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# WEST AFRICA FERTILIZER STUDY

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Prepared for

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by West Africa Study Team
International Fertilizer Development Center

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
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Volume I Regional Overview
Volume II Senegal
Volume III Mali
Volume IV Upper Volta
Volume V Niger
Volume VI Chad
Volume VII Mauritania

# PREFACE

A series of severe droughts in the late 1960's and early 1970's greatly reduced agricultural production in the Sahelian countries of west Africa. The human suffering during that time led to an international focus on the region in terms of food aid and development assistance.

The U.S. Agency for International Development (USAID) was aware of the contribution of fertilizers to food production and the limited fertilizer use in this region. Thus, USAID requested the International Fertilizer Development Center to determine the current capacity and potential of the Sahelian region to produce, market, and use fertilizers. This series of documents is a result of that assessment. Published and unpublished literature was obtained in each country and from international development agencies. Field level interviews were also conducted.

Principal team members were Ray B. Diamond (team leader), Donald R. Waggoner, and Kham Thanh Pham from IFDC along with Hans Braun on loan from FAO. Many other members of the IFDC staff contributed greatly to the report. Bernard Raistrick (consultant from the United Kingdom) and Travis P. Hignett (consultant from the United States) assisted in preliminary collection and analysis of data before the field visits. Josiah Royce (USAID, REDSO/WA) assisted in data gathering during field visits. Appreciation is expressed to representatives of national agencies, USAID, and other international organizations for assistance.

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# ABBREVIATIONS USED IN THIS REPORT

## FERTILIZERS

N . . . . . Nitrogen
P . . . . . Phosphorus
$P_2O_5$ . . . . . Phosphate
K . . . . . Potassium
$K_2O$ . . . . . Potash
B . . . . . Boron
$B_2O_3$ . . . . . Borate
Ca . . . . . Calcium
S . . . . . Sulfur

## Fertilizer Formula - % of $N\text{-}P_2O_5\text{-}K_2O$ by Weight

AS . . . . . Ammonium Sulfate (21-0-0)
DAP . . . . . Diammonium Phosphate (18-46-0)
KCl . . . . . Potassium Chloride (0-0-60)
KS . . . . . Potassium Sulfate (0-0-50)
PR . . . . . Phosphate Rock
SSP . . . . . Single Superphosphate (0-20-0)
TSP . . . . . Triple Superphosphate (0-45-0)
U . . . . . Urea (45-0-0 to 46-0-0)

## MEASURES

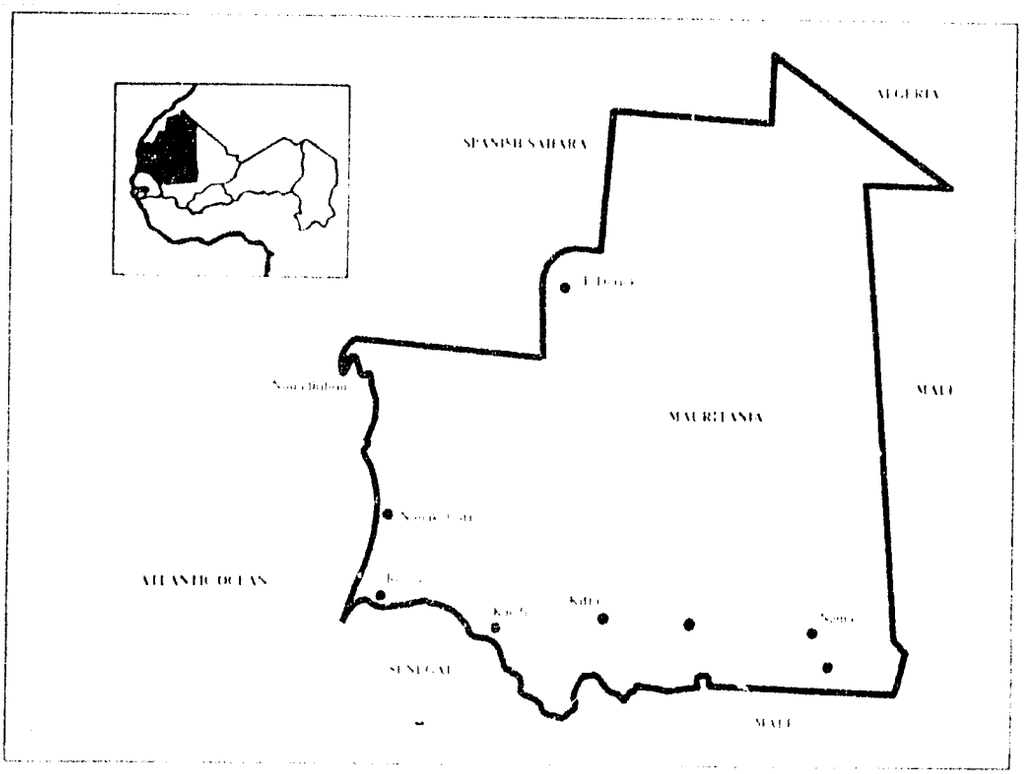
ha . . . . . hectare (2.47 acres)
kg . . . . . kilogram (1 pound = 0.454 kg)
km . . . . . kilometer (1 mile = 1.61 km)
mm . . . . . millimeter (1 inch = 25.4 mm)
mt . . . . . metric ton (2,204 pound = 1,000 kg)
% . . . . . percent

## ECONOMIC AND MONETARY

c.i.f. . . . . cost, insurance, and freight
f.o.b. . . . . free on board
GDP . . . . . gross domestic product
UM . . . . . Ouguiya (US $1 = 45 UM)

## GOVERNMENTAL AND INTERNATIONAL AGENCIES

ACPO . . . . . Accelerated Crop Production Officer
ARIDIS . . . . . Firm at Nouakchott dealing with the supply of agricultural inputs including fertilizer
BEPA . Bureau of Development for Agricultural Production
BMD . . . . . Mauritanian Development Bank
BRGM . French Bureau for Geological and Mining Research
CEEMAT . . . . . Center of Studies and Experimentation of Mechanized Tropical Agriculture
CIDA . . . . Canadian International Development Agency
CNRA . . . . . National Agricultural Research Center
FAC . . . . . Development Aid Agency of the French Government (Fonds d'Aide et Cooperation)
FAO . . . . . Food and Agriculture Organization
FED . . . . . European Development Fund
GEOMINE . . . . . A company of Rumanian origin
GOM . . . . . Government of Mauritania
IBRD . . . . . International Bank for Reconstruction and Development
ICPISAT . . . . . Institute for Crop Research in the Semi-Arid Tropics
IFAC . . . . . French Research Institute for Exotic Fruits
IFDC . . . . . International Fertilizer Development Center
OMVS . . . . . Organization for the Development of the Senegal River Basin
PPM . . . . . Party of the Mauritanian People (Parti du Peuple Mauritanien)
SAT GRAD . . . . . Semi-Arid Food Grain Research and Development
SEAF . . . . . Secretariat of State for Foreign Affairs in Charge of Cooperation (French)
SIES . . . . . Company of Fertilizer Industry of Senegal
SOGEA . . . . . Firm at Nouakchott dealing with the supply of agricultural inputs including fertilizer
SONADER . . . National Company for Rural Development
SONIMEX . . . . . National Import-Export Company
SNIM . . . . . National Company of Mining Industry
SSEPC . . . . . Senegalese Fertilizer and Chemical Products Company
TVA . . . . . Tennessee Valley Authority
UNDP . . . . . United Nations Development Program
USAID . . . . . United States Agency for International Development




## SUMMARY OF FINDINGS

1. The series of droughts in the late 1960's and early 1970's drastically reduced millet and sorghum (the staple foods) production in Mauritania.

2. Cereal imports reached 133,000 mt in 1974. Average cereal demand is projected to increase by 5,100 mt/year between 1975 and 1980 and 6,100 mt/year between 1980 and 1985. Increased urban demand will account for about 25% of the increases.

3. If only predrought levels of production are reestablished, even in years of good rainfall, cereal deficits could reach 72,000 mt in 1980 and 103,000 mt in 1985.

4. Mauritania has initiated a number of development projects. Some constraints on production are low levels of fertilizer use, mechanization, improved seed and other improved technology, and insufficient availability of credit and markets.

5. Agronomic research data is very limited in Mauritania. To some extent the results obtained by the Richard Toll Station in Senegal on the left bank of the Senegal River have been extrapolated for application on the Mauritanian bank of the river.

6. Very little agronomic work has been done on farmers' fields, and much more is needed.

7. Estimated fertilizer nutrient consumption in 1975 was 250 mt and was projected to reach about 3,600 and 5,000 mt in 1980 and 1985, respectively.

8. PR reserves of 5 million mt are known to exist in the Kaedi-Aleg-Boghe triangle and the Taoudni basin but need evaluation of the agronomic value and cost of production to define the economics of its use for direct application.

9. The present and planned transportation network appears adequate for moving increased quantities of fertilizer to the more populated areas in the near future if adequate maintenance is performed.

## RECOMMENDATIONS

1. Initiate a study of the effect of public policies for price stabilization and equalization for agricultural inputs and crops on regional and national economies.

2. Conduct an in-depth analysis of social costs and benefits from expanding land area in production as compared with increasing productivity per unit of land.

3. Conduct a study to assess the status and needs of extension, credit, and crop marketing institutions.

4. Conduct a study to identify ways to improve agricultural statistical reporting.

5. Begin a concentrated soil fertility project in liaison with current research and extension groups designed to obtain relevant information for crop response to fertilizer nutrients including indigenous PR on small- and medium-sized farms.

6. Conduct a detailed survey of the known phosphate deposits and estimate cost of producing ground PR for direct application.

