

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

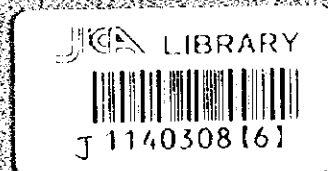
ISLAMIC REPUBLIC OF MAURITANIA  
MINISTRY OF RURAL DEVELOPMENT  
AND ENVIRONMENT (MDRE)

NATIONAL RURAL DEVELOPMENT AGENCY  
(SONADER)

THE FEASIBILITY STUDY  
ON  
IRRIGATION AND AGRICULTURAL DEVELOPMENT PROJECT  
IN UPPER DELTA OF THE SENEGAL RIVER BASIN  
IN  
THE ISLAMIC REPUBLIC OF MAURITANIA

MAIN REPORT

OCTOBER 1997



NIPPON KOEI CO., LTD.  
TAIYO CONSULTANTS CO., LTD.  
AERO ASAHI CORPORATION

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### Composition of Reports

<u>Language</u>	<u>Report</u>
Japanese	Main Report
English	Main Report
French	Main Report (TOME -1)
French	Appendices (TOME - 2)



1140308 (6)

## Preface

In response to the request from the Government of the Islamic Republic of Mauritania, the Government of Japan decided to conduct the Feasibility Study on Irrigation and Agricultural Development Project in Upper Delta of the Senegal River Basin in the Islamic Republic of Mauritania and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to Mauritania a study team headed by Mr. Yutaka Murai, Nippon Koei Co., Ltd., three (3) times between July 1996 and August 1997.

The team held discussions with the officials concerned of the Government of Mauritania, and conducted field surveys in the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Mauritania for their close cooperation extended to the team.

October, 1997



Kimio Fujita  
President

Japan International Cooperation Agency

October 1997

Mr. Kimio Fujita  
President  
Japan International Cooperation Agency  
Tokyo, Japan

Dear Sir,

Letter of Transmittal

We are pleased to submit to you the report on the Feasibility Study on Irrigation and Agricultural Development Project in Upper Delta of the Senegal River Basin in the Islamic Republic of Mauritania. This report presents the results of all works performed in both Mauritania and Japan during a period of 14 months from July 1996 to August 1997.

This Study is to examine the economic and technical feasibility of the irrigation and agricultural development in the Dioup Area of 13,730 ha located in the alluvial plain on the right bank of the Senegal river, aiming at improving the living conditions of rural people, increasing food production and conserving the environment. As a result, an irrigation and agricultural development project has been formulated, including improvement of irrigation and drainage facilities and rural infrastructure for an area of 4,730 ha consisting of 3,940 ha of paddy fields and 790 ha of pasture lands. The Project includes; (i) the establishment of an organization to operate and maintain the project facilities by beneficiaries themselves, and (ii) the training and strengthening of farmers' organizations and the extension of agricultural techniques by the National Rural Development Agency (SONADER) as well as the improvement and construction of facilities. In formulating the development plan of the Project, careful consideration is given to the conservation of natural environment of coastal swamps located adjacently to the project area, the control of desertification on a beneficiaries' participation basis and the participation of women in the development. The inhabitants in the project area are eager in the realization of the Project and are willing to participate in the operation and maintenance of the project facilities, and thus it is considered that such people's attitude will ensure the sustainability of the Project.

We believe that the Project follows exactly the policy of Mauritania which sets forth the objectives of "rectification of regional parity", "improvement of living conditions and farmers' income" and "environmental conservation and restoration of nature". We therefore hope that the Project will be implemented at an earliest date.

We wish to express our deep appreciation and sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of Agriculture, Forestry and Fisheries. We also wish to express our deep gratitude to your Senegal Office, the Embassy of Japan in Senegal, SONADER and other authorities concerned of the Government of Mauritania for the close cooperation and assistance extended to us during the field investigations and studies.

Very truly yours,



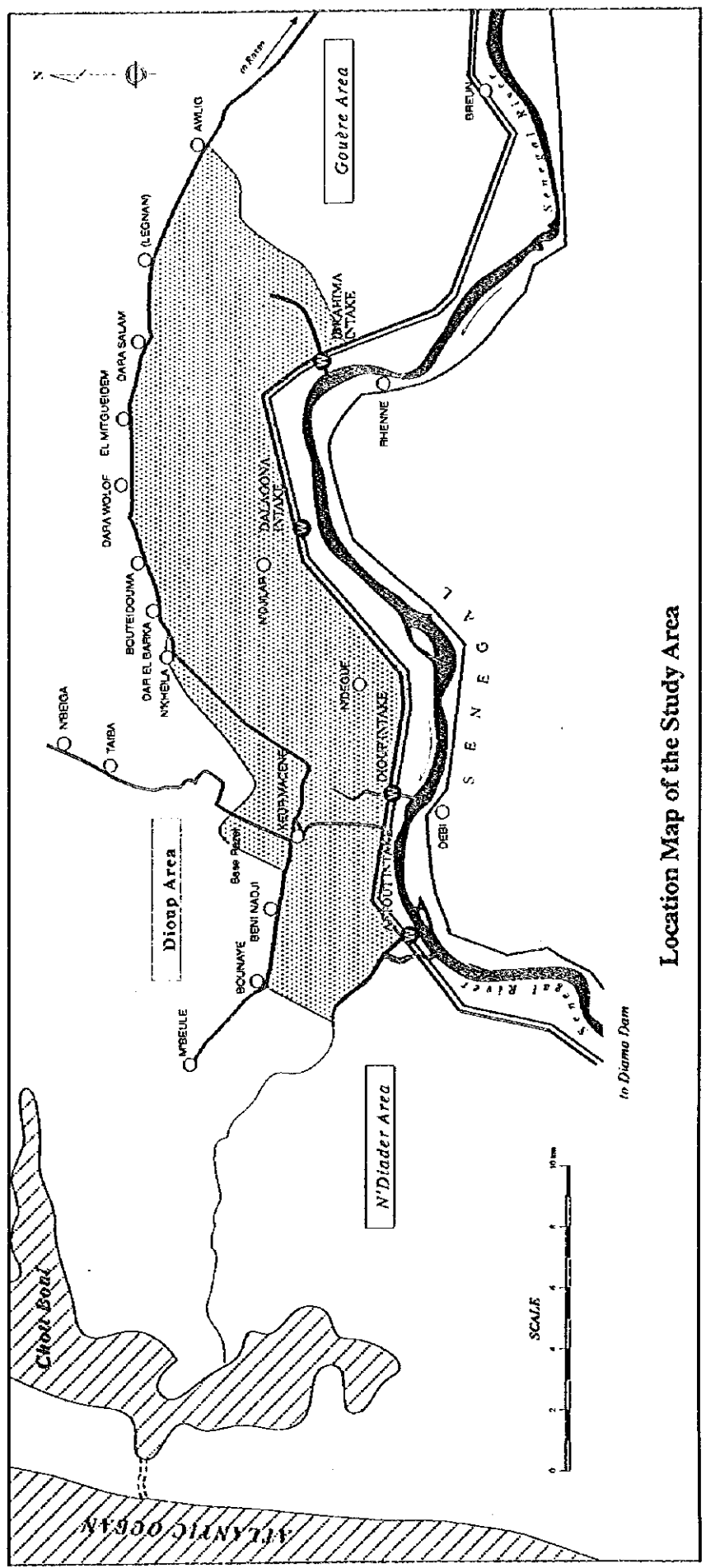
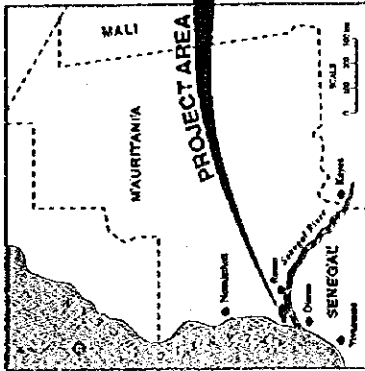
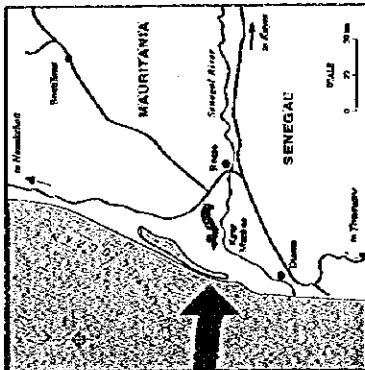
Yutaka Murai  
Team Leader  
The Study Team of the Feasibility  
Study on Irrigation and Agricultural  
Development Project in Upper Delta of  
the Senegal River Basin in the Islamic  
Republic of Mauritania

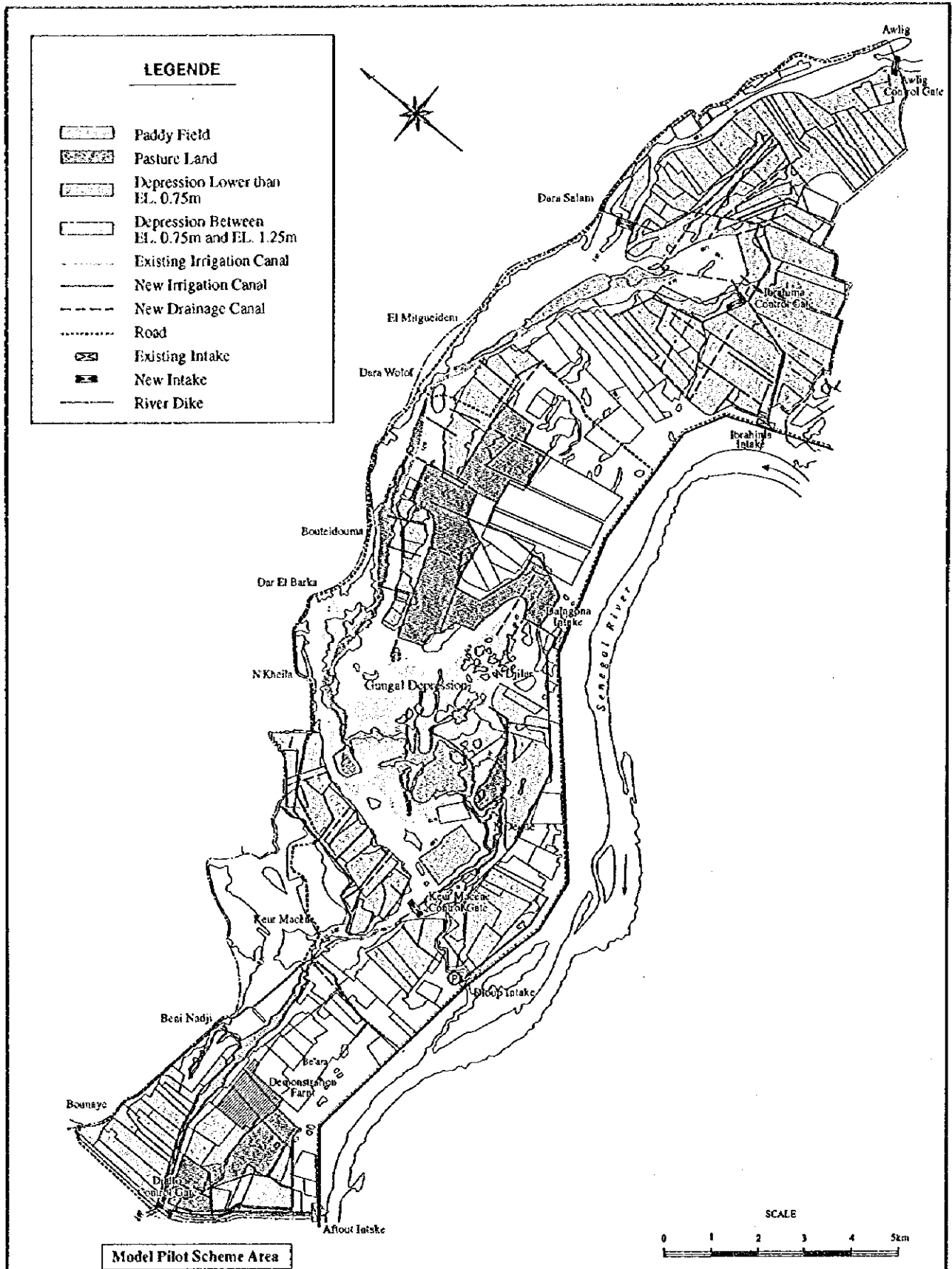


# FOOTNOTES

**LEGEND**

	Project Area
	Senegal River Right Bank Dike
	Canal
	Road
	River
	Village
	Inlet Gate

