CHAPTER 4
FORMULATION OF THE IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

4.1 Basic Development Concept

The commissioning the Diama dam (1986) and Manantali dam (1988) by OMVS has achieved the basic conditions for development of irrigated agriculture in the plain along the Senegal river, which constitutes an important agricultural region of Mauritania. To further promote irrigated agriculture development programs in the Senegal river basin, the Government of Mauritania (GOM) has formulated a ten-year program titled "Integrated Development Program for Irrigated Agriculture in Mauritania" (PDIAIM) in 1993 with its implementation scheduled for 1996. The priority objectives for the first five years of the program are rehabilitation of existing irrigation facilities and irrigated agriculture development in the Upper Delta downstream of Rosso. The irrigated agriculture development project in the Dioup area, which forms part of the present Project area, is included as a priority project in this program.

The completion of the right embankment on the Senegal river and irrigation water intakes in 1992 has provided an infrastructure necessary for agricultural development in the Upper Delta. However, the absence of a drainage system in the area enclosed by the embankment has caused problems on the natural and social environment, such as salt illuviation in the soil, degradation of water quality, and spread of stagnant water-born diseases. These factors have directly affected the household-type farmers practicing agriculture and stock farming in the Upper Delta, because they severely damage the traditional farm and livestock production which had been developed so far until the embankment construction.

Blessed with rich land and water resources, the Upper Delta possesses an extremely high agricultural production potential. Besides, the easy access to capital city Nouakchott and proximity to Rosso, which serves as a trade base with Senegal, incite activities of agricultural producers aiming at large-scale mechanized paddy cultivation. Accordingly, the Upper Delta is considered as a base for food production augmentation, as well as an advanced area in the irrigated agriculture development process that has just started on the Senegal river bank.

In this context, 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.

The basic farming system of irrigated agriculture development consists of double rice cropping and semi-intensive pasturage. Considering the fact that farming techniques required to attain this objective are not yet developed in the agricultural area on the

Senegal river bank, it is envisaged to carry out tests and extension of improved techniques under the Project. As to irrigation and drainage facilities, these will be constructed from existing intake gates up to peripheral on-farm facilities. These facilities for individual (enterprise) farmers will mainly cover cooperative group farms and the construction of on-farm facilities will be undertaken by farmers themselves at their own expense. Drainage facilities will be so arranged as not to adversely affect the natural and social environment inside and outside the development area. The rural infrastructure to be provided will consist of farm roads and water supply facilities. The Project contemplates the improvement of living conditions and transport of goods between the Project area and Rosso city by means of rehabilitation of roads connecting from east to west the northern and southern parts of the area and construction of a new south-north road.

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 Project Area

The Project area was finally delineated based on a preliminary topographic map on a scale of 1:10,000 and the results of investigation on conditions of irrigation, drainage, and topography. The 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.

4.3 Basic Agricultural Development Plan

4.3.1 Basic Principle of Agricultural Development Plan

(1) Agricultural Development Objective

The principal objective of agricultural development in the Project area is to ensure food supply through effective and continued production of foodstuffs (rice) and through improvement of pasture lands, in order to raise the living standards of the population. The basic development system to be adopted in the area is aimed at the two targets of (1) promoting double cropping of rice which is the main staple food, (ii) ensuring and improving traditional pasture lands, and (iii) disseminating partial introduction of fruit and vegetable cultivation. The cropping system and pattern will be determined taking into account the technical progress, area to be developed, environmental preservation, etc. Furthermore, an optimal land use plan will be prepared for attaining the development objectives, taking into account the land suitability and natural conditions such as meteorology, etc. The area to be developed will be decided appropriately on the basis of yield, progress of techniques relating the development of irrigation and drainage facilities, O&M of facilities, farming techniques, etc.

(2) Integrated Agriculture Development

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 tests and extension, improvement of marketing facilities and system, etc. in order to ensure successful agricultural development. To attain the objectives mentioned previously, an integrated development method combining the following elements is needed to be adopted:

a) Agricultural Support Services

- Strengthening of farmers' organizations;
- Strengthening of financial system such as rural credit; and
- Construction of experimental and demonstration farm to strengthen present activities regarding tests, extension, and training.

b) Improvement of facilities and system of processing and marketing.

c) Construction of agricultural infrastructure including irrigation and drainage system, and rural infrastructure including farm roads and water supply system.

(3) Progressive Development Method

Paddy and fodder production as well as partial production of fruit and vegetables are the direct objectives of irrigated agriculture development. Although the Government determines the objectives of agricultural development in the area as promotion of double rice cropping and development of paste lands, rice cultivation is at a standstill for many reasons. A real development can be initiated from this Project. However, considering the technical level of farmers in the area and limiting factors for development, it is essential not only to develop infrastructure such irrigation and drainage facilities but also to introduce suitable rice and fodder varieties, to establish and disseminate cropping techniques and stock farming methods, to strengthen the support system such as cropping techniques and operation fund, to provide facilities for distribution and processing of production materials and farm products, as well as to solve the land issue between farmers and stock breeders. Solid experiences and time will be needed to solve these problems. Under such circumstances, therefore, it is proposed to implement the irrigated agriculture development by setting the objectives for phase-wise development as shown in the next page.

4.3.2 Land Use Plan

(1) Basic Criteria

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 rice 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 (refer to sections on land suitability).

Village areas : Village areas will not be used for rice cultivation and pasture development.

OMVS-managed land : A 200 m wide stretch of land from the centerline of the embankment will be used for maintenance of the road on the embankment.

Phase 1 -->	Phase 2 -->	Phase 3
Paddy and Vegetable Cultivation -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)
Pasture and Stock Farming -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.
Support Services -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 market-ing 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.

(2) Land Use Plan

The plan for future land use was prepared by selecting the lands suitable to irrigated agriculture development according to the above-mentioned criteria. The land use plan is presented in Figure 4.3.1 and its main features are summarized below:

Land Type	Area (ha)	(%)	Land Type	Area (ha)	(%)
Paddy field*	3,940	28.6	Water area	910	6.6
Pasture*	790	5.8	Wood	50	0.4
Dry field	50	0.4	Bare land	930	6.8
Wild meadow with bush	880	6.4	Sand dune	100	0.7
Marshland	3,950	28.7	Village area	10	0.1
Seasonal marshland	930	6.8	Borrow area	570	4.2
Shrub wood	100	0.7	Others*	520	3.8
			Total area	13,730	100.0

Note: * Canals or roads for paddy fields and pastures.

Compared to the present land use, most of lands already developed (former arable lands now becoming wild meadows or arable lands)

(3) Arable Land Preservation Plan

Prevention of soil salinization and protection against winds are major measures to be considered for preserving arable lands in the Project area. To prevent soil salinization, it is most important to avoid submersion of farmland by providing adequate drainage. Afforestation will be an effective measure to protect arable lands against winds and sand dune invasion.

a) Salinization Prevention

Soil monitoring

It is necessary to continue measuring soil salinity as mentioned in sub-section 2.1.2 in order to watch the salinization tendency.

- Prevention of submersion of arable lands

To prevent arable lands from being submerged, an adequate drainage system should be installed to avoid flooding of the lands. Especially, during the cropping season in the area downstream of N'Diader, the water level in the N'Diader canal is to be kept high in order to take water from the Aftout intake gate for irrigation purpose, and this will result in inundation and submersion of the South and North Diallo areas. To prevent such inundation and submersion, it is required to construct a dike from the Aftout intake gate to the North Diallo area passing through the west edge of the South Diallo area and the Diallo canal.

b) Proposed Provision of a Protective Tree Belt

Since the Project area is flat, limited to the north by sand dunes and to the south by the Senegal river and there are practically no wooded lands in the vicinity, sand blow and sand dune invasion are observed in the area. In addition, planted crops are subject to strong winds. It is an efficient way to create protective tree belts to stabilize sand dunes and to protect arable lands against winds. In particular, the protection against the desert wind (highly dry Harmattan) will be required for successful paddy cultivation in the dry and hot season. Tree belts will consist of a mixture of trees such as eucalyptus, acacia, and sugar palm which are tolerant of drought and high salinity. It is recommended to promote afforestation for stabilization of sand dunes and protection of farmlands against winds, by providing cooperatives (farms) with seedlings produced by the experimental and demonstration farm.

