,000	300	6,000	350
Adrar					2,000	350
Dakhlat NDB					4,000	350
Tagant	6,500	400	24,000	400	4,000	350
Guidimaka	6,500	400	28,000	450		
Area	48,500		158,000		52,000	
Production	34,740 t.		38,350 t.		18,200 t.	

Source: Plan

SCHEDULE OF COST OF SERVICES AND SUPPLIES OF MEANS
OF PRODUCTION, 1979-1980

Gorgol pilot perimeter

CHARGE	UNIT OF ASSESSMENT	STATEMENT OF FEE	AMOUNT OR QUANTITY	OPERATING COSTS Tract: rainfed 1979 and out of season farming 1980		INDEXATION
				kg/paddy	MU	
Fixed fee	Per allotment	900 or 1,000 kg. of paddy	1,000 kg per allotment	1,000 or 900	9,000	No direct indexation. Indirect indexation on the official price for paddy
Pumping: use of power	185 KWH/ha. in season	9.5*/1,000 m^3 water	95 MU/1,000 m^3 water	9.5 x 7,0 (14,000 m^3/ha.) = 65	651	On the SONADER price per KWH
	362 KWH/ha. out of season	14.9*/1,000 m^3 water	149 MU/1,000 m^3 water	14.9 x 9 (18,000 m^3/ha.) = 134	1,341	
Sowing	Area sown	110 kg. of paddy	1,100 kg. ton	88	880	On the price of paddy
Ploughing	Area ploughed	355 kg. of paddy	3,550 MU/ha.	177.5 (every 2 years)	1,775	On the SONADER price
Spraying	Area sprayed	111 kg. of paddy	1,110 MU/ha.	55.5 (every 2 years)	555	On the SONADER price
Harrowing	Area harrowed	111 kg. of paddy	1,110 MU/ha.	55.5 (every 2 years)	555	On the SONADER price
Perlurée fertilizer (46%)	Ton	1,530 kg. of paddy	15,300 MU/ton	306	3,060	
Supertreble (47%)	Ton	1,750 kg. of paddy	17,500 MU/ton	175	1,750	On the purchase price and cost of transport

SONADER

COMPLETE LIST OF SONADER PROJECTS AS OF JUNE 1979
(million MU)

	Total cost	of which studies	of which counterpart (1)
A - Projects underway (financing acquired or firm commitment)			
Tenesouelem perimeter	6.900	-	2.400
Small village perimeters	46.000	-	5.000
Gorgol plot project	191.200	-	-
Lanasol	7.100	-	5.600
Aftout es Sahel study	21.000	-	5.000
IDA 694/MAU	196.200	-	38.700
IDA S16/MAU	10.500	-	-
Tagant development	34.400	-	4.400
Tamourt study	17.000	-	2.000
Hodhs dam	400.000	-	68.000
Boghé perimeter	1 222.000	-	122.000
Lake R'Kiz study	22.000	-	-
Guiding scheme study	15.000	-	-
5 AT (FAC + Germany)	26.460	-	3.920
New small perimeters			
Tamourt	40.202	-	1.202
FAC/CCCE	46.320	-	1.320
Coordination of small perimeters	3.300	-	700
Study of 200 small perimeters	5.500	-	450
Support for 200 small perimeters	21.000	-	500
Small Hollaldé perimeters	108.400		8.400
IDA 898/MAU	153.000	-	-
Solar pump	700	-	-
OPPI/FED	48.000	-	-
TOTAL	2,648.182		272.192
B - Projects envisaged (total durstion)			
Black Gorgol perimeter and F. Gleita dam	3,804		390
Mechanism training centre at Boghé	150		
Training centre for pilot farmers	32.3		
Sugar project (Koundi VI,VII, VIII	3,750	(50)	370
Tagant dam construction teams	400		400
Koundi III perimeter	2,045	(45)	200
Achram Diouk perimeter	4,444	(44)	400
M'Bagne perimeter	9,437.8	(37.8)	840
TOTAL	23,113.1	(176.8)	2,600
PROJECTS ENVISAGED AND UNDERWAY GENERAL TOTAL (A + B)	25,761.282	(176.8)	2,872.192

Source: SONADER

(1) Mauritanian counterpart financing of the total cost of projects.

TECHNICAL ASSISTANCE TIMETABLE (in course)

SONADER
DAF

June 1979

N°	STATUS	TITLE	ASSIGNMENT	YEARS 1979	1980	1981	1982	1983
IDA								
1	Mechanical engineer	Head of equipment department	DET					
2	Economist	Financial admin.	DAF					
3	Agro-economist	DMVP deputy	DMVP					
4	Senior rural engineer	DET deputy	DET					
5	Topographical expert	Topographical department	DET					
6	Topographical expert	Field topography	DET					
7	Agro-economist	Programming	IG (COP)					
8	Senior rural engineer	Works office	DET					
FED								
9	Agronomist	Head of project	Gorgol S.P.					
10	Mechanical engineer	Mechanic	" " "					
11	Agronomist	Agronomist	" " "					
12	Rural engineering tech.	Hydraulics	" " "					
CTE								
13	Agronomist	Head of project	DIT then DET					
14	Rural engineer	Hydrologist	" " "					
15	Agronomist	Production off.	DMVP					
16	Agronomist	Evaluation off.	DMVP					
FED								
17	Operating engineer	Coordination of production	Hodhs peri.					
18	Operating engineer	Head of team	" "					
19	Operating supervisor	Works supervising	" "					
20	Mechanic	Mechanic	" "					
IDA								
21	Rural engineer	Development of perimeters	KAEDI					
22	Agronomist	Development of small peris.	"					
23	Economist	Credit/marketing	DMVP					
FAC								
24	Rural engineer	Coordination of small peris.	DET					
25	Agronomist	Coordination of small peris.	DMVP					
26	Senior rural engineer	Technical assistance FAC	DET					
27	Rural work engineer	Technical assistance FAC	DET					
28	Agro-economist	Technical assistance FAC	DMVP					
29	Accountant-economist	Yearly accounts	DAF					
FED								
30	Agronomist	Operation of small peris.	Boghé S.P.					
31	Agricultural works engineer	Operation of small peris.	" " "					
FAO								
32	Senior rural engineer	Put at disposal	DET					
33	Agro-economist		DET					
34	Junior rural engineer	Sahel/Des. Off.	DET					
35	Junior rural engineer	Sahel/Des. Off.	DET					
Neth.								
36	Rural engineer	Development of small peris.	Rosso S.P.					
37	Agronomist	Operation of S.P.	" " "					
38	Mechanic	Operation of S.P.	" " "					