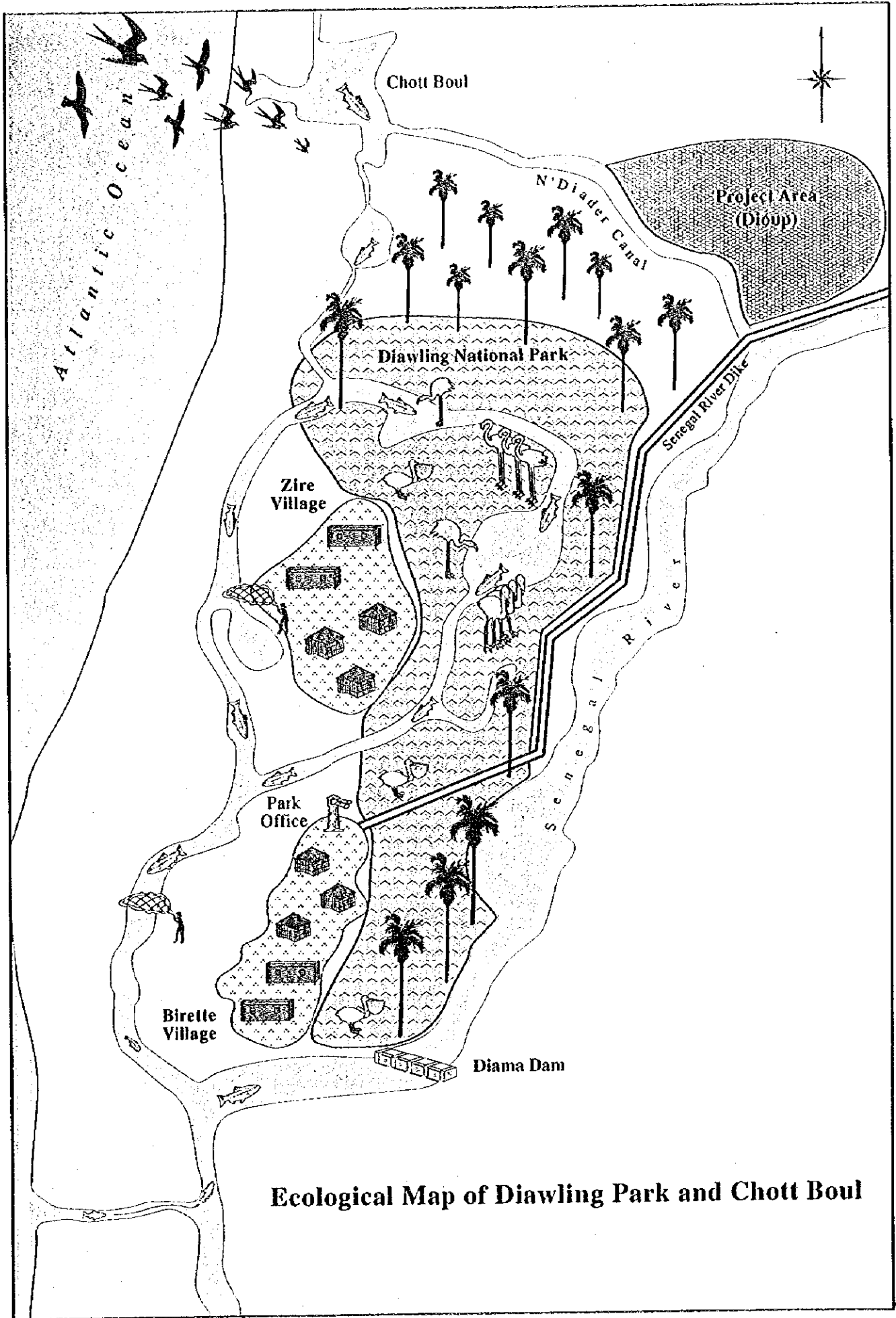




**Irrigation and Agricultural Development Plan**

**L'Etude de Faisabilité du  
Projet de Développement du Système d'Irrigation Agricole  
dans le Haut Delta du Fleuve Sénégal**

Agence Japonaise de Coopération Internationale (JICA)



**Ecological Map of Diawling Park and Chott Boul**

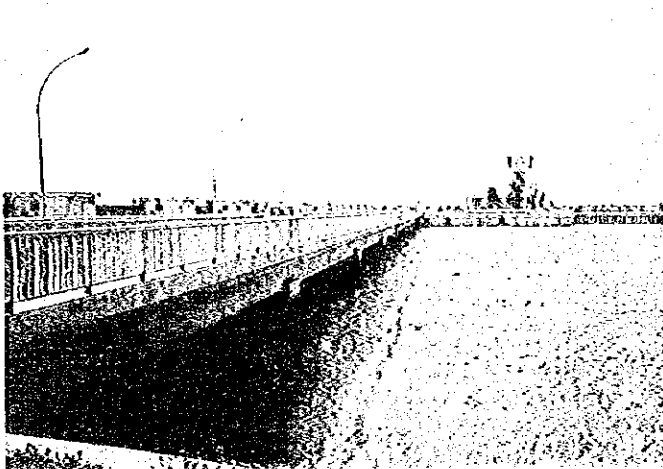
## Views of the Project Area



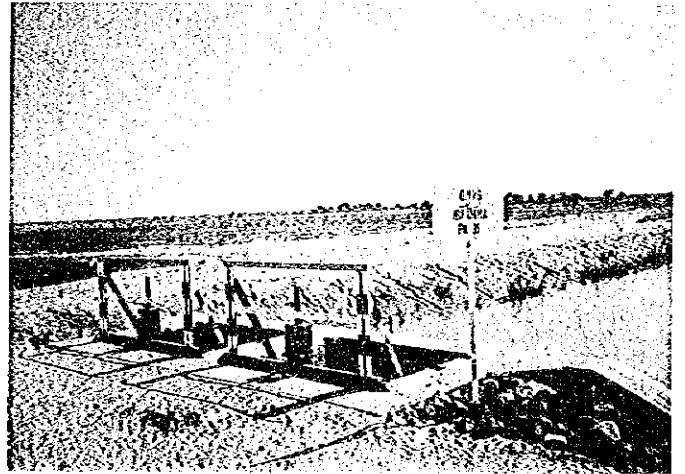
Paddy fields in the project area and field investigation



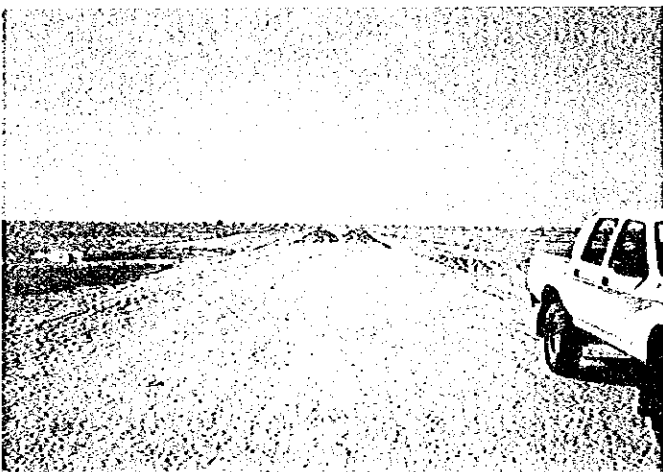
Upland crops field in the project area



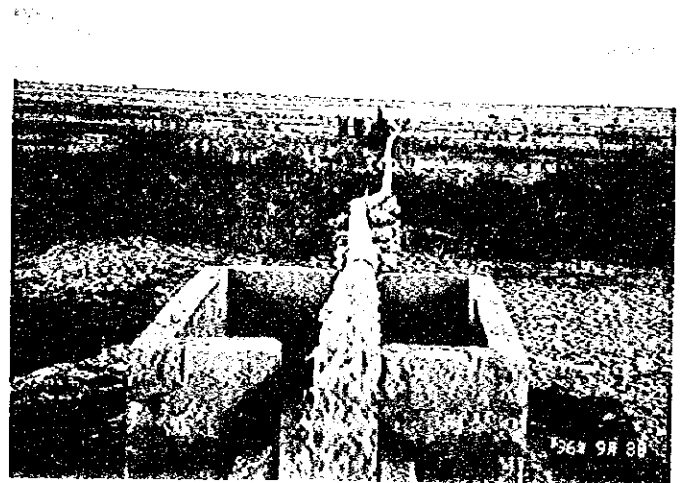
Diama dam at the estuary of the Senegal river



Ibrahima intake gate and view of the project area



Right bank dike of the Senegal river  
(downstream view)

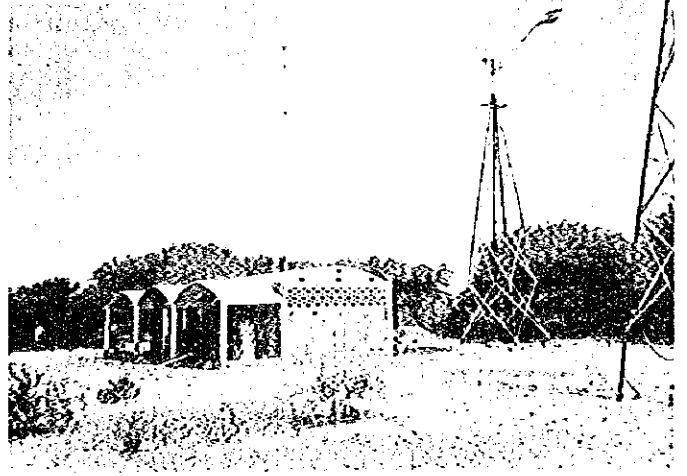


Practice of irrigation

## Views of the Project Area



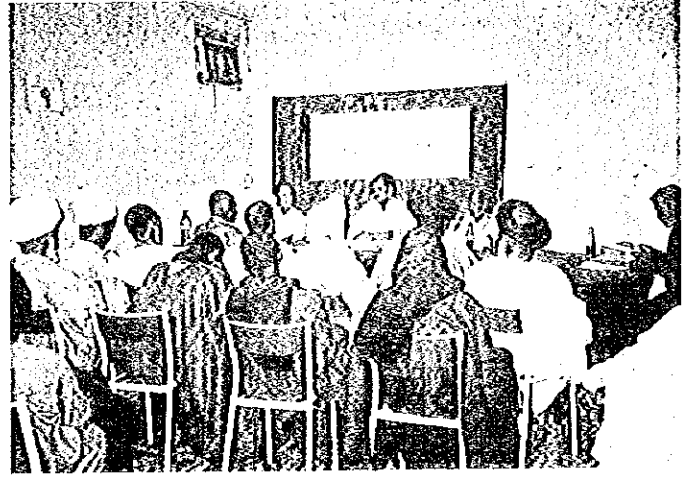
Rural road in the project area and inundated swamp



Potable water supply facility in the Keur Macène village



Farmers household survey



Public meeting with beneficiaries



Desertification control work in the vicinity area



View of Chott Boul



## SUMMARY

### 1. Introduction

#### 1.1 Authority

1. This is the Final Report prepared in accordance with the Agreements on Scope of Work between the Ministry of Rural Development and Environment (MDRE) and the Japan International Cooperation Agency (JICA) signed on March 21, 1997, for the implementation of the Feasibility Study for the Irrigation and Agricultural Development Project in Upper Delta of the Senegal River in the Islamic Republic of Mauritania (hereinafter referred to as "the Study").
2. The objectives of the Study for the area, which has been delineated to cover about 8,000 ha of land in the Dioup area in the Senegal River Delta, are as follows:
  - (a) Execution of a feasibility study of the Irrigation and Agricultural Development Project in the Dioup area in the alluvial plain located on the right bank of the Senegal river, some 150 km south of Nouakchott; the Project will be aimed at improving the living conditions of rural population, increasing food production, and preserving the environment.
  - (b) Transfer of technology to the Mauritanian counterparts through the execution of the Study.
3. The Study was carried out in two phases over two consecutive years. The scope of study works for each year was as follows:
  - (1) First year (1996)
    - a) Preparatory work in Japan
    - b) Phase I field work (rainy season)
    - c) Phase I home work in Japan, preparation of the Interim Report
    - d) Phase II field work (dry season)
  - (2) Second year (1997)
    - a) Phase II home work in Japan, preparation of the Draft Final Report
    - b) Explanation and discussion of the Draft Final Report with the Government of Mauritania
    - c) Preparation of the Final Report

#### 1.2 Background of the Project

4. The commissioning of the Diama and Manantali dams and the completion of the right bank embankment in 1992 have made it possible to irrigate an area of 8,000 ha in the Upper Delta. The people living in the Delta are aware that the increase of agricultural production will improve their living standards. In addition, the proximity of the Delta area to the important centers of Nouakchott and Rosso, as well as its adjacency to Senegal makes it an attraction pole for private investors. In this context, it can be said that the Upper Delta plays an important role in the national food production program and, at the same time, constitutes a pilot area for agricultural development in the valley.