4.3.3 Agricultural Production Plan

(1) Cropping Pattern

The primary cropping pattern was determined to meet the phasewise development objectives mentioned previously, and based on farmers' experience and technical level, social conditions such as living and marketing, and natural conditions in the site such as meteorology and soil. The table below and Figure 4.3.2 show the proposed cropping pattern:

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

(2) Proposed Farming Practice

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 rice 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 introduction of this method depends however on the choice of farmers. The transplanting method is economically more advantageous for small-size farms than the direct sowing method, due to the following benefits:

- weeding can be done easily by hand without using a large quantity of herbicides;
- shortening of the period of plantation in paddy field will save fuel consumption for irrigation;
- the number of seeds required is 3 to 4 times less than that for direct sowing; and
- it is possible to avoid damage by salinity at the initial stage of vegetation.

With regard to protection of plants, the use of a reliable and effective pesticide can prevent damage by plant diseases and insects. To avoid catastrophic damage to crops, it is planned to use only a minimum quantity of pesticide under the control of SONADER, AGETA or an agency in charge of environmental matters. Since the local population traditionally consume fish caught in the area, it is particularly important to examine the persistence of toxicity in fish when selecting the pesticides.

Since animal draught is not used for farm operations at present, a long period of time should be considered for the introduction and development of techniques for animal draught. In consequence, for the plowing by small-size farms, common utilization of farm machinery of cooperatives and rental of machinery owned by individual farms as is practiced at present, will be considered.

a) Rice Cropping by Mechanized Direct Sowing Method (practiced at present by large-size farms)

The rice cropping operations by direct sowing method with the use of large farm machinery on submerged lands are summarily described below:

- Main machinery:

Tractor	:	Wheeled type, 80 - 100 HP class
Plowing	:	Tooth plow, dish harrow, rotavator
Fertilization	:	By hand or broadcast seeder

Pesticide spraying	:	Sprayer installed on the border of fields
Harvesting	:	Combine harvester (semi-crawler type with exchangeable wheels)
Disposition, drying	:	By hand

- Working method:

Leveling

The surface of paddy field will be plowed and harrowed immediately after the harvest of previous crops before the land becomes hard and dry, in order to prevent salt illuviation due to evaporation.

Fertilization

To reach a yield of 5 tons/ha as envisaged under the Project, fertilizers will be applied at a rate of 80 - 100 kg of nitrate and 35 - 45 kg of phosphoric acid per ha.

Preparation of seeds and sowing

Only the seeds harvested specially for sowing, not those for consumption, will be used. Seeds will be sowed at a rate of 80 to 120 kg/ha in submerged condition after being immersed in water for 48 hours and left out of water for another 24 hours for accelerating germination. Sowing will be done by hand.

Water control

Paddy fields will be drained two or three days after sowing and then irrigated depending on humidity of the land surface. After the plants have sprouted sufficiently, paddy fields will be deeply submerged to avoid development of weeds.

Weeding

Weeding will be done mainly by applying herbicide after the germination stage following sowing and drainage. Since Echynochloa spp. is the main harmful weed species, selective herbicides such DCPA will be used.

Prevention of damage due to plant diseases and insects

Prevention of damage by grasshoppers and crickets is difficult to be tackled at individual level, therefore it should be dealt with at national and international levels by institutions such as FAO. As for prevention of damage by birds, the use of nets against birds will be an effective measure. Considering the damage which will eventually be caused by these predators in the future after expansion of paddy fields and introduction of double rice cropping, spraying of pesticides is envisaged to cope with the problem. Pesticides such as Fenitrothion, Bupurophezin, Dithiocabamate, and Benomyl will be selected taking into account the safety and pollution aspects. For their application, it is necessary to adopt a spraying method putting emphasis on safety. The pesticide application will be carried out only after receiving instructions from supporting organizations such as SONADER and following a training through farmers' organizations.

Harvesting and drying

Crops will be harvested by large-size combine harvesters. To minimize loss during harvest and to ensure quality of husked rice and higher yield at milling, it is essential to follow strictly the optimum harvesting time. In addition, short drying of husked rice which may result in a deterioration of its quality must be avoided.

b) Rice Cropping by Transplanting Method (practiced only by small-size farms)

The rice cropping operations by transplanting method are summarily described below:

- Main farm machinery (rental from individual farms or common utilization of cooperatives' machinery):

Tractor	:	Wheel type, 80 - 100 HP class
Plowing	:	Tooth plow, disc harrow, rotavator
Fertilization	:	Man power
Pesticide spraying	:	Knapsack-type sprayer (with motor)
Harvesting	:	Combine harvester or manual
Disposition, drying	:	Thresher, man power

- Working method:

Leveling

This will be done in the same way as for direct sowing.

Fertilization

This will be done in the same way as direct sowing, except that basal fertilizer will be applied at the time of weeding before planting. Fertilizer application will be performed by man power.

Preparation of seeds and sowing

Seeds will be sowed and buried at a rate of 30 to 40 kg/ha (paddy field area) after being immersed in water for 48 hours and left out of water for another 24 hours for accelerating germination.

Planting in paddy field (transplanting)

After basal fertilizer application and just before submersion, the land will be harrowed by means of rotavator. After submersion, seedlings will be transplanted after the land has been roughly harrowed manually. For easy weeding, the plants will be transplanted regularly at a density of 22 to 25 plants per m^2.

Weeding

Weeding will be performed mainly by man power. It is envisaged to introduce and disseminate the use of wheeled weeders to ensure effective weeding by man power.

Prevention of damage due to plant diseases and insects

The method of preventing damage by plant diseases and insects is similar to that for direct sowing.

Harvesting and drying

Harvesting will be carried out by man power, and threshing by automatic threshers to be used in common.

c) Required Quantity of Equipment

The equipment required for double rice cropping according to the farming practice mentioned above is for the farming period from the rainy season harvest to the preparation for dry season cropping (from mid-June to the end of August). During this short period the work intensity is high and there is frequent overlapping of farm operations. The works to be executed in this period are harvesting, plowing and harrowing successively. About 22 combine harvester units will be required for harvesting an area of 3,940 ha. As for plowing and harrowing, 9 tooth plows, 13 disc harrows, and 11 rotavators will be needed. A total of 33 tractors will be used for successive plowing and harrowing. Especially the harrowing by 13 discs harrows will need most tractors. these quantities are exclusive of stand-by equipment, equipment for transport of produce, etc.

(3) Expected Crop Production

a) Expected Yields

The Project is aimed at ultimately reaching a yield of 5 tons/ha of rice cultivated in the rainy season and in the dry season respectively. This yield was estimated based on the natural conditions in the Project area, results of survey on farmers, as well as SONADER's data on the Boghé and Kaédi areas. As for sorghum, a yield of 4 tons/ha, which is a minimum yield obtainable by irrigated cropping in tropical areas, was adopted as a target yield. It is envisaged that these yields will be attained five years after commencement of crop cultivation according to the practices proposed for the Project.

b) Expected Production

The period necessary for attaining the development target is estimated to be three years for Phase 1 and Phase 2, and four years for Phase 3. The table below shows the development steps to attain the projected production of paddy from the total area of 3,940 ha of paddy fields.

Development Phase	Year	Cumulated Cultivated Area (ha)	Production (ton)
Phase 1	1	610	1,500
(Full development of single	2	1,710	4,580
cropping per year)	3	3,420	9,710
Phase 2	4	3,940	12,920
(Transitional period to double	5	3,940	15,000
cropping)	6	4,550	18,700
	7	5,400	23,130
Phase 3	8	6,250	26,510
(Full development of double	9	7,100	29,790
cropping)	10	7,880	33,620
	11	7,880	35,720
Until reaching target production	12	7,880	37,380
after 3 years	13	7,880	38,620
	14	7,880	39,400

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.

4.3.4 Pasture Development Plan

(1) Basic Principle of Pasture Development

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.

(2) Pasture Development Plan

a) Development Plan of Pastures and Related Facilities

Development of pasture lands

The pasture development will cover an area of 790 ha (net) of land located at an elevation between 1.0 and 1.25 m, excluding unsuitable lands due to soil condition. Most of the area has been submerged since the construction of the Diama dam, resulting in the total disappearance of grassland for traditional pasturage during flood recession period in the dry season. Under the Project, it is necessary to introduce fodder seeds and plants suitable to the area and to disseminate their development in order to promote extension of pasture lands. The pasture development should fit the cropping and irrigation practices in which the methods of fodder production and utilization of pastures, and prevention of salt illuviation to the soil surface are taken into account.