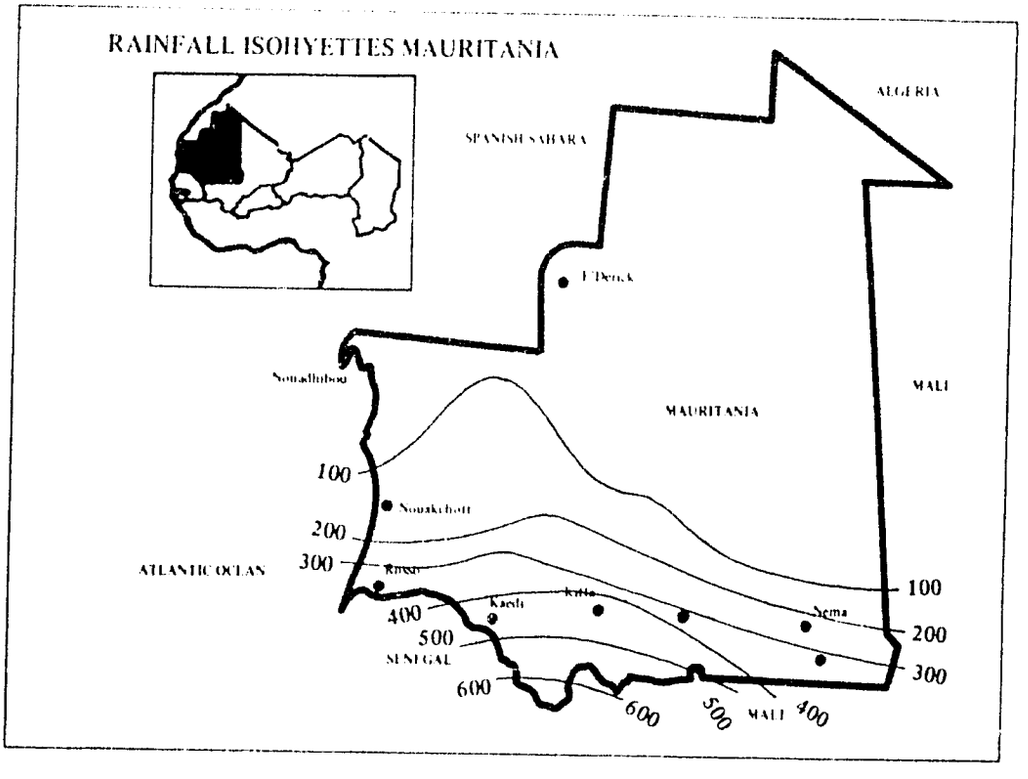
# INTRODUCTION

Mauritania is located between 16° and 25°N latitude and 5° and 16°W longitude. Total land area is 1,030,700 km² (397,954 mi²). Most of the country lies in the Sahelian desert zone. It is bordered on the north by former Spanish Sahara and Algeria, on the east by Mali, on the south by Senegal, and on the west by the Atlantic Ocean. The population was estimated at 1.3 million in 1975. Nouakchott, located on the coast, is the capital city and had a population of 55,000 in 1975. Kaedi, located on the Senegal River, is a major trading center.

## Physical Characteristics

Mauritania is a mountainous block of Sahara fronting the Atlantic. The climate is generally hot and dry, moderated by breezes on the coast. Like other Sahelian countries, great variations in annual rainfall and uneven seasonal distribution are encountered. The southernmost point of the country, Selibabi, receives an average annual rainfall of 635 mm. Crop production is limited to the area south of the 300-mm isohyet. This permits farming only in the valley of the Senegal River and scattered oases.

Soils of the agricultural zone can roughly be grouped into two categories: (a) the heavy alluvial and seasonally flooded soils on the Senegal River bank and along its tributaries, the Gorgol River and (b) the ferruginous tropical soils that have a high sand component and



are poor in clay and organic matter, except in depressions which may be seasonally flooded (1, 2, 3).

## Political and Cultural Characteristics

Mauritania became an independent republic in 1960. Executive power is held by the President and his Cabinet of Ministers. Legislative power belongs to the National Assembly which must approve the national budget.

Mauritania is one of three Sahel-Sudan states that had a civilian regime in 1979. The dominant party is the Party of the Mauritanian People (PPM).

The population is about 1/3 Moor (Arab/Berber), 1/3 Negroid, and 1/3 mixed Moor-Negroid. Almost all of the population is Moslem. French is the official language and Arabic the major trade language. Most of the Moors are nomadic pastoralists. Sedentary farmers are concentrated in the area of rainfed agriculture.

## Economic Characteristics

In 1974, Mauritania's GDP was estimated at $500 million (4).

Approximately 90% of the population currently derives its livelihood from agricultural activities. Two agricultural products, dates and gum arabic, are produced for the export market. Approximately 70% of the agricultural sector is engaged in raising livestock, an endeavor which accounts for about 10% of the annual GDP. The main activity in Mauritania's industrial sector is iron ore production. The production of iron ore accounts for approximately 90% of Mauritania's export earnings (5). Mauritania hinges much of its economic future on rich, hardly touched deposits of iron and copper.

Primary economic indicators suggest that the economy is developing. Mauritania has consistently had a balance-of-trade surplus. Both imports and exports have increased significantly in recent years: exports have increased by 132% and imports by nearly 300% since 1970 (6). In 1973 Mauritania left the Franc zone of the African Financial Community and introduced her own currency, the ouguiya (UM, from "monetary unit") issued by the Central Bank and guaranteed by Arab states (7). National budgets have tended to be balanced.

**Table 1. Estimated Population and Growth Rates in Mauritania (6)**

| Section of Population | 1970 | 1975 | 1980 | 1985 | 1990 |
|---|---|---|---|---|---|
| Total, 1,000 persons | 1,171 | 1,330 | 1,518 | 1,743 | 2,010 |
| Rural, % of total | 90.5 | 89.0 | 87.3 | 85.5 | 83.6 |
| Growth rate, preceding 5 years | | | | | |
| Total, %/year | - | 2.6 | 2.7 | 2.8 | 2.9 |
| Rural, %/year | - | 2.2. | 2.3 | 2.4 | 2.4 |
| Urban, %/year | - | 5.6 | 5.6 | 5.6 | 5.5 |
| Growth rate of active population, preceding 5 years | | | | | |
| Total, %/year | - | 2.2 | 2.2 | 2.3 | 2.4 |
| Rural, %/year | - | 1.7 | 1.7 | 1.7 | 1.7 |
| Urban, %/year | - | 5.7 | 5.3 | 5.3 | 5.4 |

## POPULATION AND FOOD NEEDS

### Population

The country's population is estimated at 1.3 million in 1975 (table 1). The population growth rate has been estimated by various sources to be 1.6-2.6%/year, and the rate is increasing with time. FAO estimates the growth rate at 2.6% in 1975 and projects it to increase to 2.9% by 1990. About 9% of the population was rural in 1960. This had slightly decreased to about 90.5% in 1970 and 89% in 1975. Estimated distribution of population by region for 1972 is shown in table 2.

Estimated population distribution by age group for 1970 is shown in table 3. Approximately one-half of the population is between the ages of 15 and 59. Mauritania is a sparsely populated country; its density is only 1.1 person/km$^2$. Only two regions have a population density greater than two persons/km$^2$.

### Total Food Requirements

Food requirement projections are based on FAO data (6). Food requirements were projected through 1990 using two methods (tables 4 and 5).

One projection (I) assumes that average per capita private consumption levels will remain constant and predicts increases based on population changes. The other projection (II) includes elasticity of demand changes based upon a 1% annual increase in per capita food expenditures and consequent preference changes in food purchases. Neither projection, however, differs much in magnitude from the other.

Table 2. Estimated Distribution of Population of Mauritania by Region, 1972 (7)

| Region | Chief Town | Population, 1,000 | Density, No./km$^2$ |
|---|---|---|---|
| I | Nema | 190 | 1.1 |
| II | Aioun El Alrouss | 99 | 1.7 |
| III | Kiffa | 190 | 4.1 |
| IV | Kaedi | 95 | 6.7 |
| V | Aleg | 210 | 1.6 |
| VI | Rosso | 220 | 2.0 |
| VII | Atar | 89 | 0.2 |
| VIII | Nouadhibou | 29 | 0.9 |
| District | Nouakchott | 48 | 48.0 |

Table 3. Estimated Distribution of Population of Mauritania by Age Groups, 1970 (8)

| Age Group, Years | Population, 1,000 | Population, % of Total |
|---|---|---|
| 0-14 | 530 | 44 |
| 15-59 | 610 | 51 |
| 60 years and over | 60 | 5 |

Table 4. Estimated Levels of Food Consumption for Mauritania (6)

| Commodity | Estimated Consumption, kg per capita/yr[a] | | | | |
|---|---|---|---|---|---|
| | 1970 | 1975 | 1980 | 1985 | 1990 |
| Millet/sorghum | 99.9 | 100.8 | 101.5 | 102.0 | 102.3 |
| Rice | 17.1 | 18.0 | 18.9 | 19.8 | 20.8 |
| Wheat | 14.5 | 15.4 | 16.4 | 17.4 | 18.4 |
| Maize | 3.4 | 3.5 | 3.5 | 3.6 | 3.6 |
| Potatoes | 1.7 | 1.7 | 1.7 | 1.8 | 1.8 |
| Sweet potatoes | 1.7 | 1.7 | 1.8 | 1.8 | 1.8 |
| Yams | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| Beans/peas | 7.7 | 7.8 | 7.9 | 8.0 | 8.1 |
| Vegetables | 1.7 | 1.8 | 1.9 | 1.9 | 2.0 |
| Peanuts | 2.6 | 2.6 | 2.7 | 2.7 | 2.8 |
| Sugar | 21.3 | 21.9 | 22.4 | 22.9 | 23.5 |
| Fruit | 12.8 | 13.3 | 13.7 | 14.1 | 14.6 |
| Meat | 35.0 | 36.5 | 37.8 | 39.3 | 40.9 |
| Fish | 14.5 | 15.1 | 15.7 | 16.4 | 17.0 |

[a]Figures for 1970 are estimated actual consumption, and others are based upon an elasticity of demand.