5. However, the lack of appropriate irrigation and drainage facilities seriously hinders irrigated agriculture development in the area. Moreover, the construction of embankment without taking into account the drainage issue has caused some environmental problems, such as increase in soil salinity, deterioration of water quality which is harmful to the health of local people and to the vegetation, and spreading of diseases due to water stagnancy. In consequence, there is an urgent need to rapidly implement irrigation and drainage and agricultural development programs taking due and adequate consideration of such an environmental condition, and aiming at increasing agricultural production and improving productivity of the area.
6. Under such circumstances, the Government of Mauritania requested the Government of Japan in September 1994 to provide technical assistance for formulation of the Irrigation and Agricultural Development Project in the Dioup area located to the west of Rosso. In response to this request, the Government of Japan, through JICA, dispatched a preliminary study mission to the site in March 1996, and the Scope of Work for the Study was signed between JICA and MDRE on March 21 of the same year.

## 2. Agriculture in Mauritania and Agricultural Development Policy

7. The main agricultural products of Mauritania are sorghum, millet, niébé, maize, and rice. The most serious problem that faced Mauritania is the succession of drought spells occurring repeatedly. In a year with normal rainfall, the production can satisfy 1/3 to 2/3 of the cereal demand, but the harvest fluctuates largely from one year to another. The self-sufficiency rate was only 20% during the drought period of 1983 - 1985. The population growth rate is about 2.9% while agricultural production remains stagnant or decreases, such as the case of irrigated rice cultivation. The shortage of food is made by import.
8. The Government introduced an irrigated agriculture development program in May 1993. This program, named "Program of Integrated Development of Irrigated Agriculture in Mauritania" (PDIAIM), constituted a concept for planning to be applied to all irrigated agriculture development projects in the Senegal river valley. The implementation period of PDIAIM is determined to be 10 years from 1996 and consists of two phases. The first 5 years will be devoted to the rehabilitation of irrigated agriculture projects and feasibility studies for new irrigation development projects. The second phase is for the extension of irrigation development. The total amount required for PDIAIM realization is estimated at 33.6 billion UM, comprising 28 billion UM from public fund and 5.6 billion UM from private fund. The public fund consists of 2.8 billion UM to be allotted from the national budget and 25.2 billion UM from foreign financing. This program envisages the construction in 1999 of the irrigated agriculture development project as a first priority project in the Dioup area which forms the present Study Area.

## 3. Present Conditions of the Study Area

### 3.1 Meteorology, Hydrology, Water Quality, and Topography

9. The area has a Sahelian climate characterized by a large fluctuation of temperatures between daytime and night time and low rainfall. Annual rainfall observed in the last 30 years in Rosso ranges from 37 mm to 338 mm, averaging 213 mm. Approximately 90% of rainfall is concentrated in the three months of July, August and September.
10. The functions of the Manantali dam are decided by OMVS after commissioning of the hydropower station anticipated in the year 2000 to guarantee minimum discharge of 250 m<sup>3</sup>/s. This discharge is enough for irrigation of an area of 100,000 ha including drinking water supply in the Senegal river valley. The Diama dam has functions to



prevent sea water intrusion and to store 250 million m<sup>3</sup> water by maintaining the upstream water level at EL. 1.5 m. From the completion of the right embankment of the Senegal river in 1992 until the second half of 1995, the water level was maintained in general at EL. 1.5 m, and thereafter the water level has risen gradually and reached EL. 2.0 m in the second half of 1996.

11. The Study Area is composed of flat lands, ranging from 2.5 m to the deepest bottom of waterway at EL. -0.9 m, while it is presumed that the groundwater level within the Study Area varies between EL. +1.2 m and -0.5 m. Since irrigated agriculture development may change the groundwater level, it is necessary to continue to observe this level and at the same time to monitor salt illuviation at the soil surface.
12. Since irrigation water will be taken from the Senegal river, measurements of pH value, electric conductivity and salinity of the river water were conducted upstream of Ibrahima. The water quality of the Senegal river has the following general values: pH = 7.4 - 7.6, EC = 0.06 - 0.44 mS/cm, salinity = 38 - 282 ppm, and is considered quite acceptable for irrigated rice cultivation. As for the wells water being used for drinking in villages, the presence of bacteria of intestinal origin, of E. Coli type, is an indication of water pollution caused by faeces and presents a risk of disease for the population who consumes this water.

### 3.2 Soils and Land Suitability

13. The soils in the Study Area were classified into three soil types, namely Eutric Gleysol, Eutric Fluvisol and Chromic Vertisol. The soils in the Study Area are physically characterized by poor natural internal drainage due to the presence of clay. Soil salinity is a main chemical factor limiting agricultural production in the Study Area at different degrees. It was observed that in most places where salinity has diminished, irrigated rice cultivation had been introduced. Accordingly, the reduction in salinity is likely due to the leaching effect of irrigation. It is recommended to conduct a systematic monitoring program in order to evaluate the tendency of eventual changes in salinity in soils which might directly affect productivity.
14. Suitability of lands in the Study Area was assessed according to the "FAO Framework for Land Evaluation". The results are summarized below. The land use types taken into account in the assessment are rice cultivation and pasturage.

(Unit: ha)

Land Suitability Class	Land Use	
	Rice Cultivation	Fodder Production
Highly suitable (S1)	810	1,720
Moderately suitable (S2)	330	5,500
Marginally suitable (S3)	1,100	2,150
Provisionally unsuitable (N1)	4,140	340
Unsuitable (N2)	7,080	3,750
Others	270	270
Total	13,730	13,730

Class N1 covers a large area but most of this area can eventually become suitable (S2 or S3 class) if an effective irrigation and drainage system is installed and proper soil management is introduced. Lands classified as unsuitable in N2 class are those presenting extremely severe constraints such as considerably high salinity and/or very difficult drainage which prevent rice cultivation and pasturage.

### 3.3 Agriculture and Present Constraints

15. The Study Area has an area of 13,730 in total, and the present land use is summarized in the table below:

Land Categories	Gross Area (ha)	Ratio (%)
Wild meadow	2,620	19.0
Meadow with bush	380	2.8
Paddy field	860	6.3
Marshland	4,590	33.3
Seasonal marshland	1,690	12.3
Shrubby forest	110	0.8
Dry field	50	0.4
Water area	910	6.6
Forest	50	0.4
Bare land	1,790	13.0
Dune	100	0.7
Village	10	0.1
Borrow area	570	4.2
<b>Total</b>	<b>13,730</b>	<b>100.0</b>

The total developed area is 4,650 ha, of which 700 ha belong to cooperatives and 1,610 ha to private farmers, and the remaining 2,340 ha have not been registered. The paddy cultivated area in the 1996/1997 rainy season is estimated to be 860 ha (770 ha net), consisting of 90 ha cultivated by cooperatives, 120 ha by private farmers, and 650 ha by unidentified farmers (non registered). A large area of cultivable land has not been used due mainly to the lack of irrigation and drainage infrastructure, soil salinity, flooding, and insufficient farm budget.

16. The most important production in the area is that of paddy cultivated by both private farmers and cooperatives. Other products are onion, sweet potato, tomato, egg-plant, okra, niébé, pumpkin, melon, water melon, as well as maize and sorghum cultivated in small areas. The paddy is planted mostly by broadcast sowing in submerged paddy fields. The land is plowed and harrowed by tractor. Smallholding farmers prepare the land manually. Animal draft is not used at all for land preparation. The average dosage of fertilizer is 100 kg of urea and 50 kg of TSP per hectare. Weeding is usually done by hand but some individual producers use herbicides. Damage caused by weeds (in particular for millet, sade and awekhaye) is so severe that harvesting is even abandoned in some paddy fields. The rice varieties adopted are limited to JAYA, TN 1, IR 28 and IKP. JAYA and TN 1 are applied by 80% of farmers. Damage to paddy is generally caused by birds. Clouds of leafhoppers appear from time to time. Damage caused by rodents and insects is also observed but it is minimal. Herbicides are used in some individual farms but pesticides are not used at all. Some fields suffer from serious damage caused by the increase of salinity.
17. Double rice cropping has never been practiced in the Study Area. The land is not cultivated in the dry season due to havoc caused by birds, lack of irrigation water, absence of adequate species (early species), etc. Paddy yield substantially differs from one farm to another, ranging from 5.0 to 0.4 tons/ha and averages 1.1 tons/ha. The extremely low yield is due to damage caused by weeds and salinity. Assuming an average yield of 1.1 tons/ha, it is estimated that the total rice production in 1996 in the Study Area was 870 tons from the cultivated area of 770 ha of paddy fields. Major factors hindering sustainable agricultural development with high productivity are: (i) insufficient irrigation and drainage facilities and high salinity; (ii) lack of

support services and efficient techniques; and (iii) inadequate marketing of agricultural inputs and products.

### 3.4 Pasture Management and Present Constraints

18. The total number livestock such as bovines and ovines in the 10 villages in the Study Area is 10,170 heads (4,240 TLU). The maximum number of animals kept per household is 7 - 8 heads, and the minimum is 0.2 head. The stock farming method observed in and around the Study Area is classified into three types: (i) seasonal herdsmen; (ii) sedentary breeding; and (iii) transhumance. The majority of oxen and cows in the Study Area are of two species: Maura and Peulh, and a herd of cattle consists of 50 to 60 heads. The pasture lands in the Study Area consist, depending upon purposes and periods, of three types of pastures on dunes, pastures at the foot of sand dunes, and lowland areas (Faux Holladé, Holladé).
19. Natural meadows are utilized mainly for grazing. The vegetation of these meadows is a mixture of herb species, in particular graminaceae. Fodder production in the rainy season in the Study Area is estimated to be 610 tons in dry weight. Fodder demand for the cattle in the 10 villages involved in the Project amounts to about 630 tons per month. Most cattle graze in meadows located in sand dunes because pasture lands inside the site are practically limited in the dry season. The animals return from the sand dunes when the rainy season's grass withers and consume it in less than a month. They then feed on the grass that grows in the dry season at the river-side and on paddy straws. However, feeding of milch cows on concentrates starts to become popular. The constraints and issues being observed or to occur with the continuation of stock farming in the Study Area would be: (i) issues resulting from the enactment of land ownership law; (ii) damage caused by animals to farmlands; and (iii) deterioration of the environment

### 3.5 Social and Agro-economic Conditions

20. The number of households in the 15 villages is 1,740. The average family size is 6.4 people. The total population of the area is about 11,180. The most serious problem is the lack of road infrastructure followed by the lack of public welfare facilities, especially those for drinking water supply, dispensaries, etc. The most frequent diseases are malaria, bronchitis, and microbial diarrhea. Keur Macène village has a primary school and a high school with eight classrooms but other villages have only 2-classroom primary schools with deteriorated buildings.
21. Economic activities of villagers consist mainly of agriculture (cultivation and stock farming at the same time), followed by stock farming, fisheries, trade, working as employees, and handicraft production. According to the results of an agro-economic survey on 103 households in 12 villages in the Study Area, the average family size is 8.5 persons (4.3 men and 4.2 women), of whom 4.4, i.e. 52%, are in the working age (both men and women aged 16 to 54). Working women account for 52%, i.e. more than half of the total working population. With regard to activities by profession, 72% of the total number of inhabitants (874) of the 103 households constitutes the working population and 73% of this is engaged in agriculture (cultivation).
22. The total cultivated area of both private farms and collectives is 11.9 ha on average, however, 34% of the total number have small size farms of less than 2 ha. The farm income of the households that farm on a small scale of 1 to 2 ha with single cropping per year, is not sufficient for their living and they have to resort to other income sources such as migrant work of male adults (in Nouakchott, Rosso), sale of cattle and milk, vegetables, handicraft goods (local mats), etc. produced by women groups.