Fodder species

Seeds of predominant fodder varieties will be sowed during the development of pastures. To this end, an importune quantity of seeds and plants will be required at a certain time. 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.

Development of facilities relating to pastures

It is recommended to adopt the alternate pasturage method taking into account the semi-intensive utilization of grassland. This type of pasturage needs the installation of obstacles (fence, ditch, hedge, etc.) separating the grazing area from the fodder cultivation area, access roads for cattle, and other facilities.

b) Pasture Management Plan

Pasture utilization pattern

With regard to utilization of pasture lands, the Project contemplates in general the fodder production by sowing a mixture of leguminous and gramineous seeds, and adopts the alternate pasturage method, which is slightly intensive compared to the present practice.

Pastoral cropping and management pattern

The pastures in the Project area are natural lands. At present these pastures are utilized only during the transhumance and for grazing. Under the Project, it is envisaged, within the framework of pasture management, to secure the production of grasslands within the pasture areas and to maintain a stable productivity. The basic actions required for this purpose are the following:

- Alternate grazing will be introduced for effective utilization of pasture lands. These lands will be divided into grazing areas where cattle grazes for four days. Assuming the period of recovery of vegetation (period between grazing cycles) to be 20 days, one grazing area will be utilized 18 times per year. Estimating the unit production of green fodder to be 36 tons/ha/year (6.7 tons/ha/year for dry fodder), the green fodder production in one grazing cycle is 2.0 tons/ha. Green fodder consumption is 25 tons/ha/year (5.0 tons/ha/year for dry fodder, with a consumption rate of 70%). A herd of bovines is assumed to be composed of 50 heads (young and adult animals together) and its fodder consumption to be 39 kg/day/head. On this basis, the required area and production of each grazing area would be about 4 ha and 7,800 kg, respectively. 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, maintain the intensity and composition of grasslands, and recover productivity of deteriorated pastures.

- Salt leaching, weeding, disposition cutting, and burning will 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 ten years.

Mechanized working system

Mechanization will be indispensable for effective execution of the above-mentioned important workloads. Considering the work components, meteorological and soil conditions at the site, etc. it is estimated that 80 - 100 PS tractors and the following machinery will be required:

Disposition cutting		
Rotary mower		Working width: 3.2 m
Leveling	Plowing: disc plow	20" x 3
	Harrowing: disc harrow	18" x 32
	Leveling: flexible harrow	Working width: 3.6 m
Fertilization	Man power	
Sowing/burying	Sowing; man power	
	Burying: flexible harrow	
	Compaction: backfiller	Working width: 3.5 m
Weeding	Man power	

The numbers of machinery required for the above works are as follows: One unit each of the above machinery and four tractors (stand-by machines are not included). The work quantities and the numbers of farm machines required for the farming practice described previously are shown in Table 4.3.1.

c) Fodder Production Plan

Expected production

The expected fodder production per ha under the above-mentioned pasture development and management system is about 6.7 tons (dry fodder) per year, consisting of quality fodder with a mixture of graminaceae and leguminosae. Since the area of pastures to be developed is 790 ha, the expected fodder production is about 5,300 tons (dry fodder).

Progressive increase of production

However, taking into account the present conditions of farmers' organization, support system, technical and financial capabilities if 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 ten 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

The vegetation of all pastures will be improved from the existing wild grass species at the initial stage of development. The rate of attainment of expected fodder production in all pastures is estimated to be 50% during the first three years. Therefore, in some areas quality fodder will be successfully produced through introduction of new species and an effective alternate grazing system, while in other areas fixed grazing with existing grass species will be maintained. Phase 2 (the next three years) is a transitional period, where the completion rate of quality fodder production and alternate grazing system is estimated to be 80%. In Phase 3, the semi-intensive pasture management system will be realized in the whole area, which will allow to reach a potential of feeding 2,000 oxen per year in the total pasture area of 790 ha.

(4) Expected Animal Production

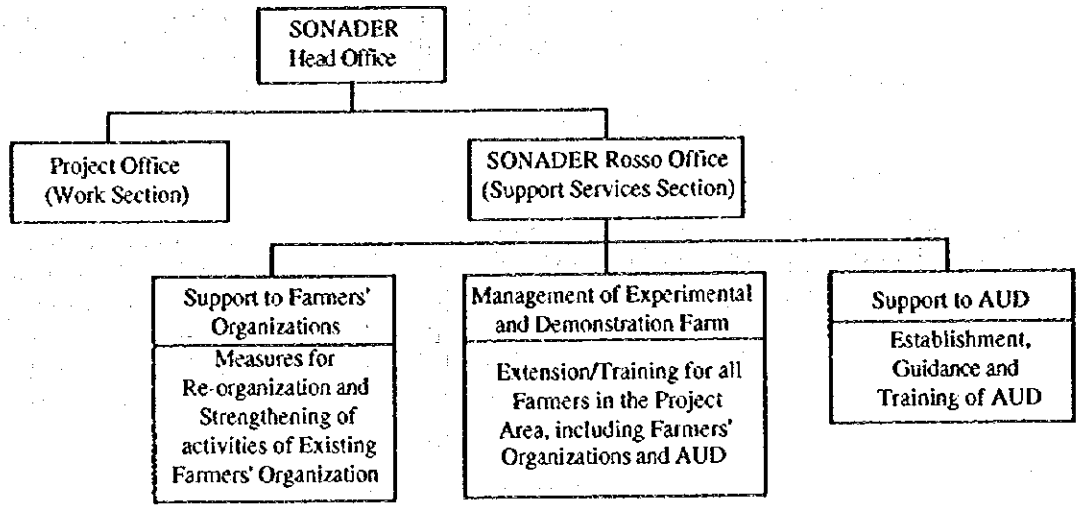
The animal production expected from the above-mentioned pasture development plan consists of the number of existing oxen and 2,000 new oxen from newly developed pasture lands. Besides, the annual production under the Project was calculated by assuming that a herd of bovines has 100 heads. The results indicate that a 2,000-head herd of bovines produce annually 100 aged oxen, 460 young beeves, and 380 tons of milk.

4.3.5 Agricultural Support Services Strengthening Plan

The agricultural support services consist mainly of the following five sectors:

a) Support in improvement of infrastructure for rural life;
b) Support in acquisition of specific knowledge of agricultural extension and training;
c) Support in facilities for supply of inputs, storage of harvested products, and commercialization and marketing;
d) Support in agricultural credit; and
e) Support in agricultural research (including experimental and demonstration farm)

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

4.3.6 Establishment of Experimental and Demonstration Farm

(1) Objectives

An experimental and demonstration farm (Keur Macène Experimental Farm, provisionally called FEK) 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.

(2) Functions

The experimental and demonstration farm shall have the following functions:

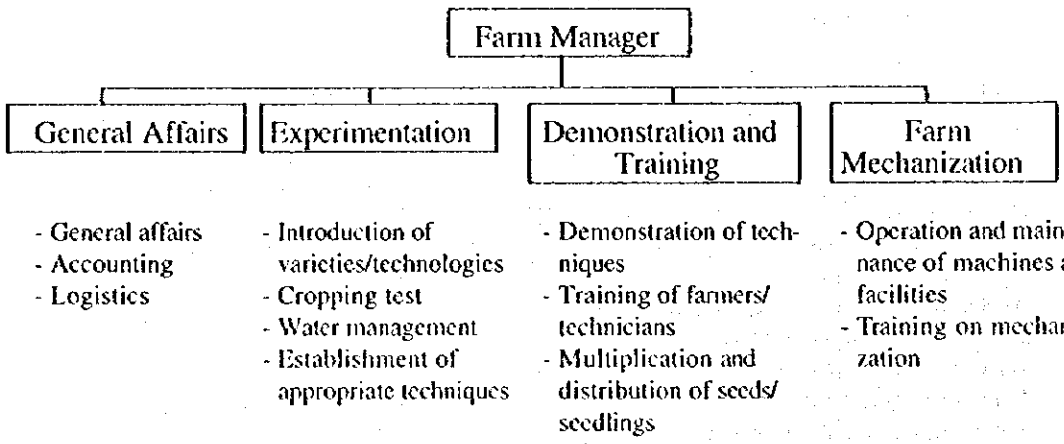
a) Introduction and experimental cultivation of varieties of rice, fodder and vegetables of better quality, demonstration, development and presentation of appropriate techniques;

b) Extension and introduction of selected varieties and established farming techniques to farmers; training of technicians and advanced farmers to undertake this function;

c) Dissemination and distribution of selected varieties of high quality, continual distribution of plants for prevention of dersertification, and creation of protective tree belts.