Table 5. Estimated Food Requirements in Mauritania, 1975-1990 (6)

| Commodity | Estimated Food Requirements, 1,000 mt[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1970 | 1975 | | 1980 | | 1985 | | 1990 | |
| | L | L | H | L | H | L | H | L | H |
| Millet/sorghum | 110 | 132.9 | 134.1 | 151.7 | 154.1 | 174.2 | 177.8 | 200.8 | 205.6 |
| Rice | 20.0 | 22.7 | 23.9 | 25.9 | 28.6 | 29.8 | 34.6 | 34.3 | 41.9 |
| Wheat | 17.0 | 19.3 | 20.5 | 22.0 | 24.8 | 25.3 | 30.3 | 29.2 | 37.0 |
| Maize | 4.0 | 4.5 | 4.6 | 5.2 | 5.3 | 6.0 | 6.2 | 6.9 | 7.3 |
| Potatoes | 2.0 | 2.3 | 2.3 | 2.6 | 2.6 | 3.0 | 3.1 | 3.4 | 3.6 |
| Sweet potatoes | 2.0 | 2.3 | 2.3 | 2.6 | 2.7 | 3.0 | 3.1 | 3.4 | 3.6 |
| Yams | 2.0 | 2.3 | 2.3 | 2.6 | 2.6 | 3.0 | 3.0 | 3.4 | 3.4 |
| Beans/peas | 9.0 | 10.2 | 10.4 | 11.7 | 12.0 | 13.4 | 14.0 | 15.4 | 16.4 |
| Vegetables | 2.0 | 2.3 | 2.4 | 2.6 | 2.8 | 3.0 | 3.4 | 3.4 | 4.0 |
| Peanuts | 3.0 | 3.4 | 3.5 | 3.9 | 4.0 | 4.5 | 4.7 | 5.1 | 5.6 |
| Sugar | 25.0 | 28.4 | 29.1 | 32.4 | 34.0 | 37.2 | 40.0 | 42.9 | 47.2 |
| Fruit | 15.0 | 17.0 | 17.6 | 19.4 | 20.8 | 22.3 | 24.7 | 25.7 | 29.3 |
| Meat | 41.0 | 46.7 | 48.4 | 53.2 | 57.6 | 61.0 | 68.6 | 70.3 | 82.2 |
| Fish | 17.0 | 19.3 | 20.1 | 22.0 | 23.9 | 25.3 | 28.5 | 29.2 | 34.2 |

[a]L is based upon per capita consumption at estimated level of 1970; H is per capita consumption based upon elasticity of demand.

Estimated per capita food consumption in 1970 and the projections for the period 1975-1990 are shown in table 4. Per capita consumption of millet, sorghum, and maize is projected to remain constant while rice and wheat could increase by 16-19% between 1975 and 1990. Consumption of sugar, fruit, vegetables, meat, and fish is projected to increase by about 10%.

Estimated (H) and (L) projections for total food requirements to 1990 are shown in table 5. Consumption of cereals could increase over the 1970 level by 30-45% in 1980; by 49-98% in 1985; and by 77-85% in 1990. Increased requirements for major cereals over 1975 requirements are shown in table 6. The average annual increase needed to meet food demand is 9,100 mt/year for 1975-1980 and 9,100 mt/year for 1980-1985.

**Table 6. Estimated Increased Requirements for Major Cereals Over 1975, Mauritania[a]**

| Food | 1980 | 1985 | 1990 |
|---|---|---|---|
| | - - - 1,000 mt - - - | | |
| Millet/sorghum | 20.0 | 43.7 | 71.5 |
| Maize | 0.7 | 1.6 | 2.7 |
| Rice | 4.7 | 10.7 | 18.0 |

[a]Based upon FAO projections considering elasticity of demand.

## Urban Food Requirements

A distinction between urban and rural food demand is important in analyzing potential food demand. Subsistence-type farming accounts for much of the agricultural production in Mauritania. With large areas of potentially cultivatable land out of production, subsistence-type farming can expand to meet growing rural food demand. In contrast, urban food requirements must be supplied through some form of commercial agriculture (domestic or imports). In Mauritania, the urban sector population is growing at more than twice the rate of the rural population.

Urban food requirements were derived for major cereals using FAO (H) per capita consumption projections and urban population growth rates (table 7). Urban food demand for millet, sorghum, maize, and rice is expected to increase at a rate of 1,200 mt/year during 1975-1980 and at a rate of 1,900 mt/year during 1980-1985. This is the element requiring an intensive effort to supply food requirements.

**Table 7. Estimated Urban Requirements for Major Cereals in Mauritania, 1975 to 1990[a]**

| Food | 1975 | 1980 | 1985 | 1990 |
|---|---|---|---|---|
| | - - - - 1,000 mt - - - - | | | |
| Millet/sorghum | 14.7 | 19.5 | 25.7 | 33.8 |
| Maize | 0.5 | 0.7 | 0.9 | 1.2 |
| Rice | 2.6 | 3.6 | 5.0 | 6.9 |

[a]Based upon FAO projections considering elasticity of demand and assuming an urban consumption pattern similar to the national pattern.

## Cereal Supply Situation

Mauritania has the potential to be self-sufficient in the production of millet, sorghum, and maize, although recently it has depended on growing imports to supply domestic food demand. Its ability to meet the national requirements of rice will depend upon expanding irrigation. About 300 ha/year of newly irrigated land must be brought into production to meet the annual increased requirements of rice (L projections in table 5) if it is assumed that the equivalent of 2 mt/ha of milled rice can be produced.

Table 8. Cereal Supply Situation in Mauritania (9, 10)

| Crop | 1961-65[a] | 1970 | 1971 | 1972 | 1973[b] | 1974[b] |
|---|---|---|---|---|---|---|
| | -Cereal Production, 1,000 mt- | | | | | |
| Total | 98 | 87 | 80 | 54 | 34 | 34 |
| Wheat | <1 | <1 | <1 | <1 | <1 | <1 |
| Rice paddy | 1 | 1 | 1 | <1 | 1 | <1 |
| Barley | <1 | <1 | <1 | <1 | <1 | 1 |
| Maize | 4 | 4 | 4 | 4 | 3 | 3 |
| Millet/sorghum | 93 | 82 | 75 | 50 | 30 | 30 |
| | -Cereal Imports, 1,000 mt | | | | | |
| Total | 57 | 63 | 75 | 83 | 156 | 233 |
| Wheat | 11 | 7 | 9 | 11 | 13 | 19 |
| Rice paddy | 7 | 11 | 17 | 20 | 28 | 32 |
| Other | 33 | 45 | 49 | 52 | 62 | 75 |
| Grain relief aid | - | - | - | - | 53 | 107 |
| | -Cereal Exports, 1,000 mt | | | | | |
| Total | 3 | - | - | - | - | - |
| Other | 3 | - | - | - | - | - |
| | Total Supply, 1,000 mt- | | | | | |
| Total | 146 | 150 | 155 | 137 | 190 | 267 |
| Wheat | 11 | 7 | 9 | 11 | 13 | 19 |
| Rice paddy | 8 | 12 | 18 | 20 | 29 | 32 |
| Maize | 4 | 4 | 4 | 4 | 3 | 3 |
| Millet/sorghum | 93 | 82 | 75 | 50 | 30 | 30 |
| Other | 30 | 45 | 49 | 52 | 62 | 76 |
| Grain relief aid | - | - | - | - | 53 | 107 |
| | -Per Capita Supply, kg/person | | | | | |
| Total | 145 | 128 | 129 | 112 | 151 | 207 |

[a] Average annual rate.
[b] Includes grain relief aid.

The changing cereal supply situation for selected years between 1961 and 1974 is portrayed in table 8. The per capita supply of cereals has ranged from 112 to 207 kg/person since 1970 averaging 145 kg/person for the period. Adjustment for milling of rice and the typical losses gives an average annual supply of cereals of 125 kg/person which is about 20% below the FAO estimated per capita consumption in 1970. However, the apparent mean supply for 1973/74 (table 8) is about equal to the FAO estimated per capita consumption. Statistics for individual years are erratic. However, the trend since 1970 is toward increasing imports. Cereal imports, including grain relief aid, increased to 233,000 mt in 1974.

Estimated food production in the early 1970's was well below the 1961-1965 levels. Total population, however, was 32% more in 1975 than the mean for 1961-1965. Thus, to maintain

the 1961-1965 per capita consumption levels without increasing imports would have required production of 47,000 mt of cereals more than was produced in the period 1961-1965.

If sorghum and millet yields average 400 kg/ha, an additional 118,000 ha under present technology would need to be brought into cereal production. As an alternative, 4,700 mt of fertilizer nutrients, assuming a response of 10 mt of grain/mt of nutrient, could also produce the needed 47,000 mt of additional grain.

The estimated c.i.f. cost of imported sorghum at Nouakchott was 6,650 UM/mt or 313 million UM for 47,000 mt. The imported cost of nutrients is considered to be 16,730 UM/mt or 78.6 million UM for 4,700 mt. While fertilizer use without the appropriate cultural practices would not produce a 10:1 yield response, the difference in foreign exchange requirements between imported food and imported nutrients (313 million UM versus 78.6 million UM) makes increased fertilizer use an attractive alternative in augmenting cereal supply.

It appears that Mauritania can benefit most by increasing crop production through both expanding area in crops and increasing productivity per unit of land. An in-depth analysis of these alternatives would be a useful guide to the government. The study would analyze the social costs and benefits from facilitating a more rapid expansion of area used for agricultural production as compared to increasing productivity by expanded use of improved technology including use of fertilizer.

It is anticipated that cultivated area will be expanded somewhat as a result of increased rural population. The cultivated area in Mauritania can increase through either subsistence or commercial types of farming. Subsistence farming feeds only the immediate population and leaves little surplus for export outside the immediate area. In order to increase agricultural production per worker, greater use of animal traction, fertilizer, and improved cultural practices will be required.

## FOOD PRODUCTION

Agriculture contributes nearly one-third of Mauritania's GDP. The population index has been increasing steadily while indices of total and per capita food and agricultural production have been decreasing since 1969 (table 9).

### Agricultural Policy Institutions

After an administrative reorganization in early 1976, rural development is now concentrated in the State Ministry for Rural Promotion. The Ministry of Planning is concerned with the planning of rural development in the context of general development. Under the State Ministry for Rural Promotion, the Ministries of Rural Development and Water Resources cover the various fields of rural development.

Under the Ministry of Rural Development are: (a) Directorate of Agriculture--responsible for project development and studies, extension services (field staff of 220 persons in 9 sectors), and agricultural training; (b) Directorate of Livestock Production; and (c) Directorate of

Table 9. Indices of Population and Agricultural and Food Production, Mauritania (9)

| Year | Indices[a] | | | | |
|---|---|---|---|---|---|
| | Population | Food Production | Agricultural Production | Per Capita Food Production | Per Capita Agricultural Production |
| 1961 | 96 | 94 | 94 | 98 | 98 |
| 1962 | 98 | 96 | 96 | 98 | 98 |
| 1963 | 100 | 100 | 100 | 100 | 100 |
| 1964 | 102 | 103 | 103 | 101 | 101 |
| 1965 | 104 | 107 | 107 | 103 | 103 |
| 1966 | 106 | 106 | 106 | 99 | 99 |
| 1967 | 109 | 108 | 108 | 100 | 100 |
| 1968 | 111 | 109 | 109 | 98 | 98 |
| 1969 | 113 | 113 | 113 | 99 | 99 |
| 1970 | 116 | 112 | 112 | 97 | 97 |
| 1971 | 119 | 108 | 108 | 91 | 91 |
| 1972 | 122 | 95 | 95 | 78 | 78 |
| 1973 | 125 | 80 | 80 | 64 | 64 |
| 1974 | 128 | 81 | 81 | 63 | 63 |

[a]World--1963 = 100.