### **3.6 Farmers' Organizations**

23. At present, there are about 50 cooperatives in Keur Macène area. Half of these cooperatives are cooperatives of male farmers. All of the male cooperatives in the area are having debts averaging 1,000,000 UM per cooperative due to poor harvests. These cooperatives are therefore unable to continue their activities in the last few years. On the contrary, despite a lack of financial means, the women's cooperatives are considered more active than the male cooperatives, especially in handicraft production. Problems facing farm cooperatives at present are: (i) existence of many cooperatives; (ii) possible existence of bad cooperatives; (iii) cooperatives organized solely for the purpose of obtaining lands or financing; (iv) insufficient supporting system for activities of farmers' cooperative; and (v) lack of enough knowledge of the importance and functions of cooperatives.
24. Besides farm cooperatives promoted by SONADER, other agricultural organizations performing in the Senegal river valley include AGETA and FAEM. AGETA is an association established with foreign assistance while FAEM is an organization of farmers-stock breeders. AGETA, among others, is a special association established in 1990 with French assistance under the jurisdiction MDRE, and plays the role of promoting initiatives of the private sector in agricultural development through extension of farming techniques and training of farmers. The main activities of AGETA are : (i) extension of modern techniques for rice cultivation and fruit and vegetable cultivation; (ii) training on technology of farm equipment; and (iii) supply of improved paddy and vegetable seeds. With regard to FAEM, their objectives are to support economic activities and production, and protection of the rights of farmers and stock breeders of Mauritania together with supporting services such as guarantee, intervention and guidance to attain maximum harvests.

### **3.7 Marketing and Processing of Agricultural Products**

25. The paddy production remains insufficient for national demand. During the last three years, an average rice deficit of 78,700 tons was observed. The deficit amount and the food security stock must be made up by imports, and the quantity of imported rice continues to increase due to the existing imbalance of supply and demand. The increase in rice import hinders the marketing of local produce to a large extent. Upon instruction by the Government in 1995, SOMINEX (National Import-Export Company) and private farmers' groups and importers have established an association called "POOL" which has the function to purchase all local paddy produce before importing rice from foreign countries. Official paddy prices fixed by the Government increase every year: 32.0 UM/kg in 1994/1995, 36.0 UM/kg in 1995/1996, and 45.0 UM/kg in 1996/1997. All the members of POOL purchase paddy according to its official price and its quality.
26. Most of rice produced in the Study Area is sold directly to the association at farm gate then transported to rice mills or to small units in Rosso city. After milling, rice is sold to merchants or wholesalers in Nouakchott, other Wilayas, or Rosso city. Vegetables such as tomato, onion and others are sold in Rosso and Nouakchott markets. Rice production in Rosso reached 16,880 tons in the 1995/1996 harvest season, while the treatment capacity was 36,000 tons.

### **3.8 Agricultural Support Organization**

27. SONADER had been playing the principal role in agricultural extension in Mauritania since a long time. The fundamental task of SONADER is to help improve productivity of farmlands of cooperatives which already possess irrigation and drainage facilities, as well as to promote activities of cooperatives. Agricultural extension services are carried out through SONADER Head Office and five Regional Offices with 83 staff. Agricultural extension personnel in SONADER Regional

Offices is composed of Specialists on Farmer Organization and Extension Supervisors, under management of the Operation and Maintenance Section. The Basic Extension Officers (AVB) organize their extension activities through farmers' organizations. The Regional Office in Rosso has eight AVBs who undertake extension services under supervision of 2 chiefs. One AVB stationed in Keur Macène provides primary guidance on promotion of establishment of cooperatives and agricultural extension by visiting the villages one after another with a motorbike. SONADER's agricultural extension services are having several problems such as maladjustment of extension activities, farmers' distrust of SONADER and insufficiency of farming techniques suitable to the site.

28. MDRE is responsible for agronomic research through the four main research agencies: (i) Research, Extension and Training Department (DRFV); (ii) National Agronomic Research and Development Center (CNRADA); (iii) National Stock Farming and Veterinary Research Center (CNERV); and (iv) National Rural Development Company (SONADER). The above organizations suffer in general from defective research equipment and lack of researchers and research fund, therefore they are not yet capable of forming a sufficient supporting system for agricultural development at present.

### 3.9 Agricultural Credit

29. In 1992, the Mauritanian Government established an autonomous agricultural credit institution called the National Union of Cooperatives of Agricultural Credit and Savings of Mauritania (UNCACEM) with assistance of France, Germany and the World Bank. At present UNCACEM is facing several difficulties: (i) a high ratio of non performing loans possibly leading to complete strangulation of the institution; (ii) lack of strictness in management due to lack of experience of administrators; (iii) absence of a long-term credit system; (iv) absence of expeditious judicial mechanism for legal actions against bad debtors; and (v) insufficiency of proper resources due to limited collection of savings.

### 3.10 Irrigation and Drainage

30. In 1991 SONADER has formulated the General Upper Delta Development Plan, entitled "Study on Construction of Hydraulic Infrastructure in Upper Delta of Mauritania". This plan covers the 3 areas of Gouère, Dioup, and N'Diader, located downstream of Rosso in the Upper Delta. The development of the Dioup area is aimed at pasture development in low depressions between EL. 1.25 m and EL. 0.75 m over a total area of 2,500 ha, and irrigated paddy development with an area of 2,630 ha at elevation over 1.25 m. Excess water is drained towards Chott Boul through the existing N'Diader canal which needs rehabilitation for allowing the discharge of 22 m<sup>3</sup>/sec.
31. In the Study Area there are 4 intake structures on the right embankment: The Ibrahima, Dalagona, Dioup, and Aftout intakes, from upstream to downstream. All these structures have been constructed by OMVS. The Study Area is surrounded by a series of 4 main waterways: Ibrahima, Dioup, Diallo, and Aftout, from east to west. The Ibrahima and N'Diader canals consist of excavated canals over the lengths of 3 km and 600 m respectively, and of natural waterways and depressions in the remaining sections. There is none drainage system in the Study Area. Irrigation waters disappear by evapotranspiration and seepage in the fields. Excess waters are stored in 2 depressions in the Study Area: Gungala and Yoraye. There are no discharge outlets for waters accumulated in these depressions. In addition, the area on the west edge of the Study Area is severely flooded resulting in non-cultivation of paddy, due to the need to raise the water level of the N'Diader canal in order to irrigate farmlands downstream of the canal.

32. The effectively cultivated and irrigated area of paddy fields in 1996 was 859 ha gross covering 30 blocks. Cultivated fields are concentrated in some areas, especially in Awlig, Ibrahima, Keur Macène, and the western part of Beni Nadji. Aerial photographs taken in December 1992 show some cultivated fields of about 580 ha in gross area, mainly along the Awlig and Dioup canals as well as in N'Degue and in the west of Keur Macène. The cultivated area of paddy fields slightly varied between 1992 and 1996, but in general it was the same.
33. The role of SONADER in operation and maintenance of the existing irrigation system in the Study Area is to control the intake gates installed on the embankment of the Senegal river within the Study Area, namely the Ibrahima, Dioup and Aftout gates, through OMVS, as well as to maintain the 3 km long Ibrahima irrigation canal and 0.6 km long Aftout canal. There is no fixed schedule for operation of these intake gates. SONADER requests OMVS to operate them according to the request of farmers. At the level of farmlands, which belong either to cooperatives or to private individuals, the owners undertake O&M of irrigation and drainage facilities in their own lands. In general, all the canals and their related irrigation and drainage system are not well built and maintained.
34. There are more than 10 depressions in the sand dunes located along the northern edge of the Study Area. At the public meeting held during the Phase-II field work, attendants expressed some opinions indicating the necessity of construction of hydraulic facilities to supply water to these depressions in order to increase the pasture potential of this area. For 6 depressions as the result of field investigation, it is proposed to install gated conduits under the roads to be constructed and approach canals connecting these conduits and the water sources for 2 reasons: (i) prevention of seepage of floodwater from the depressions into the Study Area, and (ii) storage of rainwater in the depressions in the rainy season for utilization for traditional pasturage,

### 3.11 Rural Infrastructure

35. The road network in the Study Area is composed of: (i) a road connecting the Ibrahima gate to the Aftout gate, running along the right embankment of the Senegal river (approx. 22 km); (ii) a road between Keur Macène and the right embankment (approx. 3 km); and (iii) a road from Keur Macène to Bounaye (approx. 6 km). Besides, there is a path connecting Keur Macène to Dara Salam (approx. 28 km in the Study Area) which has been formed by frequent passage of vehicles. Traffic of this path is very difficult in the rainy season. Almost all villages in the Study Area use well water or river water directly for drinking and domestic use. There are only 2 water supply stations in the Study Area. They are located in Keur Macène and Awlig. The Keur Macène station is more modern and consists of a treatment plant, a regulating reservoir, and a distribution system. Water is pumped up from the Diallo depression, stored and filtered at the station. The distribution system consists of a pipeline conveying water to each tap in Keur Macène village.

### 3.12 Project Management System

36. The irrigation project in the valley of the Senegal river has been implemented under the responsibility and management of SONADER. The SONADER head office undertakes the supervision of construction works by assigning its personnel to the site. The facilities have to be transferred to the project beneficiaries after completion of construction works. SONADER adopts the following 2 methods of operation of the projects upon their completion, based on the project size. For small-size projects (20 - 50 ha) or medium-size projects (50 - 200 ha), the project management is handed over to the farmers immediately after the completion of project facilities. For such large-size projects as the Boghé, Kaédi, and Foun Gleita projects, O&M of less important facilities (under tertiary canals) are undertaken by farmers and O&M of

more important facilities (above secondary canals) by SONADER, in principle. For this, farmers organize the beneficiary group to take charge of O&M of the project after completion of works. SONADER continues providing assistance to the group until it becomes fully competent in cooperative management.

37. The problems of the project operation system in the Senegal river basin may be summarized as follows:

- (i) As many beneficiaries and villages are involved in case of large scale project, the organization of beneficiaries and the establishment of an operation and management system take a lot of time and require long coordination on many aspects. The users' associations cannot adequately adapt themselves to the project management, due to the complexity of project components and the large number of beneficiaries.
- (ii) The agricultural development projects of a large scale implemented up to the present had not adequately taken into account the socio-economic context and local adaptability of techniques in the project design phase, so that farmers are able to operate them effectively. As a result, there are many cases in which the project O&M by farmers after handing-over of project facilities are not done so effectively.
- (iii) Since farmers have not sufficient financial means, they could not pay maintenance charge for projects completed in the past; this fact leads in many cases to difficulties in operation and management of the entire project.
- (iv) Due to the fact that SONADER still has neither experienced trainers nor training programs aimed at improving farmers' capability in operation and management of projects, it is essential to improve these issues during the implementation of future projects. SONADER is strengthening its structure through the execution of a certain number of big projects.

### 3.13 Environment

38. Within the framework of international cooperation, many studies on the environmental aspects have been conducted for Mauritania. These aspects include in particular the problems of desertification, and those relating to the development of the Senegal river basin. Many partners assist the Government of Mauritania in dealing with a large spectrum of environmental challenges. Among others, IUCN (International Union for Conservation of Nature) provided technical assistance for formulation of strategies on environment and conservation of biodiversity of Diawling National Park (PND) located in the vicinity of the Study Area. PND has been created in 1991 over an area of 15,600 ha of former flooding area of the Lower Delta, and has been included in the list of wetlands of international importance (Ramsar Convention) since August 23, 1994.
39. On the periphery of PND there exists the Chott Boul area over which the National Navy Department has a particular concern. In addition to this military interest, important censuses of species of piscivorous and nest-building birds and remarkable fauna and floral species have been conducted in the area. This has induced the National Navy to classify the area's natural reserves under its jurisdiction and submit a draft decree on this matter. If the decree is signed, IUCN plans to promote the inclusion of this area in the Ramsar Convention.
40. The following table summarizes the major points of IEE for this development project.