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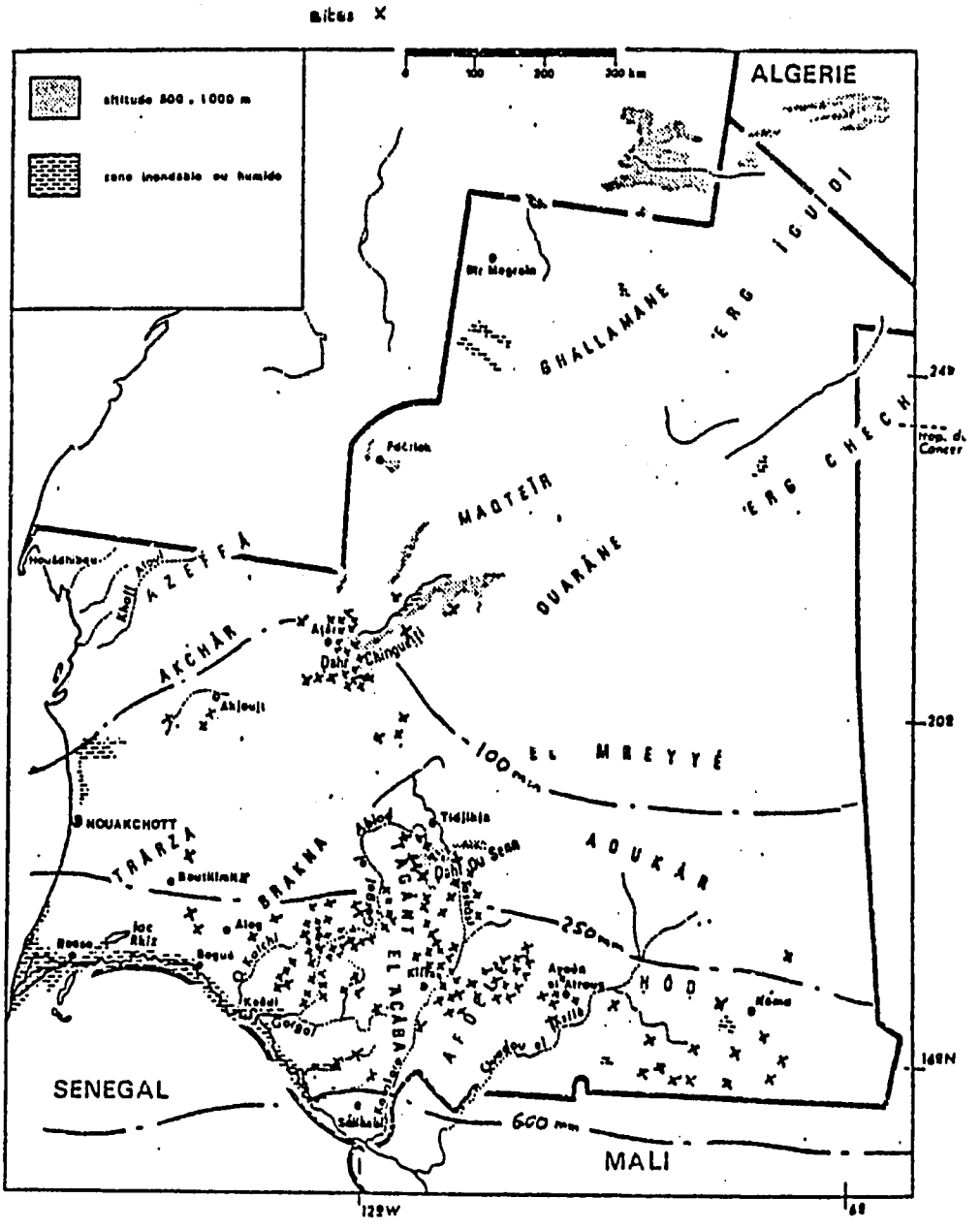