Development and Protection of the Agro-Pastoral Sector. Under the Ministry of Water Resources are: (a) Directorate of Water Services; (b) Directorate of Rural Engineering; (c) National Agricultural Research Center (CNRA); and (d) National Company for Rural Development (SONADER) which was recently created to execute agricultural development projects.

Agricultural training at the university level is provided outside the country. The agricultural vocational school at Kaedi, under the Ministry of Education, provides for training of field-level agents (moniteurs) and their immediate superiors (conducteurs). The development projects provide training, mainly of the in-service type, for their technical personnel.

Other organizations which have a bearing upon agricultural development are:

(a) Mauritanian Development Bank (BMD) is theoretically concerned with credit for agricultural inputs. In the mid-1960's an operation was undertaken in the eastern Hodh province to supply credit for plows and draft animals. It appears that the experience gained concerning repayments was not positive enough to encourage the bank to repeat or extend operations of such nature.

(b) Mauritanian Bureau of Cereal Marketing has recently taken over the distribution of emergency food aid and of cereals imported by SONIMEX. It has the responsibility to establish buffer stocks, the marketing of cereals produced locally and in excess of subsistence consumption, and the stabilization of prices for locally produced grains.

(c) National Import-Export Company (SONIMEX) has so far been in charge of the export of gum arabic and dates, the only crop products available for export, and of the import of food grains purchased abroad (1).

## Agricultural Policy

In view of the possibilities offered by the developing mining industry, the earlier development plans did not foresee adequate means for an accelerated development of agricultural production.

Since the second development plan (1970-1973), the official opinion concerning agriculture appears to give a higher priority to agriculture, possibly also because of the experience of the Sahelian drought. External assistance in food commodities amounted to a total of 120,000 tons in 1973.

The new agricultural development program proposes a greatly intensified development of water resources for livestock and crop production. In the first instance, the aim is to reach self-sufficiency in grain production and to make this production more safe against climatic hazards by adequate irrigation and diversification of crops. The improvement of cultivars, pest control, fertilizer use, and the use of animal-drawn agricultural equipment and the development of agricultural credit and marketing are considered as the principal factors necessary to reach the desired levels of production (11).

It appears that emphasis which was in the past principally concentrated on the Senegal River zone will, in the future, be equally given to the millet-growing belt situated north of the river zone and extending along the Mali border to the eastern tip of the country. Irrigation will be provided to the extent possible by the use of underground water.

A new paved road is planned to relate Nouakchott with Nema. The first portion up to Boutilimit is nearing completion. This road will be the artery of the development of the zone (12).

## Agricultural Prices

There are no fixed prices for agricultural products except for rice which is officially sold to the consumer at 20 UM/kg. Other prices are greatly varying according to the rainfall conditions of each individual season, the time of the year, and the productivity of given zones, either with a production surplus or a deficit.

Fertilizer price quotations in August/September 1975 were: urea at 11,200 UM/mt and 10-10-20 at 17,000 UM/mt, c.i.f. Nouakchott. In 1974 quotations were: urea at 9,600 UM/mt, DAP at 9,800 UM/mt, and 10-10-20 at 10,000 UM/mt, c.i.f. Rosso.

The actual average cost of urea delivered to the projects appears to be at present about 16,500 UM/mt.

With the exception of the irrigated rice projects supported by the European Development Fund (FED), fertilizers are given away free of charge. In the FED-supported projects, decreasing subsidies are applied from 100 to 0 over a period of 4 years.

This approach may be understandable from a number of viewpoints, but experience obtained elsewhere has shown that setbacks occur in the use of fertilizers, when the practice needs to be discontinued because of rising costs to supply free fertilizer.

## Crop Production

Table 10 gives an overall idea on crop production, although the reference year cannot be considered normal because of weather conditions. In a

Table 10. Cropped Area, Yield, and Production in Mauritania (9)

| Crop | Area Harvested 1,000 ha | Yield kg/ha | Production 1,000 mt |
|---|---|---|---|
| | | -1961-1965- | |
| Cereals, total | 261 | 374 | 98 |
| Wheat | <1 | 216 | <1 |
| Rice paddy | <1 | 1,788 | 1 |
| Maize | 6 | 614 | 4 |
| Millet | 254 | 367 | 93 |
| Sweet potatoes | 2 | 960 | 2 |
| Cowpeas, dry | 26 | 364 | 10 |
| Peanuts in shell | 2 | 491 | 1 |
| Watermelon | <1 | 14,186 | 1 |
| | | -1970-1974- | |
| Cereals, total | 218 | 266 | 58 |
| Wheat | <1 | 287 | <1 |
| Rice paddy | <1 | 951 | <1 |
| Maize | 7 | 571 | 4 |
| Millet | 210 | 254 | 53 |
| Sweet potatoes | 4 | 526 | 2 |
| Cowpeas, dry | 32 | 281 | 9 |
| Peanuts in shell | 2 | 500 | 1 |
| Watermelon | <1 | 11,151 | 1.4 |

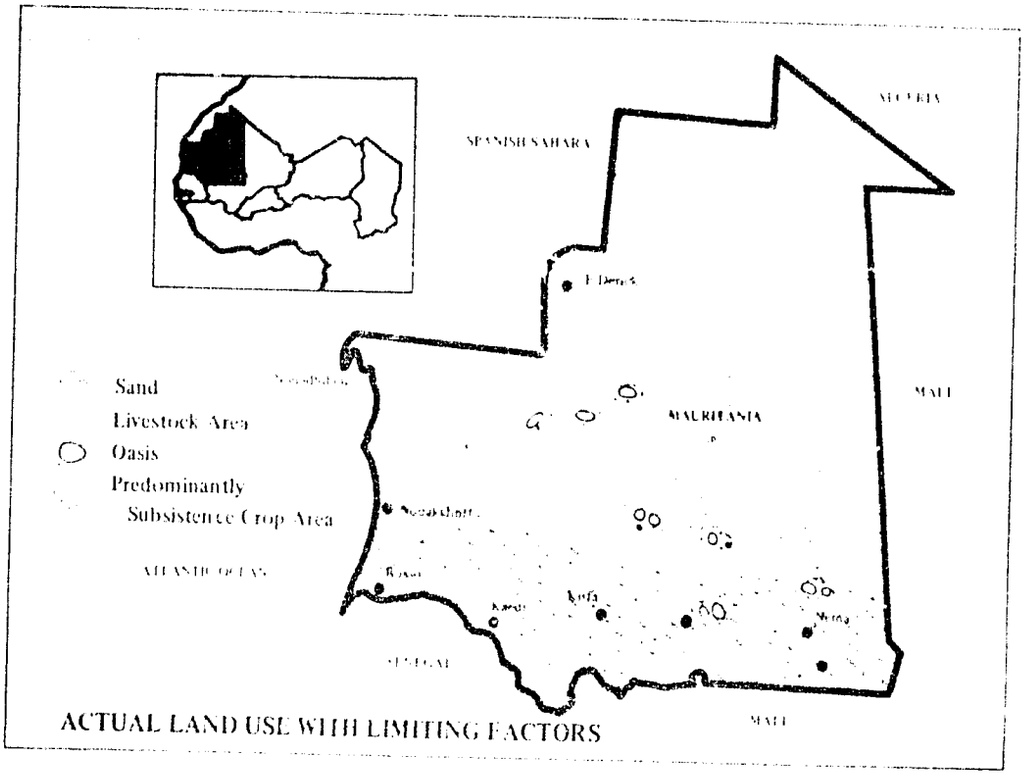
normal year, total production of millet and sorghum is about 100,000 mt. Annual rice production is at present about 4,000 mt of paddy. Annual imports of rice are between 15,000 and 25,000 tons, according to different sources. Other cereals, like maize and wheat, are of minor importance.

Date palms, covering an estimated total area of about 3,000 ha with about 800,000 trees, play an important role in the nutrition of the nomadic and seminomadic population. Half of this area is located in the mountainous region of the Adrar; another 25% is located on oases in the Tagant region. Annual production of dates is about 12,000-15,000 tons. Possibilities for extended production are mainly in the southern region of the Assaba. Production potential is estimated at about 35,000 tons (11).

Vegetable growing was one of the successful actions undertaken in the framework of the Sahelian emergency plan. In 1974 about 8,200 new vegetable growers were included in the action (11). Production in 1973 was reported at approximately 1,400 tons. A general problem of vegetable growing is the salt content of the irrigation water.

## Pattern of Land Use

The land tenure system in Mauritania has a share-cropping system which is considerably more important than in the other Sahelian countries. This land-tenure system acts as a constraint to accelerated agricultural development. The institutional framework of services to support agricultural development exists but lacks adequate funds and manpower.



ACTUAL LAND USE WITH LIMITING FACTORS

Rice is grown under irrigation and monocropping. In schemes using irrigation water from the Senegal River, only one crop per year can be produced because of the salt water backing up from the sea during the dry season.

Sorghum is grown on the banks of the Senegal and other rivers as the flood recedes. On the sandy soils, millet is grown under rainfed conditions, in association with mainly cowpeas or peanuts or in pure stands. Shifting and recurrent cultivation with savanna fallow is practiced to regenerate natural soil fertility.

## Crop Production Projects

Small-Scale Rice Development--By 1975 a total of 1,311 ha had been developed for irrigation and intensive production of rice (table 11). In 1976, the total area of developed rice land reached 1,418 ha. Since 1970 these projects have developed at a rate of about 200 ha/year (13). Average yields have been 3.5-4.5 mt/ha. For various reasons, mainly of climatical and technical nature, the potential is not always used to the full extent.

Gorgol Basin Irrigation Development--The Gorgol River is the principal tributary of the Senegal River in Mauritania. The valley extends over about 55,000 ha. At present the floods of both the Gorgol and Senegal River permit the cultivation of about 8,000 ha of crops every year. Mainly sorghum is grown with residual soil humidity after the recession of the floods.