### I. Natural Environment

	Categories of Impacts	Evaluation	Positive Impact	Negative Impact	Evaluation Basis
1.	Salinity and Deterioration of Water Quality	A	O		Some developed lands are left uncultivated due to loss of fertility resulting from excessive salinization or excessive flooding without possible drainage. The encountered problems will continue to remain with the implementation of the Project, however, the latter will remedy this condition in most of the area by improving the drainage problems.
2.	Desertification, Degradation of Hinterland, and Deforestation	B	O		Desertification constitutes a serious problem of the area. This is aggravated by overgrazing, human actions, and drought. Many sand dunes are observed. The envisaged development will reclaim vast land areas, causing a reduction in vegetation. The Project, however, will propose measures for improving and controlling desertification and sand deposition.
3.	Effects of Lagoonal Formation by Drainage Waters and Impact on Wet Ecological Areas	B		O	The presence of wet ecological areas (PND and Chott Boul) is observed in the vicinity of a potential area for discharge of drainage waters. If this drainage alternative is adopted, this will generate harmful effects on the environment of these areas.

### II. Social Environment

	Categories of Impacts	Evaluation	Positive Impact	Negative Impact	Evaluation Basis
1.	Population Settlement and Involuntary Exodus	B		O	It is possible that the new development activities will attract settlement of new population, in particular nomads and new landowners. This will lead to the monopolizing of land ownership by foreign investors in the area and an accumulation of pressure on lands and pastures. On the other hand, the risk of flooding in the area may cause exodus of part of the population if adequate preventive measures are not taken.
2.	Spread of Water-born Diseases	A		O	With the development of rice cultivation and the impounding of land parcels in a longer period, these diseases will increase.
3.	Conflicts between Communities and People	B	O		Risks of conflict between farmers and stock breeders will always subsist, even though local authorities confirm differently.

(SIE: Sensitive Impact on Environment)

A : SIE will undoubtedly be induced by the Project

B : SIE will probably be induced by the Project

### 3.14 Women in Development

41. Women groups have been organized in the Study Area to promote handicraft production and fruit and vegetable cultivation on small family farmlands. Many



groups are engaged in both activities. Most popular handicraft products are mats (carpets) which are sold in Keur Macène and Rosso markets. In addition, in Keur Macène a group of about 50 women members manufactures clothes with 5 sewing machines. The major problem facing women groups generally in handicraft production is the lack of capital for construction of adequate buildings for their work, as well as for purchase of equipment and tools. With regard to fruit and vegetable cultivation, the most serious constraints to production are the lack of fund and price increase that restrict the purchase of equipment and inputs such as seeds, fertilizer, and irrigation pump. But in spite of this fact, women are very active and cooperative. At present most of women groups are registered as female cooperatives.

### **3.15 Public Meetings with Beneficiaries**

42. Two meetings were held on February 18 and March 12, 1997 in the Regional Office of SONADER in Rosso. The meetings' objective were to explain the main features of the development plan in the Study Area to the beneficiary farmers and local governmental agencies concerned, to grasp the problems and their wishes relating to the development plan and to reflect them to the project formulation. The principal requests by the beneficiaries were: (i) irrigation water supply; (ii) development of pastures; (iii) formulation of a pasture development plan that will not incite traditional conflict between farmers and stock breeders; (iv) drinking water supply and development of farm roads; (v) water supply to the desert depressions located at the northern edge of the Project area; (vi) concrete support plan for women groups; (vii) development of equipped farmlands to compensate for the loss due to the construction of the embankment of the Senegal river; (viii) protection of houses against flooding; and (ix) technical assistance from foreign countries. For smooth implementation of the Project as well as its operation and maintenance, the Study Team requested to confirm the following subjects to the beneficiaries: (i) establishment of AUD; (ii) necessity of strengthening of farmers' organizations; among others, joint management of pastures through the creation of a future cooperative; and (iii) operation and maintenance of the Project facilities by the beneficiaries at their own costs.

## **4. Formulation of the Irrigated Agriculture Development Project**

### **4.1 Basic Development Concept**

43. The irrigated agriculture development in the Study Area is focused on improvement of the living standards of local farmers and stock breeders as well as on assistance in establishing a stable food supply system, following the basic development initiatives mentioned below:
- a) Increase of agricultural production and income through extension of improved agro-pastoral techniques and through construction of irrigation and drainage facilities;
  - b) Improvement of living conditions through development of rural infrastructure; and
  - c) Preservation of the natural and social environment inside and outside the Project area.
44. The Project area is bounded by a road connecting Keur Macène to Rosso to the north, covering Tifaj and the Bounayatt depression in the sand dunes, by the Senegal river embankment to the south, the western edge of the Gouère area to the east, and the Aftout canal to the west. The total Project area is 13,730 ha. The basic development system to be adopted in the area is aimed at the 2 targets of (i) promoting double cropping of rice which is the main staple food, and (ii) ensuring and improving

traditional pasture lands. In view of the factors limiting agricultural development in the area, it is indispensable not only to develop agricultural and rural infrastructure but also to strengthen various supporting services such as extension, improvement of marketing facilities and system, etc. in order to ensure successful agricultural development. The Project development plan will be formulated taking into consideration the following 2 aspects:

- a) The facilities completed under the Project will be handed over to the beneficiaries and the latter will be responsible for their O&M and management. Therefore, the facilities shall be properly operated, maintained and managed according to the technical level of the beneficiaries.
- b) The Project implementation shall not exert any strong impact on the natural and social environment not only in the Project area but also in the adjacent areas.

#### 4.2 Basic Agricultural Development Plan

45. Paddy and fodder production as well as partial production of fruit and vegetables are the direct objectives of irrigated agriculture development. Considering the technical level of farmers in the area and limiting factors for development, it is proposed to implement the irrigated agriculture development by setting the objectives for phase-wise development as follows:

Phase 1 -->	Phase 2 -->	Phase 3
<u>Paddy and Vegetable Cultivation</u> -Cultivation of paddy at 100% in the rainy season by direct sowing and transplanting method. -Cultivation of various cereals such as sorghum in the dry season. (Grazing in arable lands is partially possible in the dry season)	-Cultivation of paddy at 100% in the rainy season and partially in the dry season. Sorghum, etc. are cultivated partially. -Double rice cropping by advanced farmers.(Grazing in arable lands is possible in the dry season)	-Double rice cropping at 100%. (Grazing in arable lands is possible in the dry season)
<u>Pasture and Stock Farming</u> -Introduction of paste management and fodder production by stock breeders (or breeder groups). -Introduction of semi-intensive stock farming practice. -Review of solutions to problems on land use with rice growers under a new land system and a new land law	-Improvement of pasture management by stock breeders (or breeder groups). -Clear division of land use (pasture or paddy field) by farmers. -Solution of problems on land use with farmers who practice double rice cropping	-Expansion of semi-intensive stock farming. -Solution of land problems between stock breeders and farmers, and coexistence of both parties.
<u>Support Services</u> -Experimental and demonstration farm: Construction and operation for strengthening of support services -Introduction tests, demonstrative cultivation and provision of crop and fodder seedlings of good quality. -Dissemination of new land system and new land use method to stock breeders inside or outside the Project area. -Improvement of facilities for marketing and processing of agricultural materials and crop products. Instruction on operation to the private sector.	-Development of techniques for double rice cropping, fodder production and fruit/vegetable cultivation. -Dissemination of double rice cropping and fruit/vegetable cultivation techniques to advanced farmers. -Improvement and dissemination pasture management techniques to stock breeders -Development and dissemination of semi-intensive stock farming practice. -Establishment of an effective system of operation of facilities for marketing and processing of agricultural materials and crop products by the private sector.	-Continuation of instruction on techniques for cropping improvement. -Continuation of execution of tests on introduction of higher quality species, and of development and dissemination of farming techniques. -Development and dissemination of semi-intensive stock farming practice. -Continuation of effective operation of facilities for marketing and processing of agricultural materials and crop products.

46. The basic criteria for land use for irrigated agriculture development in the Project area are as follows:

**Elevation** : The lands with an elevation of over 1.25 m will be used for paddy cultivation, those with EL. 1.25 - 1.00 m for pasture, and those with EL. below 0.75 m will be submerged. For the South Diallo area, seasonal marshlands located between EL. 1.75 and 2.00 m will be used for pasture development.

**Soil** : Based on the results of soil survey, all unsuitable lands, except those utilizable after slight improvement, will be excluded from the development area.

The land use plan is summarized below:

Land Type	Area (ha)	(%)
Paddy field	3,940	28.6
Pasture	790	5.8
Marshland, water surface	5,790	42.2
Shrub, bare land, etc.	3,210	23.4
<b>Total</b>	<b>13,730</b>	<b>100.0</b>

47. The primary cropping pattern was determined to meet the phasewise development objectives mentioned above, and is shown below:

Development Phase	Proposed Cropping Pattern	
	Rainy Season	Dry Season
Phase 1 (Beginning of development)	100% paddy cultivation	100% sorghum cultivation, etc.
Phase 2 (Transitional period)	100% paddy cultivation	50% paddy cultivation, 50% sorghum cult., etc.
Phase 3 (Completion of development)	100% paddy cultivation	100% paddy cultivation

The rice farms in the Project area are divided broadly into small-size farms (0.5 to 1.0 ha/farm) consisting mainly of farm cooperatives, and individual farms each having about 30 ha of land on an average (maximum area is 300 ha). Most farms of all types in the area are adopting the method of direct sowing in submerged condition for paddy cultivation. It is proposed, in principle, to continue to apply the same method of direct sowing for large-size individual farms. As for small-size farms, standard transplanting is recommended to be practiced by farms which are relatively small in area but capable of securing necessary labor for paddy re-planting. The equipment required for double paddy cropping of 3,940 ha is: 22 combine harvesters, 9 tooth plows, 13 disc harrows, and 11 rotavators for plowing and harrowing. A total of 33 tractors will be used for successive plowing and harrowing.

48. The Project is aimed at ultimately reaching a yield of 5 tons/ha of paddy cultivated in the rainy season and in the dry season respectively. As for sorghum, a yield of 4 tons/ha is adopted as a target yield. It is envisaged that these yields will be attained 5 years after commencement of crop cultivation according to the practices proposed for the Project. The present production is about 850 tons from a rice cultivated area of 770 ha. Compared to the "without Project" condition, the production will increase by about 38,500 tons per annum owing to the completion of the Project.

### 4.3 Pasture Development Plan

49. The basic criteria for development of pastures are as follows:

- The State (its executing agency) will undertake the development of pastures;
- The area of pastures to be developed is 790 ha (net area);
- The beneficiaries (stock breeders or their organizations) will take charge of O&M and management of pastures after their development; and
- The cattle in the villages concerned will benefit from favorable effects of the development.

Species which develop extensively in wild condition but are easily adaptable such as wood millet grass and fine short grass will be planted mainly, considering the availability of seeds and plants, ease of crop management, and technical level of stock breeders. It is envisaged at the same time to introduce and extend the production of quality fodder by cultivating a mixture of leguminous and gramineous plants through the experimental and demonstration farm.

50. Alternate grazing will be introduced for effective utilization of pasture lands. These lands will be divided into grazing areas where cattle grazes for 4 days. A herd of bovines is assumed to be composed of 50 heads (young and adult animals together). The area required annually for a herd of bovines is 20 ha, i.e. 5 grazing areas. Techniques concerning irrigation, fertilization, alternate grazing, and additional sowing will be introduced in order to ensure fodder production throughout the year, and maintain the intensity and composition of grasslands. Salt leaching, weeding, disposition cutting, and burning will also be introduced in order to avoid decrease of productivity due to soil degradation, weeds, as well as damage caused by plant diseases and insects. In addition, pastures will be renewed appropriately to maintain their production potential. Renewal will be done approximately every 10 years. The expected fodder production per ha is about 6.7 tons (dry fodder) per year, consisting of quality fodder with a mixture of graminaceae and leguminosae. or about 5,300 tons (dry fodder) in total for 790ha pasture land.