(3) Organization of the Farm

The proposed farm will be managed by and operate under the supervision of the Regional Office of SONADER in Rosso following the processes indicated in the diagram below. A department in charge of operation of the experimental farm will be newly established. The farm will be created in Keur Macène and the farm's personnel will be stationed in the area. The farm will operate under the management of a Manager and consist of four sections as shown in the proposed organization chart below:



The number of personnel necessary for execution of services such as tests and training is estimated to be 28 persons in total.

(4) Facilities

To fulfill the above-mentioned functions, the farm will be provided with fields and ancillary facilities for tests, demonstration, presentation, training, as well as dissemination of seeds, and management facilities. Those are described below:

a) Fields

- Experimentation field (rice, vegetables, and fodder) 10 ha
- Demonstration and training fields (rice, vegetables: 30 ha, fodder/pasture: 50 ha) 80 ha
- Field for nursery and others 10 ha

b) Buildings

- Room for culture and conservation of rare species, room for plants, workshop, etc.
- Building for administration, laboratory, classroom for training
- Shed, garage, building for treatment of seeds and rice mill, drying space
- Electric power and water supply facilities
- Housing for personnel

c) Farm machinery (to be utilized mainly for rice cultivation and pasturage, including equipment for training)

Machinery	Specifications	Quantity
Tractor	4 x 4, 80 - 100 PS	2
Tractor	4 x 4, 40 PS	3
Tractor	crawler type, 60 PS	1
Disc plow	26" x 3	2
Disc harrow	18" x 20	2
Rotavator	800 mm	2
Submergible harrow	3,000 mm	2
Combine harvester	automatic threshing	3
Seeds adjuster	composed system	1 set
Rotary mower	disc type	2
Combine spreader-tedder	5,000 mm	1
Rake-reaper	3,100 mm	1
Hay binder	1.5 hr/ha	1
Trailer	3,000 kg	2
Other machines/repair tools		1 lot

d) Equipment for Experimentation and Training

- one set of equipment and tools for examination of seeds, investigation of harvest, examination of fertilizers, etc.

- Equipment and instruments for meteorological observation:
  one set of equipment and instruments consisting of thermometers, a hydrometer, an evaporimeter, an instrument for measurement of insolation, etc.

- Rice mill for training:
  one set of equipment including a cleaning machine, a rice separator, a milling machine (with power generator).

4.4. Irrigation and Drainage Plan

4.4.1 Basic Principles (Selection of Pumping Drainage Method)

(1) Irrigation

Like the Study on Construction of Hydraulic Infrastructure in Upper Delta of Mauritania conducted by SONADER in 1991, the land use plan proposed under the present Study is to allocate the lands located at EL. over 1.25 m to rice cultivation, those between EL. 1.25 and 0.75 m to pasturage, since the remainder is submerged. Paddy fields will be irrigated with water pumped from main or peripheral canals. With regard to pasture development, however, while the SONADER 1991 plan recommended the traditional method of utilizing flood recession areas, the present plan proposes to introduce a semi-intensive pasture development practice controlled by fertilization and irrigation. Since the water level in the Senegal river is maintained at EL. 1.5 m, irrigation of pasture lands will be done by gravity.

(2) Selection of Pumping Drainage Method

The following three alternatives were conceived for water drainage from the Project area, among which the method of drainage of waters by gravity to Chott Boul via the N'Diader canal was proposed by SONADER in 1991:

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.

In examining the drainage plan for the Project area, it is necessary to take into account the impacts of drainage on the natural and social environment inside and outside the area. These include the impact of contamination of submerged basins inside the area on the natural environment and the life of local population, and the impact of waters from farmlands on the conservation of the environment of the Diawling National Park including the Chott Boul marshland.

Progressively with the development of irrigated agriculture, illuvial salts which are or will be present at the soil surface, will be leached by irrigation waters and deposited in the Gungala depression. In addition, part of fertilizers and pesticides applied to paddy fields and pastures will also infiltrate into the depression. At present, it is difficult to drain waters out of the Project area for hydrological reasons and, moreover, there are no drainage facilities. If irrigated agriculture is introduced in such circumstances, it is obvious that the water remaining in the Gungala depression, which collects waters from 95% of the Project area, will deteriorate rapidly. It can be easily anticipated that the deterioration of water quality in the submerged area will have a considerable impact not only on the natural environment but also on the local people which uses the Gungala water for their daily needs. Therefore, drainage alternatives other than drainage by evaporation from water surfaces in the Project area should be considered.

The Study Team conducted an IEE (initial environmental evaluation) and analysis for the Diawling National Park and Chott Boul area during the Phase I work. The Team also collected supplementary data and information during the Phase II field work. The results of these studies and investigations indicated the possibility of an important adverse impact on the natural environment in the area, especially with regard to water quality, if excess water from the Project is drained to the Chott Boul area via the N'Diader canal. This drainage alternative requires improvement of the N'Diader canal which has small capacity at present. And if it is implemented, large scale rice cultivation can be introduced in an area over 3,600 ha along the N'Diader

canal. The consequences will be harmful for the areas concerned. It should be noted in particular that the N'Diader area is adjacent to the Diawling Park and Chott Boul area.

On the other hand, many development prospects are envisaged for the coastal area facing the Atlantic Ocean. This area is called "Aftout Es Sahel" and is located between Nouakchott to the north and the Diawling National Park to the south. The development plans cover tourism, oil exploitation, pastoral development, fish protection, especially mullet which is a main input for industrial fish processing for export, and agricultural development in the Senegal river Upper Delta. The military aspect also is involved. A national consensus is very necessary for the selection of an optimum development alternative in perfect harmony with the environment in Aftout Es Sahel. Scientific study of the plan should be one of the required means for evaluation. In other terms, this would necessitate monitoring over a long period of time to obtain reliable results.

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. 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.

4.4.2 Irrigable Area and Development Priority Order

(1) Irrigation Development Area

The possible irrigation development area was determined based on the classification of lands according to the soil study results. The classification covers paddy fields and pasture lands. The lands where irrigation development is possible are those up to category 4 for both paddy fields and pastures. The irrigation area was delineated on the basis of topographic conditions, irrigation and drainage conditions, and the land use plan according to elevation as mentioned in sub-section "Basic Principles of the Project". The total irrigation area thus determined is 4,730 ha, consisting of 3,940 ha for rice cultivation and 790 ha for pasturage. Further, the Project area was divided into nine blocks as shown in Figure 4.4.1 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 Gross	Paddy Field Net	Pasture Land Gross	Pasture Land Net	Total Irrigation Area Gross	Total Irrigation Area 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	(*1) 355	320	(*2) 225	200	580	520
	Total	4.376	3.940	875	790	5.251	4.730

Note: *1 The Bellara area (net 250 ha) which forms part of the existing development project, is excluded.
*2 Selected as a test pasture area, located at EL. over 1.25 m.

(2) Development Priority Order

There exist following irrigation and drainage constraints for agricultural development in the Project area: To develop pastures in an area located at EL. 0.75 - 1.0 m, it is necessary to keep the water level in the Gungala depression at EL. 0.75 m, which requires drainage pumps of large capacity. On the other hand, among the nine irrigation blocks in the Project area, the Gungala (Block IV) and Dalagona (Block V) have two land types, one for rice cultivation and the other for pasturage. If for instance a part of the block has pasture lands even of small size, it is necessary to keep the water level in the whole Gungala depression at EL. 0.75 m, even if irrigated agriculture is developed progressively in the respective blocks. It is therefore indispensable to provide drainage pumps of large capacity right at the beginning of development in order to lower the water level in the whole depression, even if irrigated agriculture is introduced progressively by block (horizontal development method).