A pilot development program of 700 ha is planned to go into production by 1977. This is to be followed by three main phases: phase I would expand the double-cropped rice area to about 3,000 ha by 1979/80; phases II

Table 11. Rice Development Projects, 1975 (13)

| Project | Area Developed (ha) |
|---|---|
| M'Pourie | 800 |
| Dar el Barka | 250 |
| Bakao | 25 |
| Vinding | 50 |
| Tiekane | 30 |
| Leboudou | 23 |
| Rindiao | 39 |
| Diovol | 28 |
| Sori Male | 22 |
| Olo Ologo | 22 |
| N'Giorel Guidal | 22 |
| Total | 1,311 |

and III would increase the developed irrigation area to a total of about 10,000-12,000 ha by 1985. Alternative crops to rice would be wheat, forage, and sugarcane (8, 11, 13). The project requires considerable hydraulic engineering and construction work.

Irrigation Development of the M'Pourie Plain--It is planned to extend the present area under intensive rice cultivation to a total of about 4,000 ha. By 1979/80 about 2,500 ha should be in production with the remainder probably by 1985 (11, 13).

Irrigation Development Projects in the Framework of OMVS--The Boghe Plain Project will be carried out in the framework of the Organization for the Development of the Senegal River Basin (OMVS). It will consist of a pilot phase covering a total of 1,000 ha, of which 500 ha are projected to come into production by about 1978/79. Total area under this project will be about 3,000 ha, presumably coming entirely into production by 1985.

There will be development of irrigation in other areas of the Mauritanian part of the Senegal River basin. Initiation of engineering work on about 5,000 ha in the area of Maghama is projected for 1980. Irrigation of about 7,600 ha of soils that are now saline and are situated upstream from Rosso at the junction of the Garak and the Senegal Rivers is projected to start by 1985 (11).

Development of Southeast Mauritania--This concerns the regions of Western and Eastern Hodh and of Guidimaka, south of the 300-mm isohyet. A number of small dams are being constructed to retain seasonal streams as a source for supplemental water supply for extended cropping on about 4,500 ha. In 1974, a feasibility study for an integrated agricultural development of the zone was undertaken. The objective is to extend the area under cultivation by about 60,000 ha, principally under millet and sorghum, and to increase the productivity per unit area of land already in crops by about 25%, basically by the extension of the use of animal-drawn agricultural machinery (2, 11).

Other Development Possibilities--There are a number of other development possibilities under consideration in various zones of the country:

(a) Controlled flooding of the Aftout es Sahel, a natural depression 200 km in length, extending parallel to the coast from Nouakchott towards the Senegal River. The project would allow the installation of pastures under controlled flooding. Precondition is the construction of the Diama dam. A feasibility study began in 1974 (11).

(b) Development of Lake R'Kiz, a large depression 30 km long and 10 km wide, northeast of Rosso and inundated annually by the flooded water of the Senegal River. The idea is to use the lake as water storage for the irrigation of about 5,000 ha of cereals, mainly wheat, and forage

crops, with about 2,000 ha in a first phase (11).

(c) Water control of swamps in the Guidimaka region by means of simple constructions.

(d) In the Tagant area, water conservation of the Tamourt en Naaj, a seasonal stream. A study had been undertaken under the Sahelian drought emergency plan.

(e) Production of tomatoes for canning on an irrigated site of 300 ha near Rosso.

## AGRICULTURAL RESEARCH

Agricultural research on cereals, mainly on rice agronomy, is carried out by the CNRA situated at Kaedi. Agricultural research in the area is also carried out by an FAO/UNDP research project cooperating with the OMVS dealing with Mali, Mauritania, and Senegal.

The French Research Institute for Exotic Fruits (IFAC) has been active since 1952 in the improvement and development of date palm, banana, and citrus growing. Centers are at Kankossa and Kaedi. In 1975 an agreement concerning technical cooperation in the specific field of research was signed between the governments of Mauritania and France (11).

### Crop Response to Fertilizers

Fertilizers on irrigated crops play an important role in reaching the potential production capacity, the basis for which is provided by the irrigation. Thus, fertilizers are a decisive factor for the amortization of investments in infrastructure for irrigation.

Some applied research concerning soil fertility and fertilizer use is carried out by the CNRA at Kaedi and by some development projects such as the agricultural-hydrological research project in the framework of OMVS and the M'Pourie rice development scheme. Research data on crop response to fertilizer is scarce in Mauritania, and farm-level response is practically nonexistent.

Work has so far been concentrated on rice. To some extent the results obtained by research carried out in Senegal on the left bank of the Senegal River, Richard Toll Station, have been extrapolated for application on the Mauritanian bank of the river.

Under the prevailing conditions, nitrogen is the principal nutrient required for rice production. Concerning phosphate, it appears that trials carried out at the Richard Toll Station to compare various phosphate sources have shown that phosphate had a significant effect on yields only when combined with nitrogen in the form of ammonium phosphate. It seems that no attempt was made to explain this phenomenon.

By 1972, the fertilizer recommendations for rice and wheat were 130 kg/ha of DAP and 130 kg/ha of urea. This amounts to a total application of nutrients per hectare of about 80 kg N and 60 kg $P_2O_5$. At present in the irrigation projects practicing transplanting of rice, 150-160 kg of urea/ha or 67.5-72 kg N/ha is applied to the nursery and 60 kg urea/ha or 27 kg

Table 12. Fertilizer Recommendations in Mauritania, 1976[a]

| Crop/Project | Fertilizer Recommendation, kg/ha | | Nutrient Recommendation, kg/ha N | P2O5 | K2O |
|---|---|---|---|---|---|
| Rice/small scale | Urea | 150 | 67.5 | - | - |
| | DAP | 100 | 18 | 46 | - |
| | Total | 250 | 85.5 | 46 | 0 |
| Rice/M'Pourie and Gorgoi/Boghe-DAP | Urea | 200 | 90 | - | - |
| | DAP | 50 | 9 | 23 | - |
| | Compound | 50 | 5 | 5 | 10 |
| | Total | 300 | 104 | 28 | 10 |
| Vegetables | Urea | 100 | 45 | - | - |
| | DAP | 100 | 18 | 46 | - |
| | Compound | 700 | 70 | 70 | 140 |
| | Total | 900 | 133 | 116 | 140 |
| Sorghum/(after flood) | Urea | 100 | 45 | 0 | 0 |

[a]Personal communication, Directorate of Agriculture, April 1976.

N/ha to the fields as a basal dressing before transplanting. Fertilizer recommendations by the Directorate of Agriculture are shown in table 12.

Because of the lack of suitable information on the effect of fertilizers in Mauritania, estimates of required responses at various paddy and fertilizer prices were calculated. These responses required to give an economic incentive (value:cost = 2) to farmers to use N fertilizer are shown in table 13. At the highest urea cost which corresponds to the estimated actual average cost delivered to projects, a value:cost ratio of 2 is obtained when yields are 9-14 kg of paddy/kg of N. Based upon experiences elsewhere under comparable conditions, these levels of response may not be easily obtainable at the farm level. However, the required responses at the other assumed price combinations can likely be obtained by farmers.

Table 13. Paddy Response Required to Arrive at a Value:Cost Ratio of 2 at Varying Urea and Paddy Prices

| Farmers' Paddy Price, UM/kg[a] | Paddy Production for Value:Cost Ratio of 2 kg/kg of N, Farmers' Price of Urea, UM/kg 10.00 | 12.00 | 16.50 |
|---|---|---|---|
| 8.04 | 5.53 | 6.63 | 9.12 |
| 5.70 | 7.80 | 9.35 | 12.86 |
| 5.36 | 8.29 | 9.95 | 13.68 |

[a]Based on the official sales price of 20 UM/kg rice, diminished by 33% for loss in processing, and the assumption that the farmer receives 60, 50, or 40% of the base price for paddy.

Based on the experience of other Sahelian countries, the use of mineral fertilizers on rainfed staple food grains at their cost: price ratio is not feasible for the farmer because the crop market and marketing system is insufficient to provide an economic incentive to induce farmers to use more fertilizer.

On the other hand, fertilizer use on these crops might well be in the economic interest of the country, provided recommendations are carefully formulated to avoid losses when water becomes periodically the limiting factor for production.

## FERTILIZER USE AND POTENTIAL

### Fertilizer Use

The use of mineral fertilizers in Mauritania is still in its early stage. Annual consumption is, at present, about 700-1,000 mt of fertilizer material. Most of the fertilizer is in the form of urea. The apparent fertilizer nutrient consumption from 1970 to 1975 is presented in table 14.

### Potential Fertilizer Use

Assumptions based on government estimates of fertilizer rates and area fertilized were used to project future fertilizer demand in Mauritania to 1985 (table 15). Material consumption is converted to nutrients in table 16. These projections are likely optimistic in light of present use, but use could be expanded rapidly from the present very low level if the necessary emphasis is taken by GOM.

The GOM assumed that annual fertilization of flood recession crops would occur on 50,000 ha in both 1980 and 1985. Since hardly any use of fertilizers on these crops had been reported in the past, this assumption demonstrates a strong desire of the government to start and rapidly increase fertilization of these crops.

The IFDC team considers that no more than 10,000 ha of flood recession crops will be fertilized by 1980 and about 25,000 ha by 1985. This results in decreasing the GOM estimates by 4,000 mt of urea in 1980 and an additional 2,500 mt of urea in 1985. Therefore, the nutrient consumption may be expected to reach about 1,800 mt by 1980 and 3,900 mt by 1985.

**Table 14. Estimated Fertilizer Nutrient Consumption in Mauritania, 1970-1975 (1)**

| Year | Nutrients, mt[a] | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| 1970 | 32 | 23 | - |
| 1971 | 52 | 38 | - |
| 1972 | 54 | 40 | - |
| 1973 | 170 | 30 | 15 |
| 1974 | 40 | 40 | 50 |
| 1975 | 170 | 40 | 40 |

[a] Source for 1973-1975 was personal communication, SSEPC, Dakar, Senegal, 1976.