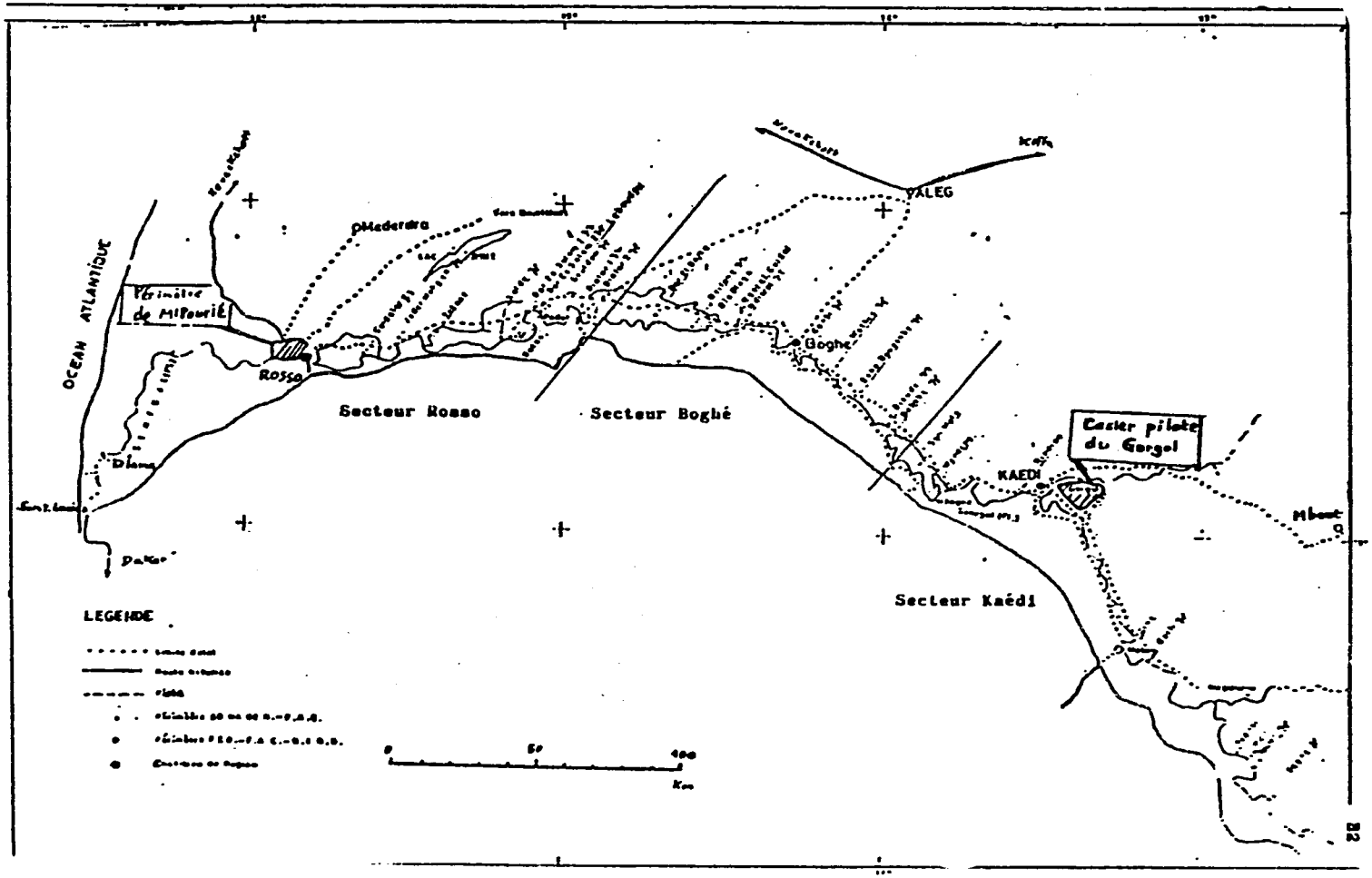
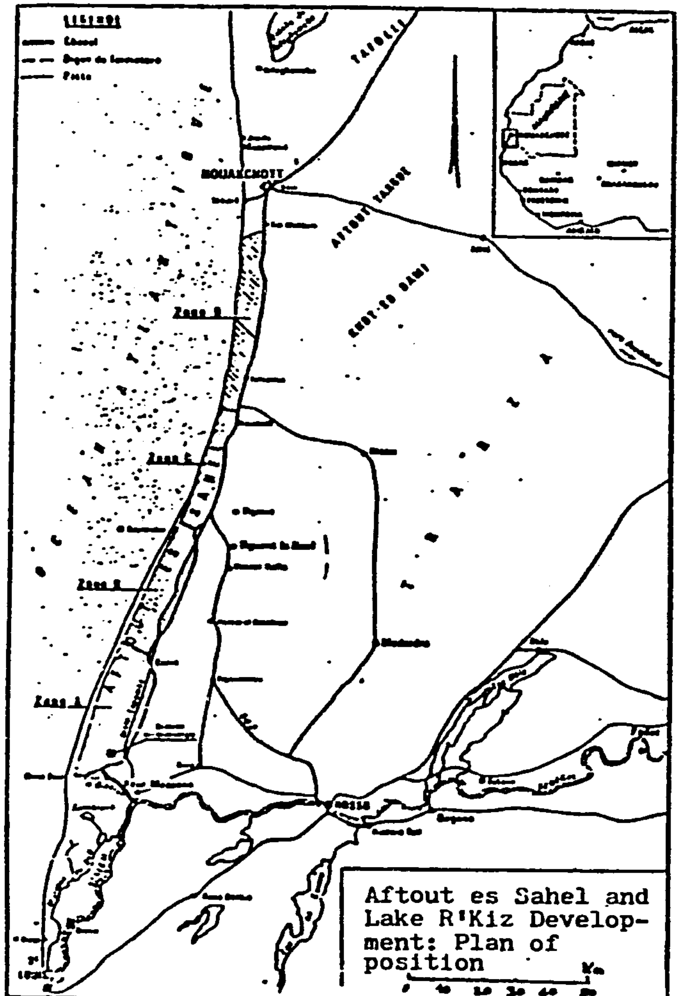
REGISTERED DAM SITES