From the above standpoint, 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 two steps as mentioned above was 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
	Paddy Field	Pastures	Total	Depression (EL. m)
Step I (Plan A)	3,940	200	4,140	1.00
Step II (Plan B)	3,940	790	4,730	0.75

4.4.3 Preliminary Irrigation and Drainage Requirements

(1) Irrigation Water Requirement

Irrigation water requirement was calculated by assuming the drought year with a 5-year probability as the design drought year in the irrigation plan. The crops envisaged for irrigated farming in the Project area are paddy, sorghum, and fodder, therefore irrigation water requirement was estimated for each of them.

Water consumption of plants was estimated by multiplying potential evapo-transpiration obtained by modified Penman method from meteorological data of Rosso by crop coefficient. Useful rainfall was calculated from the rainfall of 143.9 mm in 1991, which is nearest to the 5-year probable drought year according to the daily rainfall data covering 31 years from 1964 to 1994. The following figures were used to determine water consumption of plants and irrigation water requirement:

- Crop coefficient : Modification of the value adopted by FAO
- Leaching water : 80 mm/plant
- Saturation water : 175 mm/plant
- Irrigation efficiency
  a) Efficiency in fields : Net efficiency in paddy field: 65%, pasture: 60%
  b) Efficiency in tertiary canals : 95%
  c) Efficiency in main and secondary canals : 85%

Irrigation water requirement for paddy fields and pastures was calculated under the above-mentioned conditions and the results are shown in Table 4.4.1. The gross irrigation water requirement for each month is indicated in the table below:

(unit : L/s/ha)

Crops	Jan.	Feb.	Mar	Apr.	May	Jun.	Jul.	Aug	Sept	Oct.	Nov	Dec
Paddy (dry season)	-	1.21	2.09	2.04	2.22	1.67	1.37	-	-	-	-	-
Paddy (Rainy season)	-	-	-	-	-	-	1.13	1.52	1.37	1.67	1.49	0.67
Fodder	0.73	0.76	0.85	1.11	1.13	0.79	0.50	0.38	0.50	0.50	0.59	0.75

(2) Drainage Requirement

The drainage plan will be so designed as to drain rapidly excess precipitation in the rainy season from paddy fields and pastures, in order to avoid adverse effect on the growth of paddy and fodder. The rainfall in the Study Area is characterized by a short period of rains from July to September, i.e. three months, and by very heavy rains concentrated within a limited time (3 to 5 hours). As the months of July and August correspond to the period of sowing of paddy in the rainy season, it is necessary to avoid submersion of paddy fields during the germination stage in the case of cropping by direct sowing. For pastures also, excess precipitation should be drained within a shortest time. Considering these conditions, the basic criteria for formulation of the drainage plan were determined as follows:

- Rainfall with a 10-year probability is considered in calculating the drainage requirement;

- Taking into account the necessity of drainage during the germination stage of directly sown paddy, rainfall of one day will be completely drained within two days. As for rainfall in three successive days, it will be drained within three days.
- The unit drainage requirement per ha is the higher value between rainfall in one day and rainfall in three successive days.
- Seepage loss is not taken into account.
- Evaporation of 4 mm/day is taken into account.

Rainfall with a 10-year probability mentioned in sub-section 2.1.1 is as follows:

- Rainfall in three successive days : 95 mm
- Daily rainfall : 71 mm

Thus, the unit drainage requirement is calculated by the following formula:

$$Q = (R - 4Ev) / 8.64\ T$$

Where, Q : Unit drainage requirement (l/s/ha)
R : Rainfall (mm)
Ev : Daily evaporation (mm/day)
T : Drainage period (day)

The calculation results are as follows:

- Rainfall in 3 successive days : 3.2 l/s/ha
- Daily rainfall : 3.6 l/s/ha

Based on the above results, the unit drainage requirement is determined at 3.6 l/s/ha.

(3) Water Sources

The irrigation area planned to be developed in the Project area is 3,940 ha for rice cultivation and 790 ha for pasturage. Based on the irrigation requirement for paddy and fodder cropping as calculated in sub-section 3.3.1 above, the maximum irrigation water requirement for the whole Project area is estimated at 10 m^3/s. As mentioned in sub-section 2.1.2 "Hydrology", the guaranteed discharge of the Senegal river at Bakel after the commissioning of the Manantali dam and start of power generation is estimated at 250 m^3/s all the year round. This discharge 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.

(4) Salt Contents

a) General

The soil study results revealed considerably high salt contents in the soil in the Study Area. Saline substances in the soil are soluble and will be carried into the Gungala depression via drainage canals together with infiltrated or surface irrigation waters discharged from cropping fields, and leaching water. Without adequate drainage of the Gungala depression, the gradual increase of salt concentration in waters stored in the depression will have a serious adverse impact not only on agricultural production but also on the life of local population and on the natural environment. Therefore, the Study Team estimated the quantity of saline matters carried from cropping fields after the introduction of irrigated agriculture in order to work out an appropriate drainage plan for the Gungala depression. 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 three typical saline soil categories in the

Study Area. The unit quantity of saline matters carried per ha (kg/ha) in each month was thus obtained.

b) Calculation Criteria

Soils concerned

The salt content simulation was conducted for three representative saline soil types in the Study Area as shown in the following table:

Soil Type	Type 1	Type 2	Type 3
Name of soil	Vertisol, Gleysol, and Fluvisol with Low Salinity	Vertisol, Gleysol, and Fluvisol with Extremely Low Salinity	Vertisol, Gleysol, and Fluvisol with Moderate Salinity
Root layer			
Thickness (cm)	30	30	30
Salt concentration (mmho/cm)	2.7	1.6	9.7
Drainage layer			
Thickness (cm)	70	70	70
Salt concentration (mmho/cm)	2.7	2.0	9.5
Ratio to cultivable area			
Paddy field (%)	44	35	21
Pasture land (%)	0	85	15

Hydrological and irrigation criteria

- Salinity of irrigation water: 0.4 g/l
- Rainfall: Rainfall in 1991 is taken as design rainfall for irrigation

c) Calculation Results

The calculation results indicate that soil salinity and quantity of transported saline matters will gradually be reduced by irrigation and leaching, except for one case. Salt concentration in soil and quantity of transported salts will stabilize after a period of about five years. Salt concentration and salt quantity transported annually by soil type in the first and fifth years are shown in the table below:

Soil Salinity in Root Layer (Unit: mmho/cm)

Fields	Year	Soil Type		
		Type 1	Type 2	Type 3
Paddy Field	At the beginning	2.70	1.60	9.70
	5th year	1.22	1.04	2.89
Pasture Land	At the beginning	2.70	1.60	9.70
	5th year	2.55	2.11	6.16

Annual Salt Quantity Transported from Fields (Unit: kg/ha/year)

Fields	Year	Soil Type		
		Type 1	Type 2	Type 3
Paddy Field	1st year	2,851	2,025	8,757
	5th year	1,723	1,505	3,817
Pasture Land	1st year	383	284	1,037
	5th year	371	323	756

4.4.4 Water Balance in Gungala Depression and Capacities of Drainage Pumps

(1) Analysis of Water Balance in Gungala Depression

General

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:

a) The calculations are made for Step I (Plan A) and Step II (Plan B) based on the requirements and conditions defined in sub-section 4.4.3. above.

b) The water balance analysis covers a period of 20 years (from 1975 to 1994) in which annual rainfall showed a declining tendency. The balance is calculated for every 10 days.

c) To preserve the quality of water n 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.

(2) Determination of Capacities of Drainage Pumps

The water balance in the Gungala depression was calculated for the following three 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 the 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 the 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 the 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 the 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	3C	3B
Area to be Irrigated	4,140	4,730	4,140	4,730	4,140	4,730
Paddy Field (ha)	3,940	3,940	3,940	3,940	3,940	3,940
Pasture Land (ha)	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^3/s)	11	12	1.5	3.9	1.5	3.1
Water Quantity Drained per Year on Average (1000 m^3)	11	37	13	28	13	30
Maximum Salinity (ppm)	750	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 was selected. The required capacity of drainage pumps will be 1.5 m^3/s in the first step and 4.0 m^3/s in the second step. The design capacity of pumps is therefore determined to be 4.0 m^3/s.

Figure 4.4.2 shows the water level fluctuations in the Gungala depression in the case of adoption of Alternative 2.

4.4.5 Hydraulic System

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

(1) Water Intakes

The two 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 two 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. In addition, a water control gate with an embankment dike will be constructed at the downstream end of the Awlig natural stream, located at the east end of the project area adjacent to the border with the Gouère Area, to ensure the water dischartge and water level for irrigatint the Awlig Block.