Table 15. Projected Consumption of Fertilizer Materials in Mauritania by Area of Use, 1980 and 1985

| Area of Use | Rate of Fertilizer, kg/ha | | Area Fertilized, ha 1980 | Area Fertilized, ha 1985 | Fertilizer, mt 1980 | Fertilizer, mt 1985 |
|---|---|---|---|---|---|---|
| Small-scale irrigation projects | 150 | Urea | 600 | 800 | 90 | 120 |
| | 100 | DAP | | | 60 | 80 |
| M'Pourie plain | 200 | Urea | 2,500 | 4,000 | 500 | 800 |
| | 50 | DAP | | | 125 | 200 |
| | 50 | 10-10-20 | | | 125 | 200 |
| Gorgol/Boghe/Maghoma projects | 200 | Urea | 3,500 | 10,500 | 700 | 2,100 |
| | 50 | DAP | | | 175 | 525 |
| | 50 | 10-10-20 | | | 175 | 525 |
| Vegetables | 100 | Urea | 1,000 | 1,500 | 100 | 150 |
| | 100 | DAP | | | 100 | 150 |
| | 700 | 10-10-20 | | | 700 | 1,050 |
| Flood recession crops | 100 | Urea | 50,000 | 50,000 | 5,000 | 5,000 |
| Total | | Urea | 57,600 | 66,800 | 6,390 | 8,170 |
| | | DAP | | | 490 | 955 |
| | | 10-10-20 | | | 1,000 | 1,815 |

Table 16. Projected Fertilizer Nutrient Consumption in Mauritania, 1980 and 1985

| Nutrient | Quantity of Nutrients, mt: GOM Estimates 1980 | GOM Estimates 1985 | IFDC Estimates 1980 | IFDC Estimates 1985 |
|---|---|---|---|---|
| N | 3,064 | 4,030 | 1,264 | 2,905 |
| $P_2O_5$ | 525 | 620 | 325 | 620 |
| $K_2O$ | 200 | 364 | 200 | 364 |
| Total | 3,589 | 5,014 | 1,789 | 3,889 |

## FERTILIZER SUPPLY

Principal supplier of fertilizers in the past has been the Senegalese Fertilizer and Chemical Products Company (SSEPC) which markets fertilizers from the fertilizer factory at Dakar, Industrial Fertilizer Company of Senegal (SIES), and from Europe. In 1975, 200 tons of urea was imported from Morocco. Two local import-export firms at Nouakchott, ARIDIS and SOGEA, are agents for the supply of agricultural inputs, including fertilizers.

Fertilizers purchased by the Agricultural Service Unit of the Directorate of Agriculture are usually delivered to Rosso, directly to M'Pourie farms, or to Nouakchott if the material arrives in the country by sea. Further distribution to the projects is the responsibility of the Agricultural Service.

The available storage capacity appears to be sufficient for the present levels of fertilizer consumption. However, without appropriate provisions, distribution and storage might become a problem, especially since the centralized pattern of the projects requires centralized storage of sizable quantities up to the time of their use.

## Raw Material for Fertilizer

Phosphate--Rough estimates of phosphate reserves indicate that approximately 5 million mt is known to exist. These deposits have not been explored in detail. The known deposits are situated: (a) in the triangle formed by the towns of Kaedi, Aleg, and Boghe and (b) between the center and the western border of the Taoudedni Basin.

Areas of early reconnaissance in the Kaedi-Aleg-Boghe triangle are as follows:

1. Cive
2. Near Aleg
3. Dioulde--Diabe (90 km upstream from Boghe)
4. Foundou (25 km WNW of Kaedi)
5. Dioudel (30 km upstream from Kaedi)
6. Koundel (2 km upstream from Kaedi)

Samples of rock from Cive have contained 26-28% $P_2O_5$ and 13-18% $Fe_2O_3$, plus $Al_2O_3$. A sample from the Taoudedni Basin was analyzed as 19% $P_2O_5$, 6% $Al_2O_3$, and 22% $Fe_2O_3$. Additional information about the deposits appears in appendix I.

Agricultural testing of these phosphate materials for direct application has not been undertaken at this time, nor has either of the deposits been explored in detail. Detailed exploration of the deposits or agricultural testing of the rock must be carried out before decisions can be made concerning the future use of the phosphate resources.

The government-owned mining company, National Company of Mining Industry (SNIM), believes that the rock phosphate deposit south of Kaedi at Cive contains considerably more reserves than the now estimated 5 million tons. It is also possible that rock deposits in the former Spanish Sahara extend into Mauritania.

Existing in the framework of SNIM is a consortium for the exploration of phosphates in Mauritania. Participating are the French Bureau for Geological and Mining Research (BRGM), the Senegalese Phosphate Company of Thies, and GIOMINE, a company of Rumanian origin.

Other Materials--Copper ore will be refined locally beginning in 1976 or 1977. This will result in about 100,000 mt/year of byproduct sulfuric acid. Production of normal superphosphate in a very small plant could be based on this byproduct acid. However, the very low-level use of $P_2O_5$ in Mauritania would not justify this.

An oil refinery is under construction at the Port of Nouadhibou, and exploration for oil is continuing in the center of the country with hope of positive results. Esso has been engaged in exploration since 1968 and AGIP since 1971. Shell is exploring for oil offshore.

## Production and Plans

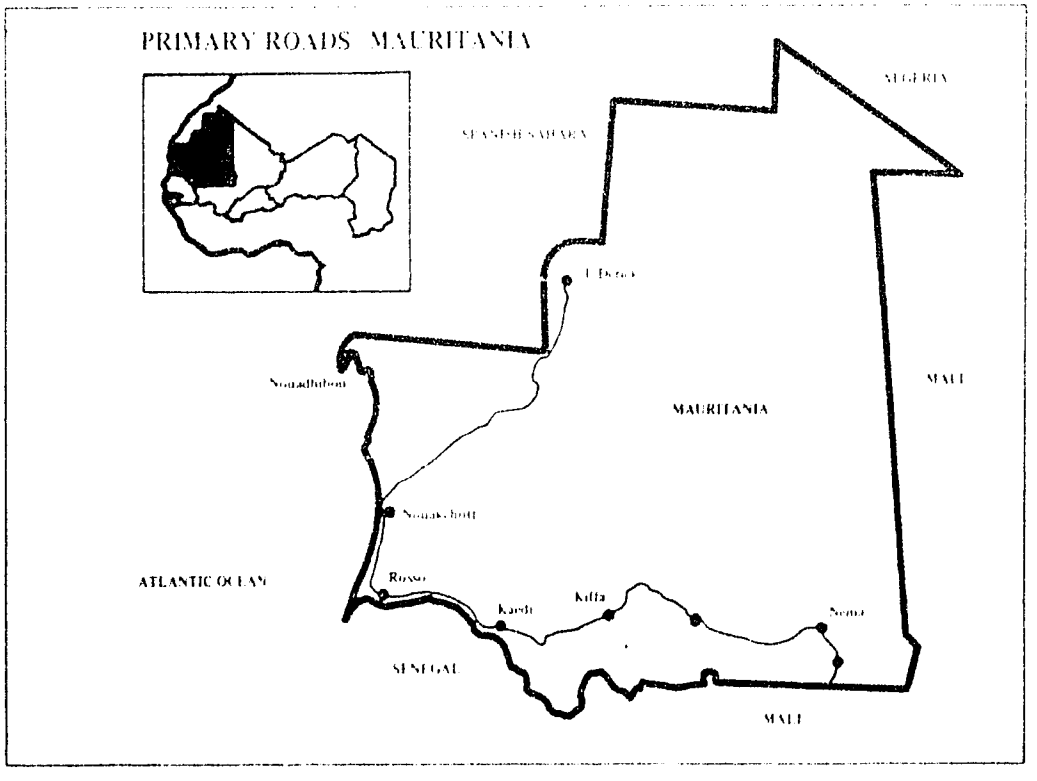
There is no local production of mineral fertilizers existing and no definite plans for production in the near future. A sewage recycling plant furnishes organic matter and salt-free irrigation water for vegetable growing around Nouakchott. Also, the Ministry of Mines and Industrialization has had contacts with Roland Marine Corporation, New York, concerning the possibility of importing town sludge in tankers. The slurry would be dried and used mainly for growing vegetables.

Byproduct sulfuric acid from a copper refinery could be a raw material for producing normal superphosphate. However, SNIM is of the opinion that a sizable local market should exist before local fertilizer production is undertaken. Perhaps an arrangement could be worked out whereby the sulfuric acid is traded to Senegal in exchange for fertilizer.

# TRANSPORTATION

## International Transportation

There are two primary routes for Mauritania's import-export traffic. Products may enter or exit through the exposed lighterage port at Nouakchott. This facility, which has a 350 m wharf, was completed in 1966 and is preferred by the GOM as the country's primary import-export gate. Imports received at Nouakchott require only 1 day for delivery to Rosso, the "hub" from which subsequent freight movement originates. The transport cost from Nouakchott to Rosso is about $15/mt.



The other route is via the Port of Dakar. Nearly all of Mauritania's international traffic was via Dakar prior to completion of the lighterage at Nouakchott, and the route continues to be heavily used because of the frequent occurrence of bottlenecks at Nouakchott. The bottlenecks at Nouakchott are in cargo unloading and in cargo transshipment to truck for internal distribution.

Mauritanian imports, upon arriving in Dakar, may be channeled to key markets through one of several alternate routes. Imports may be delivered by coastal vessels from Dakar to Nouakchott, by truck from Dakar to Rosso, by rail from Dakar to St. Louis, and by barge or truck from St. Louis to Rosso or to Kaedi. Goods may also be transported on the Senegal side of the river to Thilogne and ferried across the river to Kaedi. Shipments through Rosso also must cross the Senegal River via ferry. Four ferries are operating with 30, 40, 60, and 100 mt capacity, respectively. Only the 100-mt ferry was operating in April 1976; the other would be repaired when parts arrived for it. The river wharf at Rosso has a capacity of about 80,000 mt/year.

The time and cost involved in the movement of imports from Dakar to key market areas in Mauritania varies according to the mode of transportation and the route selected. The swiftest and most economical route from Dakar to Rosso is via St. Louis and requires two modes of transportation, rail and road. Using this route, delivery takes about 2 days and costs about $16/mt, making it quite competitive with imports via Nouakchott.

Domestic Transportation

Mauritania's domestic transportation infrastructure is designed to link population centers with the ports of Dakar and Nouakchott. The country's road network consists of about 6,000 km--hard surfaced roads (3,200 km) and dirt tracks (2,800 km). Most of the roads are in poor condition. The routes which are most critical to the country's distribution system are the roadway linking Rosso and Nouakchott and the network of roads linking Rosso with key market areas in southeastern Mauritania. Vehicles are privately owned and commercial transportation is competitive.

The road from Nouakchott to Rosso is a 203-km hard-surfaced road of two or more lanes. The Nouakchott to Rosso trip time is only 1 day, and the transport cost for fertilizers in 50-kg bags is about $15/mt. This route is potentially Mauritania's swiftest and most economical route to access international markets.

Imports destined for markets in the agricultural region of southern Mauritania nearly always pass through Rosso (the only exception being those products shipped on the Senegal River). The road from Rosso accessing the eastward market areas is subject to seasonal flooding, thus accenting the need for careful planning in product delivery.