MAURITANIA

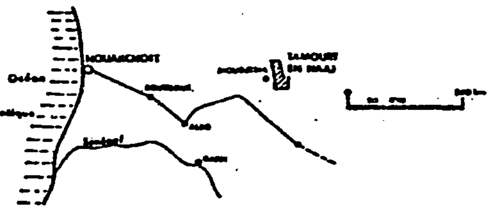
SENEGAL VALLEY: PERIMETERS EXISTING IN 1979



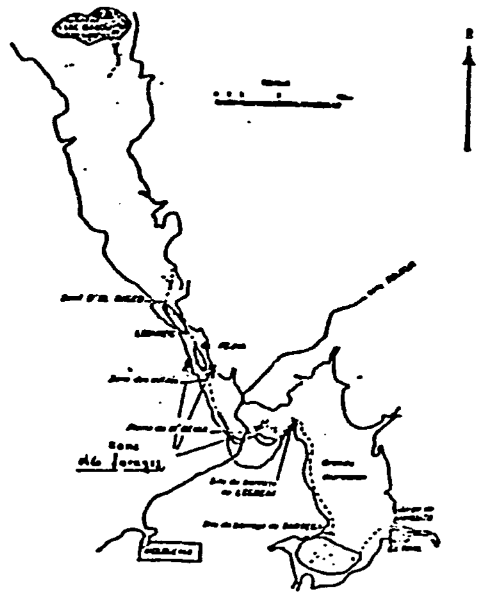


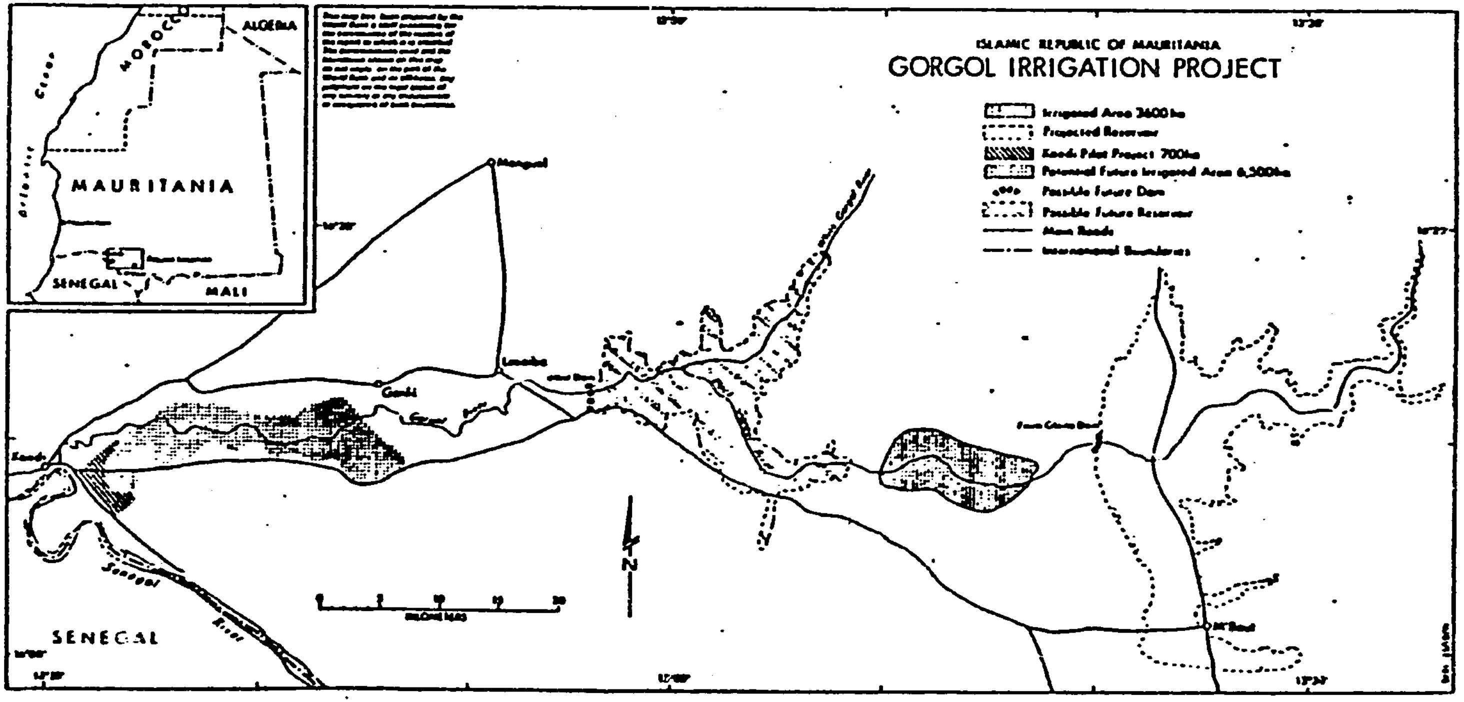
Aftout es Sahel and Lake R'Kiz Development: Plan of position

Sketch of Location



Tamourt en Naaj dépression




ISLAMIC REPUBLIC OF MAURITANIA
GORGOL IRRIGATION PROJECT
Irrigated Area 2600 ha
Projected Reservoir
Kaedi Pilot Project 700ha
Potential Future Irrigated Area 6,300ha
Possible Future Dam
Possible Future Reservoir
Main Roads
International Boundaries
ALGERIA
MAURITANIA
SENEGAL
MALI
SENEGAL

ANNEX C

NOTE ON THE AGRICULTURAL PRODUCTION POTENTIAL OF THE SENEGAL VALLEY

FOREWARD

I. TRADITIONAL PRODUCTION

- 1.1 Dieri plantations
- 1.2 Oualo plantations.

II. POTENTIAL

- 2.1 Rice
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  - 2.12 Sowing
  - 2.13 Calendar
  - 2.14 Farming methods
  - 2.15 Fertilizing
- 2.2 Wheat
  - 2.21 Varieties
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  - 2.23 Fertilizing
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- 2.5 Fodder crops
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- 2.6 Sugar cane
- 2.7 Other crops

NOTE ON THE AGRICULTURAL PRODUCTION POTENTIAL IN THE SENEGAL VALLEY

FOREWARD

The aim of the present note is to summarise the main results obtained in OMVS/FAO projects of agronomic research and to indicate possibilities which can be exploited in the short and medium term.

In part I, investigations into traditional crops, which seem difficult to improve considerably, are briefly presented.

The conclusions reached by FAO experts after full-scale crop tests are reviewed in Part II. The yields may seem high, 5 to 8 tons of rice per hectare and per rice crop, 3 tons of corn or wheat per hectare and between 10,000 and 25,000 UF per hectare; but they were nevertheless tested in real conditions (Chinese rice perimeters at Guédé and Pété Galoya, FAC fodder perimeter at Kaédi); and it appears that these figures can easily be reached in careful family farming.

I. TRADITIONAL PRODUCTION UNIT

The present traditional production unit comprises 10 persons, of whom 4 active, spending approximately half of their time to farm 2 or 3 hectares of "diéri" and 1 to 3 hectares of "oualo" yielding in all 2 to 3 tons of cereal.

1.1 Dieri Soil plantations

These field crops are sown in July during the rainy season on brown sub-arid sandlike granular soil; millet, niébé, beref and sometimes groundnuts are the main crops grown on them.

Agricultural calendar and working time

Time of year	Type of work	Number of man days
Beginning July	Preparation of soil	5
	Sowing in 1.2 x 1.2 m layout	4
Mid July-August	Weeding, hoeing	32
Mid September/ mid October	Maintenance	32
Mid October - Beginning November	Harvest, transport	10
		83

The cost involved is quite low (seeds, purchase of tools); yields vary between 0 and 600 kg. per hectare and fluctuate violently depending on the regularity and abundance of rainfalls; a few farming improvements (seed processing, sowing closer in line, weeding...) could increase yields slightly (to 1 ton per hectare in "good" years), with, however, no further guarantee as to yields in the region between St. Louis and Kaedi where 250 mm. of rainfall is guaranteed eight years out of ten.

1.2 Plantations on oualo soils

They are grown in the subsidence season in basins of "hollaldé" soils from October to December after the water level has declined; the crops are mainly sorghum and corn, with niébé.