(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.

4.4.6 Irrigation and Drainage Facilities Plan

(1) General

The irrigation and drainage plan was prepared based on the 1:10,000 scale topographic map. Irrigation and drainage systems consisting of main canals up to tertiary canals will be provided in each of the nine blocks forming the Project area. The main canals will consist only of the three existing canals: The 3.1 km long Ibrahima canal, 3.4 km long Aftout canal, and 8.9 km long Diallo canal. All secondary canals will be newly constructed. Tertiary canals which will divert water from secondary canals will consist of existing canals after their rehabilitation and newly constructed canals. The drainage system will be similar to the irrigation system, except that, in principle, all the canals will be new ones.

Figures 4.4.3 and 4.4.4 show the layouts of the irrigation and drainage systems.

(2) Design Criteria for Structures

Hydraulic structures will be designed following Mauritanian standards (Land Inquiry, West Trarza, Volume 1) and based on the plan and completion of similar works in the surrounding areas.

(3) Preliminary Design of Main Structures

a) Description of Main Structures

A description of main structures is given below:

Irrigation Canals

Description	Name of Canal	Length (km)	Irrigation Area (ha)	Design Discharge (m^3/s)	Irrigation Block
Existing Main Canal	Ibrahima	3.1	2,030	5.28	East and West Ibrahima
	Aftout	3.4	1,405	2.99	South and North Diallo
	Diallo	8.9	1,107	2.48	South and North Diallo
New Secondary Canals	Ibrahima S1	5.5	1,567	3.56	East Ibrahima
	Ibrahima S2	3.2	344	0.79	West Ibrahima
	Gungala	5.7	592	0.76	Gungala
	Dlagona	4.9	284	0.59	Dalagona
	Dioup S	2.6	277	0.64	South Keur Macène
	Aftout S	1.8	298	0.52	South Diallo
	Diallo S	4.4	321	0.74	East Keur Macène
	Total	43.5			

Drainage Canals, Depressions

Description	Name of Canal	Length (km)	Drainage Area (ha)	Design Discharge (m^3/s)	Irrigation Block
Existing Main Canal	Tinweirat D	3.0	-	1.72	Awlig
	Dioup	-	-	4.00	Ibrahima, Dalagona
New Secondary Canals	Ibrahima D1	3.6	47	1.53	East Ibrahima
	Ibrahima EP	1.6	-	5.28	East and West Ibrahima
	Ibrahima D6	4.5	520	1.87	West Ibrahima
	Gungala D1	3.6	438	1.58	Gungala
	Gungala D2	2.8	346	1.25	Gungala
	Diallo D1	3.6	604	2.17	South Diallo
	Diallo D2	0.8	873	3.14	South Diallo
	Total	26.9			

Drainage Pumps

Drainage pumps were designed according to the following criteria:

- Drainage capacity: : 1.5 m^3/s (Step I)
  4.0 m^3/s (Step II)
- Net suction lift : 2 m (EL. 0.5 to 2.5 m)

To simplify operation and reduce construction costs, submersible pumps powered by diesel generators will be used. The total drainage capacity of a pumping station will be 4.0 m^3/s. A station will be equipped with 5 pumps: 2 x 0.5 m^3/s units and 3 x 1.0 m^3/s units, taking into account a substantial fluctuation of the required drainage capacity.

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

The drainage pumping station will be built immediately downstream of the Dioup gate installed on the embankment of the Senegal river. Drainage waters will be discharged in the Senegal river directly from the Dioup gate.

Intake gates, regulating gates

Description	Quantity	Name of Gate
Existing Intake Gate	4	Ibrahima, Dalagona, Dioup, Aftout
New Regulating Gate	3	Ibrahima EP, Keur Macène, Awlig EP
New Intake Gate	9	Ibrahima S1/S2, awlig, Diallio, Gungala Dalagona,S, Dioup S, Aftout S, Diallo S
Total	16	

A preliminary layout of the above-mentioned main structures is shown in Figures 4.4.5 to 4.4.14.

b) Tertiary Canals

Under the Project conditions, a tertiary canal will irrigate a paddy cropping area of 9.4 ha. Table 4.4.2 show the irrigation and drainage area, lengths of irrigation and drainage canals, numbers of intakes on tertiary irrigation canals, crossings over irrigation and drainage canals, diversion points, and spillways.

Tertiary canals

Description	Area (ha)	Length of Irrigation Canals (km)			Length of Drains (km)	Related Structure (nos.)
		Rehabili -tation	New	Total		
Cropping Area of Cooperatives	1,908	34	112	146	114	182
Cropping Area of Individual farmers	2,822	160	67	228	260	286
Total	4,730	194	179	374	374	468

Numbers of Structures Related to Tertiary Canals

Description	Irrigation and Drainage Canals			
	Intake	Crossing	Diversion Point	Spillways
Cropping Area of Cooperatives	21	15	141	5
Cropping Area of individual farmers	37	30	214	5
Total	58	45	355	10

c) Quantities of Main Works

The quantities of main works of the Project are as follows:

(Unit: m^3)

Description	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

4.4.7 On-farm Development

The principles of on-farm development are: pumping irrigation for paddy cultivation (some areas can be irrigated by gravity however), and gravity irrigation for pasture lands. The main problems concerning irrigation and drainage in the Study Area are high soil salinity and the lack of various facilities including farm roads. Taking into consideration these principles and problems, the arrangement of paddy fields already developed and the typical layout for development of cropping areas were worked out (see Figure 4.4.15). A paddy field to be irrigated by a power pump and a tertiary canal will have a gross area of 19.2 ha, a length of 960 m, and a width of 200 m. To solve the salinity problem and maintain the fields in proper cropping conditions, the irrigation canals and drainage canals will be constructed separately at an interval of 100 m. Farm roads will be constructed along main, secondary and tertiary canals. The proposed road width is 6.0 m for main and secondary canals and 1.0 m for tertiary canals. Water intakes will be provided at intervals of 80 m on tertiary canals. The size of a plot will therefore be 100 x 80 m, i.e. 0.8 ha. An access road to each

paddy field will be constructed to accommodate the traffic of farm machinery from farm roads to the fields.

Secondary irrigation canals for pasture lands will be aligned along the contour lines and tertiary canals will be aligned laterally from secondary canals at intervals of about 300 m. A drainage canal will be constructed in parallel to and between two tertiary canals and run into the Gungala depression. The length of the tertiary canal and drainage canal varies according to the area to be developed. Farm roads will be constructed along secondary canals, and access roads will be provided on secondary canals for traffic of farm machinery and passage of cattle.

4.5 Rural Infrastructure Development Plan

4.5.1 Rural Roads

The rural road development plan was formulated with the following objectives: (i) to contribute to agricultural and pastoral activities by connecting the fields and villages in the Project area; and (ii) to improve the transport of inputs and agricultural and households products from the Project area to Rosso city. The plan consists of the rehabilitation of four roads (58.4 km) and the construction of two new roads (9.5 km), i.e. six roads (67.9 km) in total.

The roads to be rehabilitated are those connecting the area to be rehabilitated and Rosso from east to west and crossing the northern and southern peripheral parts of the Project area. Two new roads will be constructed to connect these peripheral areas in the north-south direction. Following are the proposed roads:

No.	Starting Point	Ending Point	Length (km)
Rehabilitation			
1.	Keur Macène	Awlig	28.2
2.	Keur Macène	Right embankment of the Senegal river	3.0
3.	Keur Macène	Bounaye	6.2
4.	Ibrahima Gate	Aftout Gate	21.0
	Sub-total		58.4
Construction			
1.	Dara Wolof	Right embankment of the Senegal river	6.6
2.	Bounaye	Diallo Gate (planned)	2.9
	Sub-total		9.5
	Total:		67.9

The roads to be rehabilitated or newly constructed will have a crest embankment width of 4.0 m, an embankment height of 10 to 30 cm from the natural ground surface (from the present ground surface for the roads to be rehabilitated), a pavement width of 2.5 m, and a pavement thickness of 15 cm. An underground gated aqueduct will be installed along the road passing through the northern peripheral part of the Project area so that surface waters running from the north can be controlled artificially for agricultural and pastoral activities in the depressions located in the north of the Project area.