In addition to road movement, organized waterway services on the seasonally navigable Senegal River are available. This activity includes a few powered craft and barges requiring manual loading and unloading. In its present condition, the Senegal River is navigable for only about 3 months out of the year. The construction of a dam at Diama (currently in the discussion stage) would permit year-round navigation of the river.

Mauritania's only railway extends 700 km from Nouadhibou to F'Derick in the northern desert region. The railway serves as the export route for Mauritania's iron ore shipments and is of no potential value to the agricultural regions of the country.

Transport development policy has been directed largely to the maintenance and improvement of existing roads. The Government is now

Table 17. Transportation Rates to Key Market Areas

| From | To | Mode | Distance, km | Estimated Transportation Cost, $/mt[a] |
|---|---|---|---|---|
| Rosso | Kaedi | Road | 310 | 10.72 |
| Rosso | Kiffa | Road | 615 | 18.43 |
| Rosso | Aioun-el-Atrouss | Road | 855 | 26.15 |
| Rosso | Nema | Road | 1,150 | 33.87 |
| Rosso | Zemra Guie | Road | 1,240 | 36.23 |

[a]Includes handling estimated @ $3.76/mt.

engaged in construction of a paved road from Nouakchott to Boutilimit and realignment and paving of the road Boutilimit-Aleg-Kiffa-Nema; neither of these projects appears to be economically justified, however, since traffic levels are generally low, and the roads bypass important agricultural regions (14). The portion Nouakchott-Boutilimit (about 150 km) was nearing completion in April 1976. Representatives of FED and International Bank for Reconstruction and Development (IBRD) are planning to assist the government in the construction of feeder roads from this axis southward into the agricultural zones. The Government is also considering construction of a deep-water port at Nouakchott to further decrease the country's dependence on the port of Dakar. Planning for this has been carried out by the People's Republic of China which may eventually finance the project. However, the poor condition of the Nouakchott facility has resulted in about 90% of Mauritania's import-export traffic being channeled through Dakar.

Estimated costs for importing and transporting fertilizers through Dakar, St. Louis, and Nouakchott to Rosso are given in volume I. Internal distribution costs from Rosso to several key market areas are estimated in table 17.

Assuming that the small quantities of fertilizer now used are ordered and delivered in a timely fashion, distribution should be a minor problem unless the operation coincides with a food transport emergency.

There is a total storage capacity in Nouakchott of 15,000-20,000 mt near the port. About a 15,000-mt storage capacity exists at Rosso. In addition, about 50,000 mt of storage capacity exists along the axis Aleg-Kiffa-Aioun-Nema. At present, the latter storage areas are mainly used for storing food supplies. Although the location of this capacity is north of the agricultural zone, it could be used in the future for intermediate storage of agricultural inputs in connection with the planned feeder roads into the agricultural area.

Approximate transit times for goods are: exit vessel Dakar to Rosso--2 weeks to 2 months; exit port Dakar to Rosso--1-2 days; exit warehouse Nouakchott to Rosso- 1 day; exit warehouse Rosso to Kaedi--1 day; exit warehouse Nouakchott or Rosso to Nema--7-10 days.

Grains and other goods distributed under the Sahelian relief program are transported by a total of about 300 trucks, partly purchased by the

Government of Mauritania and partly donated. Beginning in 1976, a newly created bureau (The Mauritanian Bureau of Cereal Marketing) assumed responsibility for distribution of emergency aid. This duty was formerly handled by the defense ministry.

## ALTERNATIVE FERTILIZER SUPPLY SCHEMES

Historically, fertilizer has been imported from France, Senegal, and Morocco. Senegal and Morocco have the nearest fertilizer plants located on the continent.

Bulk or semibulk imports combined with bagging in port are theoretically possible through the port of Dakar. In the case of semibulk importation, rebagging could take place in Mauritania. However, in view of the fertilizer quantities presently used (approximately 1,000 mt/year) and the nearby factory in Senegal, cost savings resulting from bulk import or bulk blending would be negligible. It appears that the fertilizer needs of Mauritania can best be met through purchases from Senegal and imports of urea via Dakar.

After the phosphate deposits are explored in detail and agricultural testing of phosphate rock is completed, establishment of a small rock-grinding operation should be considered. These would be dependent on increased local consumption of fertilizers.

## POTENTIAL PROJECTS

Mauritania has the land resources to achieve self-sufficiency in food (except rice) production for its people. Only 12% of the potentially arable land is, at present, under cultivation. However, of the potential, 63% receives less than 350 mm of rainfall/year. While crops are grown on about 260,000 ha, there is about 800,000 ha of potential agricultural land which typically receives more than 350 mm of rainfall/year (6). Also, there is a good potential for irrigation, but it will be costly.

In the short run, food production can be increased through greater yields on existing cropiands. The use of improved production practices on currently cultivated land can significantly increase the productivity of Mauritanian agriculture. Productivity per worker can be increased by increasing yields and providing power to increase land area cultivated per worker.

Transformation of subsistence farming into commercial agriculture is the key to meeting present and future food requirements. Essential to this process will be market development, more production incentives, new technology, improved transportation, and

the increased availability of necessary farm supplies and equipment. A key input in such a development program will be fertilizer, currently only used in limited quantities.

Mauritania has phosphate rock (PR) deposits which possibly can supply some of the $P_2O_5$ nutrient requirements. Other nutrients can be imported from nearby Senegal.

Adoption of fertilizer involves more than just the ability to accurately recommend and supply fertilizer. A stable price relationship between the value of yield gain and cost of fertilizer application must provide an economic incentive to the farmer. Even when this relationship appears to be economically favorable, the farmer may still be reluctant to adopt fertilizer. Extension education and fertilizer response demonstrations are important in assisting him to more accurately evaluate the benefits and risks of fertilizer use.

The following project recommendations are suggested to accelerate the use of fertilizer in Mauritania.

## Soil Fertility Project

A fertilizer trial and demonstration program is needed in Mauritania to obtain data and demonstrate response for major crops at various levels of on-farm management. Method of land preparation and tillage, varieties, plant population, timing of seeding, weeding and harvesting, and soil type and moisture need to be correlated with crop response to fertilizer.

PR deposits exist in Mauritania that may be suitable for direct application. The effectiveness of these rocks in providing plant nutrients needs to be determined for the major crops under varying soil and moisture conditions. Phosphate rock should be tested in comparison with other standard PR and soluble phosphate fertilizers. Research findings can then be incorporated into an extension education and demonstration program which can advise farmers on new production practices.

IFDC recommends that an expatriate team of crop production specialists be assigned to Mauritania to work closely with existing research and extension organizations to obtain crop response data and demonstrate responses to farmers. Project team members would be responsible for agronomic and economic research on crop response and for training nationals in methods of agricultural research and extension education. The term of the project is 5 years. A detailed description of the proposed project is contained in appendix II.

## Public Policy Studies on Price Stabilization and Equalization

Fertilizer use is highly dependent upon the relationship between the cost of fertilizer and crop prices.

IFDC recommends that alternate public policies on price support and cost subsidization be studied to determine their effects on fertilizer adoption, food production, and overall economic development. IFDC recommends that one expatriate economist work with Mauritanian economists from the appropriate planning organization to carry out the study. The term of this project is 6 months. See appendix II for additional detail.

## Other Projects

Other potential projects for which no detailed proposals were developed are to survey the phosphate deposits to determine the feasibility of mining and grinding PR for direct

application; to assess the status and needs of extension, credit, and crop marketing organizations; and to identify methods of improving agricultural statistical reporting.

## Estimated Budgets

The estimated foreign exchange requirements for the budgets for the recommended projects are:

| Project | Period, Years | Budget |
|---|---|---|
| Soil Fertility | 5.0 | $825,000 |
| Public Policy | 0.5 | 31,000 |
| | | $856,000 |

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7. Africa South of Sahara, Europe Publications Ltd., London, 1975.

8. Mauritania, Report No. P 1396, IBRD, 1974.

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11. L'Agriculture Africaine, Ediafric la Documentation Africaine, Paris, 1975.

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14. Sahel Transportation Paper, IBRD, 1975.

# APPENDIX

# APPENDIX I

## Fertilizer Raw Material Deposits and Literature References

| References | Composition of Samples | | Location | Other Information |
|---|---|---|---|---|
| Reference 1 | 40-60% $Ca_3(PO_4)_2$ occasionally reaching 75% | | Valley of Senegal River Ornolde, Garly, Cive | Thin layers (1-2 m). Has been ground for direct application at Cive. Several million tons. |
| Reference 4 | $P_2O_5$ | 26-28 | Cive | This is on the right bank of the Senegal River and quite close to it. There are three phosphate layers, sometimes four. Total thickness is probably less than 2 m. |
| | CaO | 29-35 | | |
| | $Al_2O_3$ | 7-10 | | |
| | $Fe_2O_3$ | 4-7 | | |
| | $SiO_2$ | 18-19 | | |
| Reference 5 | $P_2O_5$ | 14.4% | Ikiaone and Tchichit | It is phosphated limestone by contact with guano. No practical interest. |
| | CaO | 27.5 | | |
| | $CO_2$ | 8.2 | | |
| | $Al_2O_3$ | 6.0 | | |
| | $SiO_2$ | 38.6 | | |
| | $Fe_2O_3$ | 2.2 | | |
| Private sources | Brines | | Ikaouen Island<br>Sebkha D'Idjil<br>Fodere | |
| Private sources | Sulfur | | 120-150 km east of Nouakchott | Commercial exploitation is being studied. |

FERTILIZER RAW MATERIAL DEPOSITS AND LITERATURE REFERENCES (Continued)

| References | Composition of Samples | Location | Other Information |
|---|---|---|---|
| Europe-Outremer 1974, May, p. 184 | Sulfur<br>Phosphates<br>Gypsum | | Tremendous reserves of gypsum. Production 15,000 tpy. |
| C. Rends, Paris. 1971, 272D, 1041-3 | Dawsonite<br>Na Al $(CO_3)$ $(CH)_2$ | Richat (Adrar de Mauritanie) | Sample contained 93% Dawsonite and 7% lepidocrosite. Deposit probably small. |
| Bull. direc. mines et geol. 1957, 20, 197-254 | Pyrrohotite | Guelb Moghrein Akjoujt | Pyrrhotite is one of the three primary minerals; the other two are magnetite and chalcopyrite. |

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4. Notice explicative sur la feuille Dakar-Est. Carte geol. Reconn. No. ND 28-E. XIII A.O.F., 1943. 34 pp., refs., map. (In French) Phosphates, pp. 25-26.