Agricultural calendar and working time

Period	Nature of work	Number of days per hectare
Mid November to end December according to the subsidence of the river	Removal of cover, holing, sowing and re-covering (1.2 x 1.2 m. pockets)	11
10 days after sowing	Hoeing	20
Mid February - Beginning April	Maintenance	48
April	Harvest, transport	6
	TOTAL	75

Yields are 400 to 500 kg. per hectare; they could be improved slightly (seed processing, closer in line). At all events, these crops are still very vulnerable to onslaughts by birds which, in the dry season, concentrate on these oases of green.

II. POTENTIAL

A marked intensification of production cannot be guaranteed in traditional farming, by reason of the uncertainties of climatic and flood conditions.

Agricultural production must thus be mainly based on irrigated farming.

The following crops can be taken, on the basis of past and current experience, as suitable for "large scale" farming.

On Hollaldé soils: rice, wheat, tomato, sorghum and sugar cane.

On Fondé soils: wheat, tomato, corn, sorghum, niébé, fodder, sugar cane and possibly rice, which grows well if it is watered sufficiently.

As a first step, one should concentrate essentially on cereal crops, which are the basis of food supply for the local inhabitants, and are generally in overall deficit for the region as a whole.

2.1 Rice: This is the most "popular" crop, and the one on whose development most emphasis should be placed.

2.11 Varieties and yields

Varieties with an average growth cycle of 125 to 140 days and fast-growing varieties (95 to 120 days) can:

- reduce pumping,

- avoid the cold at the beginning of the cycle,

- free more time for preparing soil and harvesting.

7 to 9 tons per hectare are grown in the station in the rainy season and 8 to 10 tons per hectare outside it. The main varieties sown at present are IKP (1 Kong Pao), TNI (Taichung Native 01), Kwang she Sheng, IR 1561.228.3, IR8, Jaya, TTW (Thin Thou Way); in the long-term, the yield to be expected from careful individual farming is 6 to 8 tons per crop with replanting.

2.12 Sowing

80 to 100 kg. of seeds cast or machine-sown are required per hectare. They are extremely vulnerable to attack by birds and weeds, and smoothing must be perfect.

Replanting takes 40 to 90 man/days of work per hectare; the complete cycle from sowing in the nursery takes 5 or 6 days more. Nursery gardens account for approximately 200 to 250 sq. meters per hectare farmed; they must be carefully cultivated and are extremely sensitive to cold; the simple "Dagpog" technique which consists of a plastic-sheathed breeze-block produces plants ready for replanting within 15 to 20 days; its advantage is that it limits nursery space to 20 sq. meters per hectare, yields flexibility of the agricultural calendar, is well protected against birds, supplies homogeneous plants and, in some instances, limits damage to nurseries caused by the cold in December and January.

2.13 The Agricultural calendar

Yields and harvest dates are the same in the dry season, whether the field be sown in November, December or January. There is thus no need to sow before end January; however, late sowing delays harvesting to beyond the beginning of June, inducing heavy water consumption in the period of low flood and shortening the time for preparing the winter crop. The "Dagpog" technique can be extremely useful for avoiding the cold spells of Jaunary and February in nurseries and in shortening the cycle.

Late sowing in the rainy season (September), (frequent in the light of water shortage and the limited time available to prepare the soil and to receive supplies), subjects the rice in full growth to the November cold, which lowers yields considerably; hence, rice should have been planted by the end of July.

2.14 Farming methods

Yields can be affected by the invasion of weeds and the attacks of borers in the rainy season, by lack of water (water-stress) and by heat waves in the dry-hot season.

Smoothing must also be performed with accuracy (+ 5cm.). This can only be done on small tracts, the more so as scraping uncovers very poor soils and pseudogleys, whose defects can be remedied rapidly as regards rice farming, with additional fertilizers, but take several years to eliminate under other crops (e.g. wheat, corn, fodder crops).

2.15 Fertilizers can be provided for as follows:

Nitrogen: 45 kg. of nitrogen are used per hectare for long straw varieties (type D5 237). With full control over water, doses of 90 to 120 kg. increase yields, but a late excess of nitrogen delays growth and lowers production. The bottom urea should be covered with earth before replanting, similarly to the top urea at time of suckering and of the rising.

Phosphorus: The soils are poor in assimilable phosphorus, but the response to phosphatic fertilizers does not appear clear; doses of 30 to 50 kg. of P2 05 per hectare seem reasonable.

Potash: (potassium carbonate): The response is even less marked than for phosphorus. The soils seem to be well enough supplied during the first few years.

2.2 Wheat

Although it has long been known in the OMVS countries, wheat has not been subjected to thorough research in the Senegal valley since 1966 (IRAT - Richard Toll) and, above all, 1969 (OMVS/FAO) at Guédé.

2.21 Varieties

52 varieties of wheat were tested in full-scale cultivation and 436 in farming trials.

The Mexipak (Triticum aestivrum SP. Vulgare) with a 105 day cycle can be taken as the basic variety. In 1975/76, yields varied from 2.5 to 6 tons per hectare; a weight of 1,000 grains: 43 to 47 g., with a volumetric weight (density) of 79 to 85.

Other varieties, which are basically of Mexican origin, can compete with Mexipak: Inia "S" - ON X Inia - BD, has a better yield but is more vulnerable to birds, Nor. Ono X Jar, Inia Bd; mediterranean varieties can also be mentioned: SA-42, which is an early variety with a 90 day cycle and Chenab - 70.

Triticales, cross-breeds of wheat (triticum) and rye (Secale), were also tested. They resist diseases (blight, mildew and septoriosis) and can be grown on acid and alumina soils; triticales yields are higher than for wheat on light, but lower on heavy soils. The baking quality of their flour, however, is not yet fully satisfactory.

2.22 Farming methods

The Fondé soils are the best. Their yield exceeds that of the soils in between Fondé and Diéri by 15 to 20% and that of the Hollaldé soils by over 40%.

Wheat reacts well to a previous rainy season crop farmed on a clean field (corn), a vegetable crop (niébé, beans), or a fodder crop. A 30 to 40 days' rest is nevertheless necessary to ensure decomposition of the vegetable substances.

The most appropriate dressing seems to be by scarification (disk-ploughing after a vegetable crop) followed by 2 passages with the rotovator and one with the levelling blade in order to obtain perfect smoothing, which is the precondition for success, wheat being very sensitive to excess water during rising and suckering.