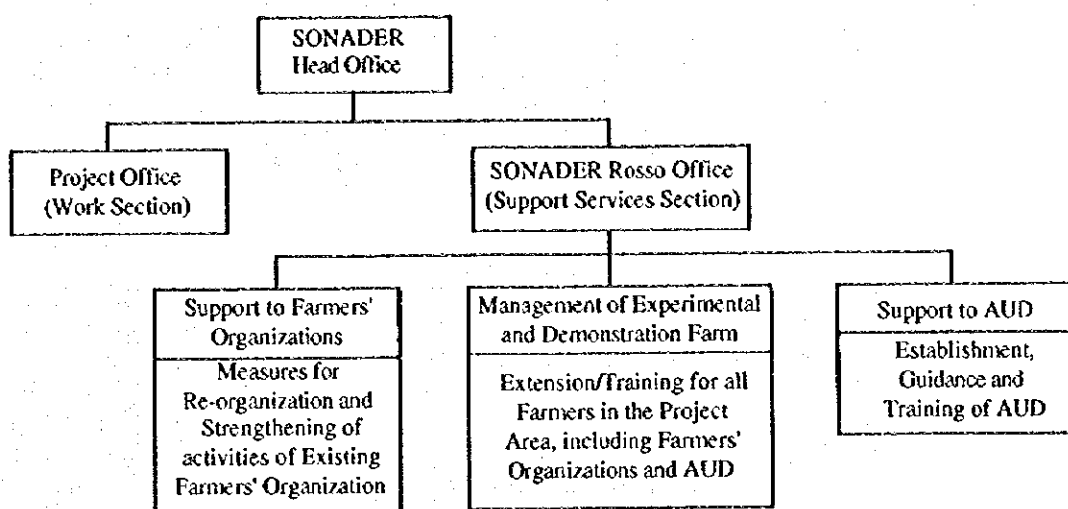
51. However, taking into account the present conditions of farmers' organization, support system, technical and financial capabilities of support organizations, it is deemed difficult to develop semi-intensive stock farming simultaneously in all pasture lands. Therefore, it is recommended to promote improvement in certain parts then the effects will be extended to the remaining area. More concretely, advanced farmer groups will be selected from farm cooperatives and guidance on pasture management and livestock production will be provided to them in intensive development areas to be determined at the same time. The effects obtained in these areas will be disseminated to surrounding areas. It is recommended to implement of fodder production plan indicated below following this method for a period of 10 years:

Objectives	Phase 1 (3 years)	Phase 2 (3 years)	Phase 3 (4 years)
Rate of attainment of target production (%)	50	80	100
Fodder production (dry fodder, ton)	2,650	4,240	5,300
Feeding potential (cattle: head/year)	1,000	1,600	2,000

### 4.4 Agricultural Support Services Strengthening Plan

52. The agricultural support services under the Project will be undertaken mainly by SONADER in coordination with other institutions concerned. The implementation

system of the initial support program under the Project can be summarized as shown in the following diagram:



The support services will consist of the following components:

Type of support services	Project office	SONADER Rosso office	Gov. agencies concerned	Other org. concerned
Construction	●	◎		
Strengthen cooperatives & WID		●		
Operation of Demonstration Farm		●	◎	○
Agricultural extension and training		●	◎	○
Guidance & training of AUD		●	◎	○
Basic culture, primary education		●	◎	○
Supply of equipment		●	◎	○
Store, commercialize & market		●	◎	○
Agricultural credit		○	●	○
Agricultural research		○	●	○

Note ●: Principal role, ◎: Secondary role, ○: Partial participation

53. An experimental and demonstration farm will be established in order to strengthen SONADER's capacity in undertaking agricultural support services. The main objective of the farm is to contribute to effective promotion of agricultural development in the Project area through introduction of rice and fodder varieties of better quality and suitable to the natural conditions in the area, demonstration of technical aspects peculiar to the area, development and presentation of optimum techniques for rice and fodder cultivation, as well as training of technicians and farmers. The proposed farm will be managed by and operate under the supervision of the Regional Office of SONADER in Rosso. The number of personnel necessary for execution of services such as tests and training is estimated to be 28 persons in total. The farm will be provided with fields and ancillary facilities for tests, demonstration, presentation, training, as well as dissemination of seeds, and management facilities within a total area of 100 ha.

#### 4.5 Irrigation and Drainage Plan

54. Paddy fields will be irrigated with water pumped from main or peripheral canals. Since the water level in the Senegal river is maintained at EL. 1.5 m, irrigation of pasture lands will be done by gravity. The following 3 alternatives were conceived for water drainage from the Project area:

- a) Drainage by evaporation from existing water surfaces in the area;
- b) Drainage by gravity to Chott Boul; and
- c) Drainage by pumping into the Senegal river.

Drainage alternatives other than drainage by evaporation from water surfaces in the Project area should be considered in view of the impacts of drainage on the natural and social environment inside and outside the area. Based on the general results of examination and studies of the site and the present social conditions relating to the environment in the aforesaid Diawling National Park and Chott Boul depression, it is considered that the method of drainage by gravity in Chott Boul is not suitable. In consequence, only the pumping drainage method seems to be the optimum alternative.

55. However, drainage by pumping which imposes extra technical and financial burden on beneficiaries, is not so suitable for a sustainable development of the Project. On the other hand, it is possible that a plan aimed at protecting the environment in the Diawling Park and Chott Boul depression against the impact of waters resulting from agricultural development in the Upper Delta, or minimizing such an impact, will be formulated in the future on the basis of scientific study and analysis of environmental impact through a long observation of the environment. In consequence, it is proposed to adopt the method of drainage by power pumps in the irrigation and drainage plan of the Project, provided that:

- a) the equipment for drainage by power pumps be so designed that it can be operated easily by beneficiaries and can be maintained at low costs; and
- b) hydraulic facilities be so planned and designed that they can be incorporated easily into the gravity drainage and irrigation system in the case this system is adopted in the future.

56. The total irrigation area is 4,730 ha, consisting of 3,940 ha for rice cultivation and 790 ha for pasturage. Further, the Project area is divided into 9 blocks from the viewpoints of topography and organization of irrigation and drainage. The irrigation areas of the respective blocks are shown in the table below:

(Unit: ha)

Block No.	Block Name	Paddy Field		Pasture Land		Total Irrigation Area	
		Gross	Net	Gross	Net	Gross	Net
I	Awlig	838	750	0	0	838	750
II	Ibrahima East	854	770	0	0	854	770
III	Ibrahima West	566	510	0	0	566	510
IV	Gungala	352	320	592	540	944	860
V	Dalagona	227	200	58	50	285	250
VI	Keur Macène East	446	400	0	0	446	400
VII	Keur Macène South	415	380	0	0	415	380
VIII	Diallo North	323	290	0	0	323	290
IX	Diallo South	355	320	225	200	580	520
Total		4,376	3,940	875	790	5,251	4,730

57. The development of paddy fields in areas having an elevation over 1.25 m will be implemented first by maintaining the water level in the Gungala depression at EL. 1.0 m. During this period, activities of training/extension of techniques and introduction of semi-intensive pasturage in test pasture areas at EL. over 1.25 m will be carried out. The water level in the Gungala depression will be lowered to EL. 0.75 m when development of paddy fields has been completed and accumulation of improved techniques of pasture development has reached a satisfactory level, which will allow to proceed with pasture development in areas located at EL. between 0.75 and 1.0 m. The irrigation and drainage development plan in 2 steps is formulated as follows:

Step I (Plan A) : Paddy fields with a total area of 3,940 ha will be developed by keeping the water level in the Gungala depression at EL. 1.0 m. An experimental pasture area of 200 ha will be created at EL. 1.25 m in the Keur Macène area for extension of techniques and training on exploitation of pastures.

Step II (Plan B) : The total area of 4,730 ha including 3,940 ha for rice cultivation and 790 ha for pasturage will be developed by maintaining the water level in the Gungala depression at EL. 0.75 m.

The 2 steps of the above-mentioned plan can be summarized as follows:

Propose Plan	Irrigation Area (ha)			Water level in Gungala Depression (EL. m)
	Paddy Field	Pastures	Total	
Step I (Plan A)	3,940	200	4,140	1.00
Step II (Plan B)	3,940	790	4,730	0.75

58. Irrigation water requirements for paddy and pastures are estimated at 2.2 lit./sec and 1.13 lit/sec at maximum, respectively. The unit drainage requirement is determined at 3.6 l/s/ha. On the other hand, the guaranteed discharge of the Senegal river by the Manantali dam at 250 m<sup>3</sup>/s all the year round is considered sufficient for irrigation of areas along the Senegal river provided that the total irrigated area in the basin does not exceed 100,000 ha. The quantity of saline matters carried in soluble form together with drainage water was calculated by a simulation of salt contents in soil layers, covering 3 typical saline soil categories in the Study Area. The calculation results indicate that soil salinity and quantity of transported saline matters will gradually be reduced by irrigation and leaching, and salt concentration in soil and quantity of transported salts will stabilize after a period of about 5 years. The salt quantity transported in the fifth year varies from 1.7 to 3.8 tons/ha in the paddy field and from 0.4 to 0.8 ton/ha in the pasture land, depending upon the soil types.

59. The water balance analysis was conducted to grasp the mutual relation between the irrigation area and drainage pumps in order to determine the size of pumping facilities. The following criteria were adopted in the water balance analysis:

- The calculations are made for Step I (Plan A) and Step II (Plan B) based on the requirements and conditions;
- The water balance analysis covers a period of 20 years from 1975 to 1994 and is calculated for every 10 days; and
- To preserve the quality of water in the Gungala depression, salinity of waters stored in the depression is to be kept at 750 ppm by exchanging them with the Senegal river water by means of drainage pumps. A temporary rise in salinity not lasting for one month and not exceeding 1,000 ppm may be acceptable.

The water balance in the Gungala depression was calculated for the following 3 alternatives:

Alternative 1 (Absolute Plan)

- Alternative 1A : For Step I (Plan A) development, the water level in the Gungala depression will be kept absolutely under EL. 1.0 m.
- Alternative 1B : For Step II (Plan B) development, the water level in the Gungala depression will be kept absolutely under EL. 0.75 m.

Alternative 2 (10-year Probable Plan)

- Alternative 2A : For Step I (Plan A) development, the water level in the Gungala depression will not exceed EL. 1.25 m for no more than 10 days in 9 years for 10 year period.
- Alternative 2B : For Step II (Plan B) development, the water level in the Gungala depression will not exceed EL. 1.0 m for no more than 10 days in 9 years for 10 year period.

Alternative 3 (5-year Probable Plan)

- Alternative 3A : For Step I (Plan A) development, the water level in the Gungala depression will not exceed EL. 1.25 m for no more than 10 days in 8 years for 10 year period.
- Alternative 3B : For Step II (Plan B) development, the water level in the Gungala depression will not exceed EL. 1.0 m for no more than 10 days in 8 years for 10 year period.

The results of water balance analysis are shown in the table below:

Description	Alternative 1		Alternative 2		Alternative 3	
	1A	1B	2A	2B	3A	3B
Area to be Irrigated (ha)	4,140	4,730	4,140	4,730	4,140	4,730
Paddy Field	3,940	3,940	3,940	3,940	3,940	3,940
Pasture Land	200	790	200	790	200	790
Water Level in Gungala Depression (EL., m)	1.0	0.75	1.0	0.75	1.0	0.75
Required Pump Capacity (m <sup>3</sup> /s)	11	12	1.5	3.9	1.5	3.1
Water Quantity Drained per Year on Average (1000 m <sup>3</sup> )	11	37	13	28	13	30
Maximum Salinity (ppm)	780	750	(*1)985	750	(*1)985	(*2)840

Note (\*1): 750 ppm after the 5th year

(\*2): 750 ppm after the 2nd year

Based on the results of water balance analysis mentioned above, Alternative 2 is selected. The required capacity of drainage pumps will be 1.5 m<sup>3</sup>/s in the first step and 4.0 m<sup>3</sup>/s in the second step. The design capacity of pumps was therefore determined to be 4.0 m<sup>3</sup>/s.