4.5.2 Rural Water Supply

The plan to install water supply facilities for rural areas was worked out with the concept that these facilities form part of the rural infrastructure to be developed under

the irrigated agriculture development project, and that they should be simple for easy operation by village communities in the future. 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 (Keur Macène, Awlig, Sara Salam, Er Mitgueidem, Dara Wolof, Bouteidouma, Dar Er Barka, N'Keila, Beni Nadji, Bounaye, N'Djilar, and N'Degue). The pump will be of wind-mill type which is popular in the neighboring areas. Water will be pumped into a purifier/tank and distributed from an outlet connected to the tank. It is therefore necessary to create in each village a water supply system composed of facilities for water pumping, purifying, storage, and distribution. The villages to be equipped with water supply facilities and the layout of a water supply system are indicated in Figures 4.5.1 and 4.5.3, respectively.

4.6 Model Pilot Scheme

There exist many technical and social constraints to the formulation of a sustainable project. The major constraints are the following:

- Farmers are still in the stage of acquiring paddy cultivation techniques.
- Beneficiaries include rich private farmers and poor local farmers, who shall work in collaboration for future management of the Project.
- Society in the Project area is composed of different ethnic groups with different customs and modes of life.
- SONADER has not sufficient competent staff in number for agricultural extension, information and training of beneficiaries on operation and maintenance of facilities.

As specific measures to ensure the project sustainability, it is proposed to implement the agricultural development in 3 phases until materialization of double rice cropping and perfection of semi-intensive pasture management techniques, and to establish a demonstration farm for experimentation and extension of farming practices. In addition to these measures, it was envisaged to create an advanced area for agricultural development and irrigation before developing the total Project area. This plan is called "Model Pilot Scheme".

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). Under this Project, the area to be irrigated in these two blocks for the Model Pilot was set at 610 ha of paddy fields and 200 ha of pastures. The 100 ha demonstration farm will be established within the Model Pilot area as shown in Figure 4.6.1.

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 (AUD and UUEs) in O&M of the Project facilities, while making efforts to improve farm cooperatives at the same time. Thereafter, the experience gained by beneficiary farmers and WUAs in this area will be disseminated to the remaining Project area. SONADER itself will acquire experience in proper methodology of instruction on extension and guidance services, as well as in training of farmers on O&M.

The extension and guidance services as well as training in the Model Pilot area shall be carried out for a period of three 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. To implement such a program, it is indispensable to strengthen SONADER's test and research activities. SONADER's human resources also shall be strengthened to ensure a successful implementation of the program. To support the program and to strengthen SONADER's capabilities, foreign technical assistance from ODA sources or from NGOs, etc. will be required.

4.7 Operation and Maintenance of Facilities

4.7.1 Irrigation and Drainage Facilities

O&M of irrigation and drainage facilities will consist of operation of intake gates on the Senegal river embankment, control of water level and discharge of irrigation and drainage canals in the Project area, control of water level and operation of the drainage pump in the Gungala depression, as well as control, maintenance and repair of canals and hydraulic structures. The O&M method for each facility is described below.

(1) Intake Gates on the Senegal River Embankment

Among the intake gates installed on the Senegal river embankment, four gates (namely Ibrahima, Dalagona, Dioup, and Aftout) will be used for the Project area. These gates will be fully open during the irrigation period and water intake will be controlled by water level regulating structures and intake structures installed downstream of the intake gates. SONADER will request OMVS to operate the gates according to the irrigation program prepared by AUD. This system will enable WUAs to conduct water management autonomously.

(2) Main Irrigation Canals

The Ibrahima canal and Diallo canal will constitute the main irrigation canals. The water level in the Ibrahima canal will be kept in principle at the same level as that in the Senegal river by means of the Ibrahima regulating gate installed at the end of the canal. As for the Diallo canal which is controlled by the Diallo and Keur Macène gates, the water level will be kept in principle at EL. 1.0 m. These two canals and three gates will be managed by AUD.

(3) Gungala Depression and Drainage Pumping Station

All drainage waters from the Project area except part of the Awlig block and flood waters from sand dunes at the northern edge of the area will flow into the Gungala depression. The regulation of water level in the depression will be extremely important for the Project operation. Among others, the development of pastures in lowlands will require delicate water level regulation. The water level in the Gungala depression will be maintained at EL. 1.0 m during Step I of the Project, and at EL. 0.75 m during Step II when pastoral development in the Gungala block starts. The water level in the depression will be regulated by drainage pumps to be installed at the Dioup intake gates. The pumps will be operated according to the results of analysis of the water balance calculated from the water level and rainfall measured at the pumping station in the Gungala depression, rainfall measured in Keur Macène, and the results of visual observation of rains inside and outside the Project area. As the pumps will have to be operated for a long period especially in the rainy season, it is necessary to carry out maintenance and repair of the pumps and power generators as well as supply of fuel in the dry season. It is also necessary to limit salinity in the Gungala depression to 750 ppm by means of pumping drainage and introduction of fresh

water from the Senegal river through the Ibrahima regulating gate. Management of the Gungala depression and drainage pumps will be undertaken by AUD.

The type of drainage pump to be procured will be of "movable and centrifugal" submersible, which does not need a skillful operation technique. However, the electric motor is placed in water together with pump, and consequently very aged pump will have a possibility of water seeping into motor unit. To avoid and minimize such troubles, the pump sets will have to be removed from water and kept in a dry condition in the storage room in the dry season. Sufficient quantity of spare parts, particularly the mechanical seals for preventing water seeping into motor unit, should be included in the procurement of pump sets.

(4) Secondary Irrigation and Drainage Canals, and Fields

Operation of secondary irrigation and drainage canals commanding each irrigation block will be undertaken by UUE. In principle, water in a secondary canal will be diverted to the tertiary canal in a paddy field by the use of a small-size pump to be operated and maintained by the owner of the field. Considering the elevation of 1.25 m of paddy fields, permanent pumping would be required since the control water level in the Senegal river is set at 1.50 m. However, as the river water level is kept at present between EL. 1.80 and EL. 2.0 m, a large part paddy fields will be irrigated by gravity. UUE shall ensure strict water control to avoid excess water intake due to irrigation by gravity, which will require to operate additional drainage pumps. Pastures will be irrigated by gravity except for the 200 ha Model Pilot area. Excessive irrigation will directly adversely affect pasture management due to its impact on the growth of fodder and the water level control in the Gungala depression. Therefore, irrigation of pastures will require a more delicate water management than in the case of paddy fields. The owner of each field will be responsible O&M of tertiary canals and their related structures within his field, under the supervision of AUD.

(5) Maintenance and Repair of Irrigation and Drainage Facilities

UUE's members in charge of maintenance and repair will periodically inspect the facilities so as to repair quickly and properly the deteriorated parts or parts liable to be deteriorated.

Emergency inspection will obligatorily be conducted after a violent rain or sand storm. Repair works will be classified according to the extent and cost for their execution: The works to be carried out by the UUE's member himself, those to be carried out with the use of maintenance equipment of AUD, those by sub-contracting, those by a combined method, etc.

4.7.2 Operation and Maintenance of Rural Infrastructure

O&M of the rural infrastructure planned for the Project, which consists of rural roads and water supply facilities, will be conducted in the following manner:

(1) Rural Roads

Four existing rural roads with a total length of 60 km will be rehabilitated and two new roads of 9 km long will be constructed, totaling 69 km. In addition, maintenance roads will be provided along the main and secondary canals. O&M of these roads will be undertaken by the people in charge and by irrigation blocks under the following organizations:

Roads along the Senegal river embankment	:	OMVS and the Government of Mauritania
Other rural roads	:	AUD
Canal maintenance roads	:	AUD and UUEs
Village roads connected with rural roads	:	Villages

(2) Rural Water Supply Facilities

Water supply facilities will be installed in the 12 villages covered by the Project area. These facilities will be handed over immediately after their completion to the villages concerned, and the latter will take charge of O&M and management of the facilities.