The fields must be sown between November 15th and December 10th to draw benefit from the cold spells from December to February; a sowing density of 160 kg. per hectare should yield 600 ears per m^2 after suckering.

Weed killers used on the previous crop which leave a clean surface make it necessary to apply another dose. However, cyperacea should first have been limited.

Plantations are endangered by rats and, in particular, by birds, especially when fields are lightly sown.

2.23 Fertilizing: the best-adapted manure contains 140 kg. of nitrogen (bottom and top fertilizer when suckering and rising and after earing), 80 kg. of phosphorus and 60 kg. of potash as a bottom fertilizer.

2.24 Irrigation: must guarantee permanent water reserves in the soil, but without excess: weekly doses of 500 cubic meters per hectare seem to be the best ration.

2.3 Corn

The variety is already widely grown in Africa as "Maka"and is grown during both the rainy and out of season.

2.31 Varieties and yields

Local "Maka" populations provide yields of the order of 3 tons per hectare in the dry, hot or cold counterseason and in the rainy season.

The hybrids Appolo 125 and 136, from Italy, are appropriate for the dry-cold and hot seasons, as well as two Indian hybrids, Ganga and Safed, whose yields can exceed 5 tons per hectare.

Composite varieties have the advantage of producing seeds for 5 to 6 generations, whereas hybrids' seeds must be renewed every crop year. The results are almost as good as those of the best hybrids: 4.3 tons per hectare in the dry-cold season, 2.8 to 4.7 tons per hectare in the dry-hot season, and 3.3 tons per hectare in the rainy season. The following composites can be mentioned: Katumani, Penjalinan, Early Thai (IRRI), CPS Bouaké; Indian composites: Kisan, Hunis, Diara ; Nigerian: SC N2,3, NCB and NLA, with 80 day cycles in the rainy season, 120 days in the dry-cold season and 95 days in the dry-hot season.

2.32 Farming methods

Fondé soils are the most suitable for growing corn; plants suffer from excess water in Hollaldé soils; by contrast, in transition soils between the Fondé and Dieri types, there is waterstress and further problems are caused by termites. A vegetable crop (niébé, beans) is a good preparatory crop but corn can be grown two or three times on the same plot.

Recommended practise is to work the soil by disk ploughing to a depth of 15 cm. to bury vegetable substance, followed by a passage with the levelling blade and the furrowing machine.

The best fertilizer is bottom manuring - N26, P2 05 80 - K60, followed by three 45 kg. nitrogen spreadings when suckering, at rising and after flowering.

The optimum dates for sowing appear to be between October 20th and November 20th in the dry-cold season, January or the beginning of February in the dry-hot season (there is extreme vulnerability to the harmattan wind from April, especially on the edges of plots, and the end of June in the rainy season, which enables plants to resist grasshoppers and shamsh fly in September and to free the land for preparation of the soil.

Sowing can be performed manually on the side of furrows or on the flat with a disk-fitted seeding machine if the plot is very well smoothed, with a density of 60,000 to 70,000 plants per hectare in the dry-cold season and 55,000 plants per hectare in the dry-hot season.

Cyperacea lower yields considerably. They can be killed with Glyphosat, but this depresses the growth of the corn, Thus, similarly to wheat, the most suitable treatments are those performed in the inter-crop periods.

Water requirements are 800 to 900 mm. in the dry-cold season, but exceed 1,300 mm. in the dry-hot season. They fall to 600-800 mm. in the rainy season, according to rainfall.

Corn is liable to attack by parrots and turtle-doves. Thus, varieties with a cob sheathed with long kafs must be grown in priority. Borers and night pests can do great damange in the rainy season.

2.4 Sorghum

2.41 Varieties and yields

The local varieties are a selection by the traditional populations of the valley, and should be the first to be extended. They are: SD-10, RT 13, RT 35, RT 50, White Guédé, IRAT-13, IRAT II in the dry-hot or cold season. Yields exceed 3 tons per hectare and can increase to 6 tons per hectare. The most appropriate varieties in the dry-hot season are IRAT-13, IRAT-11 and L63-18.

Non-photosensitive hybrids are often short, with yields exceeding 4 to 5 tons per hectare; most of them come from the USA: NK-280, C42Y, C43Y, W 823.

2.42. Farming methods

Fields are ploughed 20 to 25 cm. deep by reason of the depth of roots. The recommended fertilizers are : N140, P2 05 and K 60.

The best dates for sowing are: end of October, beginning of November for the dry-hot season and in the second fortnight of June for the rainy season crop.

Sowing must be executed so as not to exceed 75,000 plants per hectare. Sorghum needs less water than corn for irrigation: 5,000 m³ in the dry-cold season and 6,000 cubic meters in the dry-hot season.

The most intractable difficulty (which has not yet been overcome) is the damage done by birds in the dry season.

2.5 Fodder Crops

The following varieties underwent testing at Guédé for several years: Brachiarias, Pennisetum, fodder sorghum and stylosanthesis.

2.51 Brachiarias

Three types of brachiarias were experimented with at Guédé, and proved to grow well in the valley, but seem to be somewhat sensitive to cold:

- Brachiarias mutica: flat replanting with a 40 x 50 cm. spacing. It is cut every three months in the cold season, every two months in the hot season, with yields of the order of 100 tons per year (22,000 Uf); this fodder grows well on heavy soils, is resistant to long submersion and can be planted in basins which are difficult to develop. It is appreciated by animals but tends to invade other fields.

- Brachiarias Brizantha and Ruziziensis: these are dry-hot season and rainy season fodder, rather less savoury to animals, but which can be eliminated by simple ploughing in a rotation. Annual yield: 70 to 80 tons per hectare (2,000 to 15,000 UF).

2.52 Pennisetum

Three varieties of pennisetum purpureum have been tested: red collet, white collet and kizozi.

The pennisetum plant grows well on the heavy valley soils. It flourishes under high humidity and stands up to submersion of several days. It suffers a blockage of the cycle between November and March; and is refused by 10 to 20% of animals, especially if offered earlier cuttings.

It is planted along furrows with a 0.8 x 0.4 meter spacing; it takes 200 days from the placing of spacings to the first cutting. Thereafter, 6 harvests per year yield more than 120 tons of fodder per hectare (15,000 UF); the yield can exceed 200 tons (Kaédi).