5. Notice explicative sur la feuille Port-Etienne-Est. A. Blanchot. Carte geol. Reconn. No. N.F. 28 S.O.-E. 123. A.O.F. 1952. 22 pp. col. geol. map. (In French) Phosphates, p. 19.

6. Les phosphates du Sahara soudanais. R. Karpoff and L. Visse. Bull. Soc. Geol. Fr., Ser. 5, 1950, vol. 20, Nos. 4-6, pp. 125-131, figs., refs. (In French).

## APPENDIX II

### Recommended Projects

SOIL FERTILITY PROJECT IN MAURITANIA

Fiscal year proposed for financing: FY 1979

Priority and Relevance

A goal of AID support in west Africa is to assist in increasing food production, particularly to restore balance between production and demand. Major emphasis is being placed on this goal by AID through support of Semi-Arid Food Grain Research and Development (SAFGRAD) and country and sectional crop production and/or integrated rural development projects.

Requirements for millet and sorghum, primary food crops, are projected to increase 20,000 and 44,000 mt by 1980 and 1985 over 1975 food requirements. To help meet these needs, basic and applied research programs are being implemented to develop and distribute drought-tolerant varieties adapted to the soil and climatic conditions and to study cropping systems suitable to the area. These programs are much needed and are essential to bring about improved crop production. In addition, other measures are needed to improve crop yields and expand production.

Experimental and farm-level information is scarce for cereal response to fertilizer in Mauritania. To maximize the response to fertilizer, improved production practices at the farm level must be implemented. Little is known about farmer attitudes toward acceptance of improved cultural practices. Efforts have been made to introduce changes without much success. The lack of widespread acceptance in many cases may be due to the lack of farmer knowledge, bottlenecks in the delivery system for inputs, limited availability of credit at economical interest rates, inadequate input-output price relationships, and unstable market demand.

Description of Project

This project would implement a soil fertility program in Mauritania consisting of two "action" components followed by a project evaluation. The term of the project is 5 years. It would be implemented within the framework of existing institutions responsible for agricultural research and extension.

The objectives of the soil fertility project are:

1. Define the nature of response of food crops to fertilizer in various soil and climatic conditions at the farm level;

2. Quantify the value of indigenous PR for food crop production in relation to soluble P fertilizer and other widely used PR under varying soil and climatic conditions;

3. Train nationals in improved crop production practices, methods of conducting and analyzing trials and demonstrations and using results with farmers;

4. Demonstrate to farmers the value of improved crop production practices; and

5. Relate levels of inputs of a crop production program to outputs, changes in attitudes, and changes in practices.

This project proposes that two crop production specialists be assigned for fieldwork in the agriculture region. The specialists would be placed in the Directorate of Agriculture but would work closely with CNRA. Each crop specialist would have four assistants (nationals) who would be trained to carry on the work themselves. One or two additional new assistants would be added each year.

The specialists must have training and experience to conduct professional levels of work and must be able to effectively converse in French. Specialists should arrive in Mauritania in January or February to give time for familiarization and planning before their first crop season. Upon arrival, the specialists would familiarize themselves with existing research data and development programs and make detailed plans for the coming season in consultation with researchers and project management.

Each crop specialist would be responsible for conducting 30-40 crop production trials or demonstrations of a design suitable to measure the effect of individual plant nutrients, crop variety, plant population, timing of planting and harvesting, soil preparation, and incorporation of residue or manure application. Long-term experiments would be established to determine the effect of crop rotations and the value of residual fertilizer.

Individual trials with PR would be conducted for 3-5 years to determine the immediate as well as residual effect. The trials would include equivalent rates of $P_2O_5$ applied as TSP and PR and the lowest rates of PR with supplemental TSP. In all trials and demonstrations, soil samples would be obtained and analyzed for attempts at correlation of yield response and levels of soil-P and possibly other characteristics. Arrangements would be made for proper analysis of samples at research station laboratories. Rainfall (quantity and distribution) would be recorded at or near each location.

The specialists would coordinate statistical and economic analyses of project results, develop practical farm budgets for various cropping and economic situations, and serve as field advisors for a graduate student conducting adoption studies of changes resulting from crop production program.

The study by the graduate student would include documenting, at the village level, the following facts: kinds and number of farmer contacts; availability of credit and other inputs; input and output prices; price fluctuations; availability of markets; acceptance and implementation of new practices; and effect of these on production, labor requirements, and economic well-being. The study would attempt to define the relative importance of various inputs of a crop production program upon the diffusion, acceptance, and implementation of improved cropping practices.

Training sessions would be conducted with assistants covering how and why various things are done. In addition, training sessions would be held with each cooperating farmer before trials are established, during the growing season, during harvest, and after harvest.

## AID and Other Relevant Experiences

AID has funded many applied research, crop production, and extension training projects. The soil fertility project has particular relevance to the SAFGRAD project since it contains an action program to strengthen national institutions and to provide immediate benefits to Mauritanian farmers.

## Beneficiary

Principal beneficiaries of the project are Mauritanian farmers. Through better defined crop response data and better informed extension advisors, farmers are more likely to increase crop yields and produce more for the time spent in production.

## Feasibility Issues

Assumptions for the feasibility issue are: 10 kg of sorghum can be produced from 1 kg of N when applied at a rate of 45 kg/ha; the producer can receive 4.5 UM/kg of sorghum; and N costs the farmer 22.2 UM/kg. Thus, N valued at 1,000 UM would return sorghum valued at 2,025 UM or 1,025 UM/ha above the cost of fertilizer.

On the national basis, fertilizing 10,000 ha of sorghum would require 450 mt of nutrients and result in 4,500 mt of additional grain. Estimated economic farm-gate value of sorghum, based upon world prices, margins, and freight, is 5,530 mt which gives an economic farm-gate value of 24.9 million UM for the additional grain produced from 450 mt of nutrients. The N supplied as urea would cost 7.9 million UM delivered to Rosso (based upon estimated cost in 1976). Using the same rate for domestic freight and margins as for grain, these add 1.1 million UM for a total cost of 9 million UM for the fertilizer delivered to farms. Therefore, each million UM spent on fertilizer can yield grain to replace 2.77 million UM in grain imports.

## Other Donor Coordination

International Bank for Reconstruction and Development (IBRD), European Development Fund (FED), Development Aid Agency of the French Government (FAC), U.N. Development Program (UNDP), and AID are presently funding crop production projects and/or research and extension activities. The Federal Republic of Germany, Canadian International Development Agency (CIDA), and Ford Foundation may be interested in funding this type of project.

## Financial Plan

The annual foreign exchange cost of the project is estimated to be $165,000 or $825,000 for a 5-year period. In addition, the GOM would be expected to supply the assistants and field hands for the work, as well as office space. It is estimated that about 60% of the salaries budgeted in the

first year for technical services would be needed in the first year since they will not be in the field a full year in the first fiscal year. However, support costs will be highest the first year.

Estimated Foreign Exchange Support for Five-Year Project

| | |
|---|---|
| **Technical Services** | |
| Crop production specialists - 2 at $45,000 x 5 | $450,000 |
| Support | 250.000 |
| | $700,000 |
| Graduate student stipend - 1 at $3,000 x 2 | 6,000 |
| Support - $17,000 x 2 | 34,000 |
| Travel - $5,000 x 2 | 10,000 |
| | $ 50,000 |
| Commodities | |
| Travel for specialists, workshops, printing and logistic support | 25,000 |
| Grand total | 50,000 |
| | $825,000 |

Implementation Plan

A contractual agreement will be made with GOM. The project would be administered by a project coordinator probably placed in the administration of the Directorate of Agriculture in the Ministry of Rural Development. Very close collaboration would be needed with the managements of projects and region administrations.

Project Development Schedule

| | |
|---|---|
| Departure, project design team | January 1, 1979 |
| Project committee review, project paper | March 1, 1979 |
| Review/approval of project paper | May 1, 1979 |
| Project staff arrive in Mauritania | July 1, 1979 |

STUDY OF PUBLIC POLICIES ON PRICE STABILIZATION AND EQUALIZATION

Fiscal year proposed for financing: 1979

Priority and Relevance

Fertilizer-use level is highly dependent upon the cost-price relationship between fertilizer and a crop although other factors influence fertilizer use. Farmers tend to maximize net returns and do not use fertilizer if returns do not cover the cost plus risks involved.

Generally, a kilogram of nutrient can be expected to give 8-10 kg of cereal grain. At current world prices for grain and fertilizer nutrients,

imports of grain would cost 2.5-3 times the cost of fertilizer to produce the grain in Mauritania. An in-depth analysis would require consideration of many other factors.

Description of Project

This study would describe alternative public policies on price stabilization and equalization; subsidies for crops, fertilizers, and other related inputs; their implementation; effects upon fertilizer use; and the effects on the economy of the country sectors and regions. It would furnish guidelines for establishing policies related to fertilizer use which could effectively meet government goals. The study would require one expatriate economist working with one or more economists from the national planning agency. The study would be completed in 6 months.

AID and Other Relevant Experiences

The nature of other studies in this area financed by AID is unknown.

Beneficiary

Agricultural development would benefit rural and urban sectors. Increasing self-sufficiency in food through appropriate agricultural price and incentive policies would substantially strengthen Mauritania's international position by helping to correct current balance-of-payment problems.

Feasibility Issues

Establishing favorable fertilizer product prices could result in increased fertilizer use and increased food crop production provided other inputs are available for favorable response of crops to fertilizer.

Other Donor Coordination

Unknown.

Financial Plan

The foreign exchange cost of the study is estimated to be $31,000. In addition, the local government would be expected to supply one or two local economists to work on the project.

Estimated Foreign Exchange Support for the Study

Technical Services

| | |
|---|---|
| Economist - 1 at $30,000 x 0.5 | $15,000 |
| Support | 10,000 |
| Travel | 5,000 |
| Publication | 1,000 |
| | $31,000 |

Implementation Plan

A contractual agreement would be made with the local government. The study would be undertaken with the national planning agency. It would require cooperation and assistance from the Ministry of Rural Development, Ministry of Planning, Bureau of Cereal Marketing, and possibly other organizations.

Project Development Schedule

| | |
|---|---|
| Visit to the country for project negotiation | January 1, 1979 |
| Visit to field for data gathering (2 months) | April 1, 1979 |
| Completion of study | September 1, 1979 |