60. The Project area will be provided with the following hydraulic system:

(1) Water Intakes

The 2 existing intake gates installed by OMVS on the right embankment of the Senegal river will be used for delivering water to the Project area. These gates will be either fully open or closed. A water level regulating structure and an intake, both of



small size and capable of regulating water properly, will be installed downstream of each of these gates.

## (2) Control Water Level

Considering the plan to raise the Senegal river water level to EL. 2.5 m in the future, the possibility of irrigating many paddy fields by gravity when the water level in the Senegal river is high, and the water level to be maintained in the Gungala depression, the control water level for the irrigation and drainage system in the Project area was determined as follows:

- Maximum intake water level in the Senegal river: EL. 2.5 m
- Maximum water level in irrigation canals: EL. 2.0 m
- Maintenance water level in Gungala depression: EL. 1.0 m (Step I)  
EL. 0.75 m (Step II)

## (3) Water Level Regulators

A minimum number of water level regulators will be installed in the Project area. The water level will be controlled by 2 regulating gates: The Ibrahima gate to be installed at the end of the Ibrahima canal and the Keur Macène gate to be installed at the end of the Diallo canal.

## (4) Prevention of Submersion

An embankment will be constructed along the Aftout canal to prevent submersion of the irrigation block IX by counter-current waters from the Aftout canal.

61. Preliminary design and work quantities of main structures are summarized below.

### (a) Canals

Canal	Existing Canal		New Canal		Total	
	Nos.	Length(km)	Nos.	Length(km)	Nos.	Length(km)
Main Irri. Canal	3	15.4	0	0.0	3	15.4
Seco. Irri. Canal	0	0.0	7	28.1	7	28.1
Main Drain	1	3.0	0	0.0	1	3.0
Seco. Drain	0	0.0	7	23.9	7	23.9

### (b) Drainage Pumps

Description	Quantity	Unit Capacity		Diameter of Suction Pipe (mm)	Diameter of Outlet Pipe (mm)
		m <sup>3</sup> /s	kW		
Pump	3	1.0	55	900	700
	2	0.5	30	700	500
Power generator	1	-	280		
	1	-	120		

### (c) Intake gates, regulating gates

Description	Quantity	Name of Gate
Existing Intake Gate	4	Ibrahima, Dalagana, Dioup, Aftout
New Regulating Gate	3	Ibrahima EP, Keur Macene, Awlig EP
New Intake Gate	9	Ibrahima S1/S2, Awlig, Diallo, Gungala, Dalagana S, Dioup S, Aftout S, Diallo S
<b>Total</b>	<b>16</b>	

#### (d) Tertiary Canals and Structures

Description	Area (ha)	Length of Irrigation Canal			Drain. Canal Length (km)	Structures (nos.)
		Rehabili.	New	Total		
Cooperative	1,908	34	112	146	114	182
Individual Farm	2,822	160	67	228	260	286
Total	4,730	194	179	374	374	468

#### (e) Work Quantities

Description	(Unit: m <sup>3</sup> )		
	Excavation	Fill	Concrete
Main and Secondary Canals	454,300	445,000	2,400
Tertiary Canals	561,000	1,364,000	13,000
Total	1,015,300	1,809,000	15,400

62. The paddy and pasture fields have a square shape in principle, having a field and irrigation block with the following typical dimensions:

Description	Field Block			Irrigation Block		
	Length (m)	Width (m)	Area (ha)	Length (m)	Width (m)	Area (ha)
Paddy	960	200	19.2	80	100	0.8
Pasture	1,000	300	30.0	100	150	1.5

#### 4.6 Rural Infrastructure Development Plan

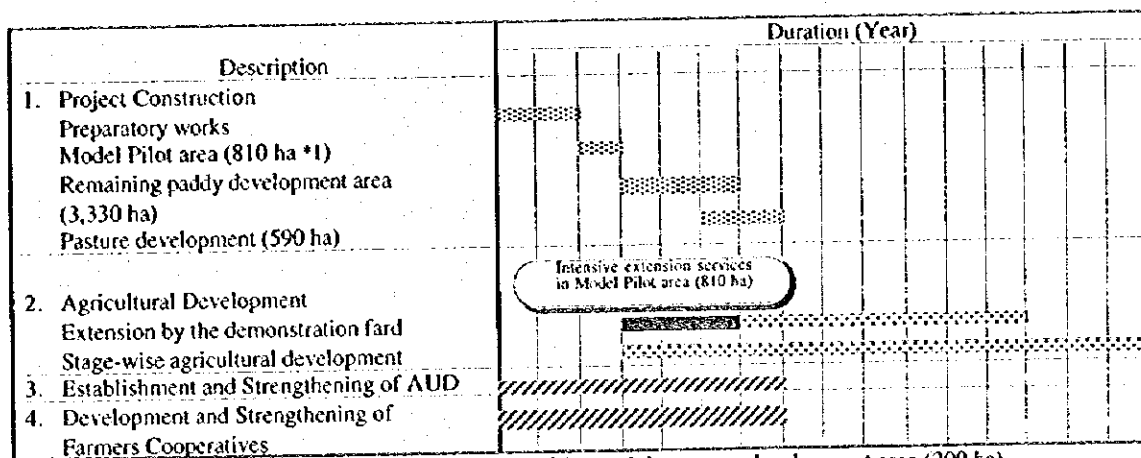
63. The rural road development plan consists of the rehabilitation of 4 roads (58.4 km) and the construction of 2 new roads (9.5 km), i.e. 6 roads (67.9 km) in total. The earthwork quantity required for rural road development is estimated at about 223,000 m<sup>3</sup>. A water supply system consisting of a shallow well and a pump will be installed in each of the 12 villages in the Project area. The pump will be of wind-mill type equipped with a purifier/tank and water will be distributed from an outlet connected to the tank.

#### 4.7 Model Pilot Scheme

64. The proposed Model Pilot area is located at the west edge of the Project area and is composed of two irrigation blocks: North Diallo (Block VIII) and South Diallo (Block IX) with an area of 810 ha. The services for agricultural techniques extension to beneficiary farmers in the Model Pilot area will be intensively managed by SONADER staff stationed in the demonstration farm. SONADER staff will also be responsible for advising and training water users' associations in O&M of the Project facilities. The extension and guidance services as well as training in the Model Pilot area shall be carried out for a period of 3 years according to the proposed 3-phase agricultural development plan under the Project, after completion of the facilities for the Model Pilot. The extension program will continue after the 3rd year so that the acquired experience can be spread all over the Project area.

#### 5.1 Project Execution Plan

65. The Project is to be completed in a period of 16 years from the design and construction of facilities to the realization of the agricultural development targets as schematically illustrated below:



(\*1) : including the area of the Demonstration Farm (100 ha) and the pasture development area (200 ha)

66. The Project construction works will take 7 years, including 2 years for design and preparatory works. The development of the Model Pilot area (810 ha) including the Demonstration Farm (100 ha) will start in the 1st year and be completed within one year. The construction of facilities for the whole Project area will follow the establishment of the Model Pilot area and be completed within 4 years. The development of pastures surrounding the Gungala depression in the center of the Project area will commence in the 6th year and be completed within 2 years. The area to be developed in each year is as follows:

Description	(Unit: ha)					
	3rd Year	4th Year	5th Year	6th Year	7th Year	Total
Paddy field	610	1,100	1,710	520	-	3,940
Pasture field	200	-	-	290	300	790
<b>Total</b>	<b>810</b>	<b>1,100</b>	<b>1,710</b>	<b>810</b>	<b>300</b>	<b>4,730</b>

67. SONADER head office will undertake the Project construction works. SONADER Rosso office will provide AUD with guidance and training on O&M and management of facilities, and operate the Demonstration Farm (100 ha) to be established in the Model Pilot area. Thus, SONADER will create 3 offices, one for construction works, one for guidance and training of AUD, and one for operation of the Demonstration Farm. The first office will be under SONADER head office and the other 2 offices under SONADER Rosso Office. The table below shows the working period and number of staff of these offices:

Project Construction Office		Project Operation Office		Experimental and Demonstration Farm Office	
Working Period: 5 years		Working Period: 9 years		Working Period: 10 years	
Personnel:		Personnel:		Personnel:	
Engineer	4	Engineer	1	Engineer	11
Assistant engineer	7	Office staff	3	Assistant engineer	5
				Operator, etc.	12
<b>Total</b>	<b>11</b>	<b>Total</b>	<b>4</b>	<b>Total</b>	<b>28</b>

## 5.2 Project Operation, Maintenance and Management Plan

68. The irrigation and drainage system in the Project area will consist of 9 irrigation blocks and one UUE will be created for each block. AUD will be a union of 9 UUEs. AUD will take charge of O&M of all Project structures except the gates installed on the Senegal river embankment, which will be under the responsibility of SONADER. The share of functions between SONADER and the beneficiaries in O&M of irrigation and drainage facilities can be summarized as follows:

SONADER	Beneficiaries	
	AUD	UUE
- Technical support to AUD	- O&M of main canals and hydraulic structures	- O&M of hydraulic structures on secondary canals
- Management of gates on the Senegal river embankment in collaboration with OMVS	- Control of water level in the Gungala depression	- O&M of tertiary canals and on-farm facilities
	- O&M of drainage pumping stations	
	- O&M of O&M equipment	

The requirements of personnel of AUD and UUEs are summarized below:

Personnel	Cooperative Member	Recruited Staff	Total
AUD	2	18	20
9 UUEs	45	0	45
Total	47	18	65

69. AUD should be established before the completion of construction works of the Project facilities. AUD will be created and trained in accordance with the following process:

Arrangement for establishment of UUEs and AUD

To be completed within one year after the commencement of the Project

Establishment of UUE and AUD

To be started one year after the commencement of the Project and completed in the 7th year

Training and strengthening of UUEs and AUD

To be started 2 years after the commencement of the Project and completed in the 7th year.

To establish and strengthen AUD, SONADER will organize, in each phase, seminars and workshops for the beneficiaries and provide courses and training for the personnel of AUD including overseas training course. The guidance and training period will last 5 years. The O&M costs during this period will be jointly borne by SONADER and AUD. However, the charge of SONADER will be reduced by 20% each year from 100% in the first year, so that AUD will bear the total costs after the sixth year. Considering the fact that the irrigation blocks will be completed progressively, it is anticipated that SONADER will bear part of the O&M costs for a period of 9 years, i.e. from the 4th year to the 12th year of the Project implementation.

## 6. Estimate of Project Cost and O&M Cost

70. The construction costs are estimated by dividing into 2 components, one to be financed by the public sector and the other by the private sector. The cost for rehabilitation and new construction of tertiary canals for individual farmers is financed by themselves. The project cost consists of direct construction cost, procurement cost of O&M equipment, engineering services cost, project administration cost and physical and price contingencies. The administration cost includes the operation of the Demonstration Farm, O&M cost (water charge) to be borne by SONADER during the period of guidance and training of AUD mentioned above. The Project cost, divided into public and private investments, is summarized in the following table:

(Unit : Million UM)			
Description	Total Project Cost	Public Investment	Private Investment
Foreign currency	3,271	2,614	657
Local currency	3,143	2,815	328
<b>Total</b>	<b>6,414</b>	<b>5,429</b>	<b>985</b>

71. The costs for O&M and management of the Project comprise the salaries of AUD's personnel, administration cost of AUD office, personnel cost, fuel cost for drainage pumps and O&M equipment, cost for replacement of drainage pumps and O&M equipment, cost of materials for maintenance and repairs, cost for maintenance and repair works to be executed under sub-contracts, as well as water charge to be paid to OMVS. These costs would amount to 90.8 million UM per year after the Project has reached the envisaged development target. AUD will undertake O&M and management of the Project facilities with the budget constituted by O&M charges collected from beneficiaries according to the size of the irrigated areas.