2.53 Panicum maximum

This is a high yielding graminaceous plant (100 tons per hectare). It is well adapted to heavy soils with a low moisture content, and is enjoyed by animals, which eat the full plant. Rapid planting on furrows as for pennisetum.

2.54 Fodder Sorghum

Except for Sudan Grass which is already well known, a dozen other varieties were tested. The results show that Trudan, Velvet Sorghum and Columbus grass are suitable and provide the best yields with 100 to 120 tons per hectare. Cutting may be performed 5 or 6 times a year without difficulty (approximately 15,000 UF per hectare).

The advantage of fodder sorghum is that the plant is well known in the valley, is easy to grow and provides good yields all year round.

2.55 Stylosanthes

Stylosanthes gracilis, which is a perennial vegetable crop, has been undergoing tests successfully for the last few years. The climatic conditions are conducive to its growth, except in the cold season, when it slows down slightly. The yields are high; they can reach 50 tons per cutting at the end of the dry season, a time when fodder is very scarce.

Stylosanthes hamilis, which is an annual vegetable crop, yielded average results at the end of the winter season (30 tons per hectare).

2.6 Sugar Cane

Sugar cane has been planted for several years on the Richard Toll perimeter; however, yields are low, of the order of 80 tons. 8 to 10% of the sugar grown is lost by reason of acute problems of salt drainage.

Partial tests were undertaken at Kaédi on Fondé soil; it is too early to draw conclusions, but it is already estimated that yields could reach 200 tons per cutting in the station and more than 100 tons when grown by farmers, i.e. approximately 10 tons of sugar per hectare.

2.7 Other Crops

Barley and oats could be developed in the future.

In addition, truck gardening crops can be grown everywhere in the dry-cold season. The Niébé plant with a very short cycle is well known by farmers and can always be grown to supply food proteins and fodder.

ANNEX D

GROUND WATER RESOURCES IN MAURITANIA

The purpose of this short note is to give a rapid (and partial) picture of the ground water resources of Mauritania's coastal sedimentary basin. It will also mention possible projects for the use of these deposits.

I. CHARACTERISTICS AND AVAILABILITY OF WATER IN THE COASTAL SEDIMENTARY BASIN

The water tables of the basin cover an area close to 100,000 sq. kms. and there is continuous hydraulic circulation within the permeable formations. This is in fact a single underground water table for the basin as a whole, and it is drawn upon at 2,500 waterholes.

Unit flows vary between 20 and 100 cubic meters per hour. Fresh water with a total concentration of less than 1gr/l can be found almost everywhere, except in the coastal zone, where it is salty.

The piezometric surface to the East touches the old base, which rises by cropping out, and sets a sharp angle on the eastern contour line of the basin.

The water tables to the South are the continuation of the Senegal river alluvial sheet, which supplies a certain amount of replenishment water.

Three water bearing strata with slightly different hydrogeological characteristics can be distinguished :

A - The water table of the Trarza Mio-Pliocene continental terminal

- covers the 3/5ths of the basin;
- circulates in the Mio-Pliocene sands and clay sandstone, partitioned by a series of clay layers;
- the thickness of the formation varies between 10 and 200 m.;
- there are two water bearing levels;
- the river feeds the sheet, but only influences a few kilometers;
- it is drawn upon most;
- unit operating flows vary between 15 and 100 cu. meters per hour;
- water temperature is 25 to 30°;

- dry residue is below 500 mg/l;
- water containing sodium chloride (common salt) with dominance of Ca over Mg.;
- piezometric level -5 to -60 m. below sea level;
- depth of the water table: - 40 to - 80 m. below the surface;
- water table seems under stress at some levels because of the presence of local clay spots;
- the water table was formed 8,000 years ago.

B - The water table of the Amechtil Eocene dolomitic limestone system

- follows the previous sheet to the East and flows through fissures in the limestone;
- its hydraulic characteristics are less satisfactory: flow rates are lower and salinity higher (0.6 to 2g/l);
- it is drawn upon by approximately 100 wells.

C - The Brakna Eocene sands

- to the East of the Amechtil sheet;
- Eastern border set by the sharp angle caused by the rising of the old base;
- good permeability;
- fresh water: 0.5 g/l. except in the neighbourhood of the substratum;
- drawn upon by 200 wells;
- water may be found at a depth of 30 to 40 m., except in the North where the deposit is 60 m. below the surface;
- it is a free water table whose piezometric surface is "hollow" in form;
- it is also believed to be fed by alluvial water from the river and streaming from the Eastern boundary.

Remark: The aspect of the coastal eocene terrain varies laterally: to the West Trarza, the soil is basically clay below the Continental Terminal formations; then, it becomes calcified and dolomitic with intermittent clay in the Amachtil; finally, the Eastern side is basically sandy (Brakna).

D - Reserves

The total reserves of the water table are believed to be approximately 100 billion cu. meters, based on a useful depth of 20 m. and a 5% coefficient of porousness.

The flow in use at present is 40,000 cu. meters per day, i.e. 146 million cu. meters per year, which is small compared with the reserves and with the present water supply originating from the alluvial table, whose flow has been estimated at 15 million cu. meters. per year.

The presence of Maestrich lands has been ascertained below these tertiary formations. This subsoil formed by azoic sand-clay changes in aspect on either side of the lake R'Kiz "dorsal ridge", which is to a Karst elevation of the base.

- East of the dorsal ridge, the base forms a plateau which is in contact with the boundary outcrops. The sediment deposit to the East varies in thickness between 100 and 200 meters.

- To the West, the base has sunk rapidly through the effect of tectonic accidents. The thickness of sediment deposits varies from 100 meters to several thousand meters.

The Maestrichtian subsoil is believed to be clayey at the level of the dorsal ridge, and sandy or clay-sandy on either side of it.

A systematic survey has not yet been undertaken, but work in the R'Kiz region has yielded the following data:

- limited flow on the dorsal ridge;

- to the West, 150 to 300 cu. meters per hour with a salinity content of 0.7 to 1.4 g/l;

- East, equivalent salinity, but lower flows because of the clayey nature of the Maestrichtian formation;

- North, the sands are thick and the initial samples at Idini indicated a salinity ratio of 17g/l.

II. EXISTING BORINGS

There are 56 borings at present in Mauritania, which are non-operational:

- 11 were equipped as of 1975 but are not working because of lack of operating means. A request for funds for two years has been submitted for 19 million MU: (10 million for machinery, 6 million for lubricating oil and 3 million for personnel);

- 25 are ready to be fitted with pumping equipment in 1979-80, these are mainly located along the Nouakchott-Kiffa highway;

- 20 are to be installed and the corresponding credits are sought (the equipment for each boring is estimated to cost 5 million MU).

Most of these borings (as well as providing water for human and pastoral consumption) can be used to irrigate crops, as their operating rate of flow is below 30 cu. meters per hour.

Their distribution is uneven; almost, three out of every four draw upon the water bearing tertiary south-western subsoils.

III. SHORT-TERM PROGRAMME

- A programme for 10 operating bore-holes in the Tamourt en Naaj (Tagant region) should begin in 1980 (SONADER).

- A programme for 10 operating bore-holes in the western region of the Hodhs for dam work requirements. They will then be used on the basis of their characteristics (SONADER).

- A programme covering 40,000 m. of drilling and boring between Kiffa and Nema for use by road work sites (70 to 120 sites projected). This activity began in July 1979 and will be completed before end 1980. (MENDES-SNIM-SASIF).

After the roads have been built, their possible use will be determined on the basis of their characteristics, taking the natural environment into consideration.

- A programme of 40 bore-holes to be drilled using the boring equipment of the Hydraulics Directorate (Failing).

Financing sought.

ANNEX E

THE SENEGAL RIVER AND THE OMVS DEVELOPMENT

I. GENERAL GEOGRAPHIC DATA

The total length of the Senegal river is 1,800 km. It rises in the hills of the Fouta Djalon in Guinea, where rain falls copiously, and after crossing the western section of Mali, constitutes the boundary between Mauritania and Senegal over a length of 800 km. It flows into the Atlantic ocean at St. Louis.

The valley between Bakel and Rosso is an alluvial plain through which the river meanders, with a network of branches and derivatives. Each year, during the rainy season, from July to October, the downstream movement of the floodwater raises the river out of the minor bed, which is 200 to 400 m. wide, to cover large zones over a width of 15 to 25 kilometers. Three types of zones can be distinguished :

- The "Fondés" which are rises on the riverbank and rarely flooded.
- The "Oualos", which are clay basins flooded every year, extended by whole network of tributaries.
- The "Diéri", which are located on the limits of the valley, outside the flooding zones.

From Rosso to the sea, the river spreads over a great delta covering more than 400,000 hectares of flat and swampy land.

The river bed gradient is very low in the delta and lower valley (less than 1 cm. per km.); as a result, the influence of the tide extends beyond Boghé, 400 km. from the estuary.

II. DESCRIPTION OF THE FLOW

The water, which is of excellent chemical quality, originates almost exclusively in the Upper Guinea and Malian basin; at Bakel at the head of the valley, the average annual flow is 23 billion cu. meters which corresponds to an equivalent permanent rate of flow of 740 m^3 per second - but with major annual fluctuations and periodic dry cycles of several years.

The river's flow pattern lags from one to three months behind the rainfalls on the Upper Basin. The flood arrives at Bakel at the end of June and reaches its maximum rate of flow around September 10th with an average discharge of 7,000 m^3/second. The delta is flooded only at the beginning of August and the water level reaches its peak at the end of October, followed by the subsidence of the river until February when the flow declines to as little as 50 cu. meters per second, which corresponds to the draining of the major bed. From March until June, the level remains very low and the flow sluggish or even non-existent, fed only by underground springs.

From January to end of July, a "salt tongue" rises 200 km. through the delta and the lower Senegal valley. The water rises perceptibly during the flood season: the difference between flood and low water level is 4 to 5 m. in the delta and lower valley, 8 to 9 m. in the middle valley from Boghé to Matam and over 10 m. in the upper valley.

III. HYDRO-AGRICULTURAL DEVELOPMENTS

These are located the length of the valley and delta; as a general rule, they must be protected against floods by an endykement and supplied with pumped water.

IV. OMVS (Senegal River Development Organisation) STRUCTURES

These are multi-purpose structures, their main functions being:

- regulation of the flow to irrigate several hundred thousand hectares all year round;
- electricity output;
- improvement of navigation from St. Louis to Kayes.

A general reconnaissance of dam sites has been carried out in the upper basin of Guinea and Mali. In the long-term, the flow of the Senegal river could be regulated to 550 cu. meters per second with an electricity output of close to 3 billion KWH.

4.1 As a first stage, the Manantali site has been selected by the OMVS. This dam, installed on the Bafing in Mali, is a regulating dam whose reservoir capacity will be some 10 billion cu. meters and whose basic functions are to :

- guarantee a flow regulated at Bakel to 300 cu. meters per second;
- produce 800 KWH of electricity, with a guaranteed power of 100 MG;
- smooth peak flood levels, reducing the centennial level to the current decennial elevation.

After completion of the dam, which is scheduled for the second half of the next decade, it will be possible to irrigate an additional 300,000 hectares to be harvested twice annually.

4.2 The Diama dam

This is located 26 km. upstream from St. Louis on the mainstream of the Senegal river. It is submersible during the floods, of the "mobile" type, whose role is to raise the upstream water level to elevation 1.5 meters, and possibly later to 2.5 m., in order to:

- stop the incursion of the "salt tongue";

- create a reserve of water upstream (250 million cubic meters at elevation 1.5 m. and 580 million cubic meters at 2.5 m);

- improve the filling of the tributaries in the lower valley and the delta, including, on the left bank, lake Guiers and the Goroun-Lampsar axis. The eddy currents caused by the dam will rise to thresholds at:

  . Demet beyond Boghé, 400 km. from St. Louis, for level 1.50 m.

  . Vinding at the source of the Doué, approximately 500 km. from St. Louis for level 2.50 m.

This dam is thus of interest to the whole of the delta and lower valley, which contain approximately 280,000 hectares of irrigable land. Close to 25,000 hectares in its zone of influence will be irrigated all year round.

Work on the site was to begin at end 1979, and the entry into service of the project is scheduled for 1983.