## 7. Project Evaluation

72. The economic output of the Project is derived from increased crop production by the effective use of irrigation water, improvement of poor drainage, organization of water users association, introduction of improved farming techniques and practices. The project benefit is estimated for 2 cases of "With Project" and "Without Project", based on the present and future productions, quantities of agricultural products and inputs used, and economic farm-gate prices. The results are as shown below:

Description	Cropping Area (ha)	Annual Benefit (UM mil./year)	Benefit per unit area (UM/ha)
Wet season paddy	3,940	334	84,700
Dry season paddy	3,940	341	86,670
Fodder crop	790	25	32,200
<b>Total</b>	<b>8,670</b>	<b>700</b>	<b>148,100</b>

73. The economic costs are calculated by multiplying the project costs by the standard conversion factor of 0.85. The costs of replacement of pumping facilities and gates as well as annual O&M and repair costs are also calculated in the same manner. The estimated economic costs are as follows:

(Unit: million UM)		
Description	Project Cost	Economic Cost
Cost of construction works	5,356	4,553
Cost of replacement of drainage pumps and gates	200	170
Annual O&M and repair cost	76	65

74. The Project is evaluated economically in terms of Economic Internal Rate of Return (EIRR) for two cost cases: Case-1 with the whole project cost; and Case-2 excluding the construction cost of water supply facilities and rural road. The calculation of EIRR gives the results of 9.4% for Case-1 and 10.4% for Case-2. Besides, a sensitivity analysis is conducted by assuming eventual fluctuations of the project costs and benefits. Those results demonstrates that the Project is justified economically.
75. To examine the Project viability in terms of farm economy, the farm budget analysis of farmers household is conducted for both the medium-size farms benefiting from irrigation and small size farms (rice cultivation+stock farming, and rice cultivation only) located in the project area under the future "With Project" condition. The results of farm budget analysis are shown in the tables below:

Description	Small-size Farms					
	Medium-size Farm		Rice Cultiv.	+ Stock Farming	Rice Cultivation only	
	W/Out	With	W/Out	With	W/Out	With
Cultivated Area	9.5	22.8	2.0	5.0	2.0	4.0
Paddy	9.5	21.8	2.0	4.0	2.0	4.0
Pasture	0.0	1.0	0.0	1.0	0.0	0.0
Gross Income (1,000 UM)	1,405	4,617	576	1,038	576	896
- Farm income	920	4,617	194	950	194	824
- Non farm income	485	0.0	382	88	382	72
Family Size (people)	8.5	8.5	6.4	6.4	6.4	6.4
Gross Expenses (1,000 UM)	1,396	2,946	573	902	573	826
- Production cost	780	2,207	109	391	109	316
- Living expenses	616	740	464	511	464	510
Net Surplus (1,000 UM)	9	1,671	3	136	3	70

W/out : Without Project W/Project : With Project

The farm budget analysis indicates that the ratio of annual cost for O&M and management of facilities to net surplus is 13.7% for medium-size farms, 42.3% for small size farms practicing rice cultivation and stock farming, and 55.0% for farms growing only rice. From this result it can be concluded that the farmers will have a sufficient capacity to pay the cost for O&M and management of the facilities.

## 8. Environmental Conservation Plan

76. The results of Initial Environmental Evaluation (IEE) suggests that the alternative of draining waters from the Project area towards Chott Boul via the N'Diader canal will probably have the following harmful effects on the environment of the Chott Boul area:

- (1) Effect of water level fluctuations in ponds and backwaters in the Area;
- (2) Effect of contamination of waters by plant protection products (pesticides and fungicides); and
- (3) Fertilizer-related proliferation effect

Chott Boul and Aftout es Saheli are the only places in West Africa where the small flamingo species multiplies. The fact that the gull-billed tern and pink flamingo reproduce in the area is "unique" since these birds reproduce only in a few places on the African coast. Chott Boul is also considered as an artificial estuary where fresh water inflow from the Senegal river through the Diawling lake and open communication with sea water from the Lower Delta through the Tiallakht lake create an ideal medium for hatching of deltatic fish, represented by "mullet". The development of the Delta in Mauritania will have negative consequences on Chott Boul, unless the need for conservation and protection of nature in the area is given due attention. Taking the above into consideration, the drainage alternative mentioned above should not be adopted.

77. The Project will include the protection works for desertification with the afforestation method in order to protect the project facilities including the farm lands, canals and farm roads. Since the desertification has advanced to the northern border of the project area, the protection works will be provided along the northern edge of farm lands and the farm roads between Keur Macène and Awlig. The both sides of main and secondary drainage canals are also afforested. The nursery trees are produced in the demonstration farm. The afforestation works and subsequent tree protection for three year period will be undertaken on a farmers participation basis subject to paying

allowance to participated farmers. Its cost is estimated at 24 million UM in total, and will be included in the project cost.

78. A resource monitoring system should be implemented urgently following the completion of the Project. Under this system SONADER and DEAR will work in concord with other agencies concerned, especially those in the hydraulic and health sectors. The monitoring items are specifically soil and water, sand dune movement and desertification, and health and epidemiology.

## 9. Women in Development (WID)

79. Women in the Project area show that they are well aware of economic activities and have sufficient experience in cooperative activities. However, it is deemed necessary to develop infrastructure relating to their activities. The required facilities include, inter alia, buildings, equipment for artisanal workshops, and irrigation and drainage facilities for fruit and vegetable crop fields. Besides, there is a need to provide training and technical guidance to women with regard to cultivation and artisanal production. The WID Program is focused on the following 2 fundamental objectives:

- (1) Improvement of villagers' artisanal workshops, fruit and vegetable cultivation by women and marketing buildings, as well as supply of basic inputs for artisanal production and fruit and vegetable cultivation; and
- (2) Basic education of women as well as training and technical guidance on economic activities (artisanal production, farming).

In this Project, a model marketing facility with roof will be constructed in Keur Macène for enabling women cooperatives to sell their products. This marketing facility will be managed and maintained by the Keur Macène village.

## 10. Indirect Benefits and Project Impacts

80. The Project will generate secondary benefits and socio-economic impacts. The main socio-economic impacts are the following:

### (1) Security of Food Production

Stable irrigation water supply, improvement of drainage, and introduction of farming techniques through the Demonstration Farm will allow farmers to increase production and have stable living conditions by reducing seasonal work for non farm income. A production surplus estimated at 38,000 tons will reduce rice import by 55% to 75%, thus contributing to savings of foreign currency to be used for payment for imported rice.

### (2) Development Demonstration Effect

The experience gained in the experimentation and demonstration farm (100 ha) and a model pilot area (810 ha) may spread not only in the project area but also to adjacent areas, as well as in the whole Lower Delta of the Senegal river. Besides, the experimental cropping and development of farming techniques for fruit and vegetable crops and marketable products in the demonstration farm, as well as the distribution of seeds and dissemination of these techniques to women farmers' cooperatives which practice fruit and vegetable cultivation around the villages, will contribute to raising farm income and improving food conditions.

### (3) Preservation of the Environment

The development of paddy fields and pastures, introduction of double rice cropping and fodder production through the perfection of irrigation, prevention of salt illuviation and improvement of pastures by a better drainage system, as envisaged under the Project, will prevent environmental degradation and increase productivity of lands in the Project area. In addition, the improvement of drainage conditions will prevent further deterioration of the environment in downstream areas.

**(4) Improvement of Transport Conditions in the Project Area**

The rehabilitation of existing roads and construction of new farm roads under the Project will substantially improve the transport conditions in the Project area. This in turn will contribute to boosting economic activities thanks to the improved traffic and transport of farm products and inputs as well as household equipment between villages and to Rosso.

**(5) Improvement of Living and Health Conditions of Villagers**

With the planned installation of a water supply system in each village for domestic use of villagers, the Project will contribute to the improvement of the living and health conditions of local people. It can be expected, among others, that damage caused by diseases and insects in the villages scattered in the northern part of the Project area will be reduced and the health conditions in that area will be improved as a result of drainage improvement and domestic water supply.

**11. Conclusions and Recommendations**

**81. Conclusions of the Study are described below.**

(1) The present Study's objective was to evaluate the feasibility of implementing the irrigated agriculture development project aimed at contributing to the improvement of living standards of farmers in villages, the increase of food production, and the environmental preservation in the Dioup area of 13,720 ha. The Study enabled to formulate a development plan for irrigation and drainage systems and rural infrastructure covering a total area of 4,730 ha including 3,40 ha of paddy fields and 790 ha of pastures.

(2) The evaluation indicates that the Project's EIRR would be 9.4% as a whole, and would increase to 10.4% if the construction of farm roads and water supply facilities is excluded. Since the Project consists of a progressive development plan over 16 years from the commencement of implementation to the attainment of the targets, and the project costs include the cost of agricultural support services to farmers, the Project's internal return is considered moderate. Nevertheless, taking into account the simplicity of technicalities, the benefit from the social and natural environmental viewpoint, and the expectable contribution to the national food security, the Project implementation is judged to be justified.

(3) The basic conditions for attaining the Project objectives are provision of effective agricultural support services using the experimental and demonstration farm as a base, and intensive extension of improved techniques in the Pilot Model area in the initial stage of the Project implementation. Both tasks are to be undertaken by SONADER. To fulfill them effectively, SONADER shall not only mobilize competent local human resources but also obtain technical assistance from advanced countries, including assignment of specialists. These tasks will bring about not only the success of the Project but also an important indirect effect on irrigated agricultural development in the Senegal river basin.

(4) The Project works will not specially require high techniques. To preserve the natural environment of the national Diawling park which covers the Chott Boul area,



the pumping drainage method was adopted. However, since the proposed pumping equipment is of small size and its O&M are easy, after its installation the equipment can be operated and managed by SONADER and AUD staff with their present technical capability. Furthermore, the O&M and management costs of the Project facilities including O&M cost of drainage pumps will be borne by beneficiaries but, these costs will be within the payment capacity of even artisanal farms.

(5) During public meetings organized in the course of the Study, the local people confirmed their strong expectation for pastoral development and their commitment to participate in pasture management by establishing cooperatives after the completion of development. On the other hand, farmers who practice only cultivation fear that their crops will be damaged by cattle. The Project contemplates to avoid penetration of animals into crop fields by installing an electric fence, and to prevent conflicts between cultivators and stock breeders through the intermediary of AUD in which both parties participate as members.

(6) The Project follows exactly the policy of Mauritania which sets forth the objectives of "rectification of regional disparity", "improvement of living conditions and income of farmers", and "environmental preservation and restoration of nature".

82. On the basis of the Study results, it is recommended that the Project be implemented at an earliest possible date according to the following procedure:

(1) It is recommended to establish a new Project construction office in SONADER and to increase the number of staff for execution of the Project and strengthening of agricultural support services. Preparations including judicial and financial arrangements (Project local currency budget) should be started quickly in accordance with the Project operation plan explained in this Report.

(2) It is recommended to initiate activities of informing beneficiary farmers of the contents of the irrigated agricultural development project in the area, and to promote preparations for establishment of new farm cooperatives (AUD, UUE) as organisms in charge of O&M and management of the facilities to be constructed under the Project, in parallel with the preparation for the operational system of SONADER.

(3) With regard to the design and preparations for execution of the Project construction works, it is recommended:

- to arrange and integrate documents relating to ownership of lands in the Project area for land acquisition and distribution of land plots; and
- to acquire land areas necessary for construction of the Project facilities including the experimental and demonstration farm.

(4) As for the Project execution, it is recommended to seek for financial cooperation from financing institutions and countries in accordance with criteria of PDIAIM, and to proceed in first priority with the Pilot Model plan and the construction of the experimental and demonstration farm. It is also recommended to request a technical assistance for the experimental and demonstration farm. The Government of Mauritania shall make the following arrangements before the commencement of the Project, as the conditions required for the Project execution with technical and financial aid from foreign countries:

- establishment of UUEs and AUD and execution of legal arrangements including their registering as associations; and

- establishment of the Project operation office and the experimental and demonstration farm office, as well as recruitment of personnel.

(5) The following actions are recommended to be taken for the Project monitoring after completion of construction works:

- to establish a system for improvement of the O&M and management system and method, based on the results of monitoring and evaluation after completion of the Project; and
- to establish a system of monitoring the environment and damage by salinity as proposed in this Report, and continuous observation of the groundwater level and evaluation of the Project impact on the environment.