4.7.3 Operation and Maintenance Equipment

The Study Team examined the kind, type and quantity of construction equipment, vehicles, and control equipment based on the type and size of the relevant facilities. As a result, the following equipment is considered necessary:

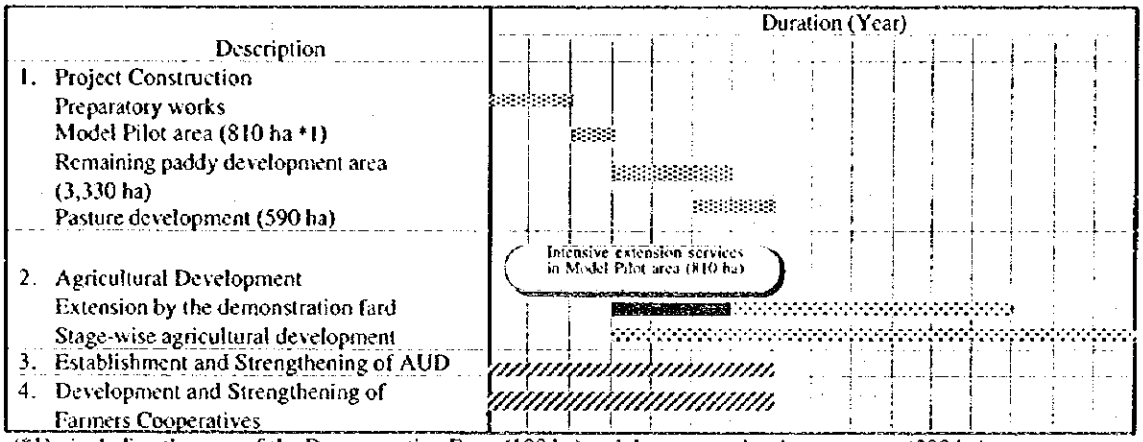
No.	Equipment	Specifications	Quantity
1.	Excavator	0.35 m^3	3
2.	Excavator	0.5 m^3	1
3.	Bulldozer	11 tons	2
4.	Wheel loader	1.2 m^3	1
5.	Tractor shovel	0.8 m^3	1
6.	Grader	3.7 m	1
7.	Compaction roller	6 ton	1
8.	Truck	5 ton	3
9.	Dump truck	8 ton	2
10.	Truck-mounted crane	2 ton	2
11.	Fuel tank	4 kl	1
12.	Pick-up	1 ton	10
13.	Truck-mounted concrete mixer	0.12 m^3	2
14.	Submersible pump	50 mm	2
15.	Portable generator	3 kvA	2
16.	Repair service vehicle	1.5 ton	1
17.	Break 4x4	-	10
18.	Motorcycle	100 cc	20
19.	Telecommunication system		1 lot
20.	Office equipment		1 lot

CHAPTER 5
PROJECT OPERATION, MAINTENANCE AND MANAGEMENT PLAN

5.1 Project Execution Plan

5.1.1 Overall Project Plan

The plan of execution and operation of the whole Project was formulated based on the irrigated agriculture development plan, taking into account the gradual development method, progressive development of irrigation blocks, extension of improved farming techniques tested in the demonstration farm which will be created in the Model Pilot area, and following the establishment of the Dioup Water Users' Association (AUD) as well as the farmers' organization strengthening program. The plan is schematically illustrated in Figure 5.1.1 and summarized below:



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

The Project will be completed in a period of 16 years from the design and construction of facilities to the materialization of the agricultural development targets. SONADER will be responsible for the construction of all Project facilities. Upon completion of the facilities in each irrigation block, they will be handed over to AUD after the latter has received a five-year training by SONADER. During this period, SONADER will provide agricultural support services consisting of extension of improved techniques in the Project area through the Demonstration Farm to be established in the Model Pilot area. The agricultural support services will last for ten years.

5.1.2 Construction Schedule

The Project construction works will take seven years, including two years for design and preparatory works. A work execution schedule is shown in Figure 5.1.1. 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 four 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 two years. The area to be developed in each year is as follows:

(Unit: ha)

Description	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
Total	810	1,100	1,710	810	300	4,730

5.1.3 Organization for Project Execution

The basic conditions for execution and operation of the Project were determined as follows:

a) SONADER will undertake the Project construction works, and the staff responsible for construction supervision will be assigned from SONADER head office.

b) SONADER will provide AUD with guidance and training on O&M and management of facilities for five years, starting from the irrigation blocks where the construction of facilities has been completed.

c) After completion of guidance and training on O&M and management of facilities, SONADER will hand over the facilities as well as O&M equipment to AUD.

d) SONADER will operate the Demonstration Farm (100 ha) to be established in the Model Pilot area.

Based on the above-mentioned conditions, the Project implementation can be divided into three phases: Construction phase, phase of handing-over to AUD, and phase of autonomous operation by AUD. An organization chart of Project execution is illustrated in Figure 5.1.2. SONADER will create three 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 two 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
Total	11	Total	4	Total	28

The operation costs for the three offices including salaries of the above-mentioned personnel will be included in the Project costs.

5.2 Project Operation, Maintenance and Management Plan

5.2.1 Dioup Water Users' Association (AUD)

SONADER and AUD, which will be established for operation of the Project, will be responsible for O&M of the facilities constructed under the Project. The irrigation and drainage system in the Project area will consist of nine irrigation blocks and one UUE will be created for each block. AUD will be a union of nine 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. Figure 5.2.1 shows the organization chart and the type and number of staff of AUD and UUE.

The personnel of AUD and UUEs can be summarized as follows:

Personnel	Cooperative Member	Recruited Staff	Total
AUD			
Representative	2	0	2
Office staff	0	2	2
Operator of facilities, Technician, etc.	0	16	16
(Sub-total)	(2)	(18)	(20)
9 UUEs			
Representative	9	0	9
Office staff	9	0	9
Operator of facilities	27	0	27
(Sub-total)	(45)	(0)	(45)
Total	47	18	65

The above personnel would eventually be insufficient for operation of maintenance machinery when repair works are concentrated after the rainy season. The deficit staff will be made up by temporarily engaged staff. 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 - Management of gates on the Senegal river embankment in collaboration with OMVS	- O&M of main canals and hydraulic structures - Control of water level in the Gungala depression - O&M of drainage pumping stations - O&M of O&M equipment	- O&M of hydraulic structures on secondary canals - O&M of tertiary canals and on-farm facilities

The functions of AUD and UUE in O&M of the respective facilities are as follows:

AUD

- Operation of AUD;
- Coordination with SONADER and other government agencies concerned;
- Preparation and implementation of the irrigation and drainage schedule;
- Preparation, financial arrangement, and implementation of the annual maintenance and repair program;
- Supervision and support of UUEs;
- Collection of water charge and financial management;
- O&M of main canals and water level regulating structures for the whole system;
- O&M of drainage pumping stations;
- Maintenance and management of main rural roads;

- O&M of O&M equipment; and
- Preparation and implementation of the program of education and training of co-operatives' members in water management and maintenance of facilities.

UUE

- Operation of UUE;
- Participation in AUD's activities in quality of AUD members;
- O&M of secondary canals and related structures in irrigation blocks concerned;
- Maintenance and management of canal maintenance roads; and
- Preparation financial arrangement and implementation of the annual maintenance and repair program.

5.2.2 Establishment, Training and Operation of AUD

(1) Establishment, Training and Strengthening of AUD

AUD should be established before the completion of construction works of the Project facilities, therefore necessary procedures should be taken immediately upon approval for the Project implementation. AUD will be created and trained in accordance with the following process (see Figure 5.1.1):

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 two years after the commencement of the Project and completed in the 7th year.

SONADER will organize, in each phase, seminars and workshops for the beneficiaries and provide courses and training for the personnel of AUD. The training program is described below:

a) Phase of Arrangement for Establishment of UUE and AUD

In this phase, SONADER shall explain to the beneficiaries the contents of this Project and the organization of beneficiaries for its operation so that they can fully understand these matters. "Project Orientation Workshops" and "Seminars on Organization of Project Beneficiaries" will be held for this purpose. These will be organized not only for the beneficiary farmers but also for the State agencies concerned, farmers' cooperatives, and women groups.

* Project Orientation Workshop

This workshop is aimed at obtaining a consensus of beneficiary farmers, people concerned in State agencies, cooperatives, and village groups on the Project objectives, development concept, and practical issues such as necessary coordination and organization during the Project execution, in order to confirm their assistance.

* Seminars on Organization of Project Beneficiaries

The objective of this seminar is to make all attendants well informed of the role and duties of AUD and the organization required for O&M and management of the Project facilities by AUD.

b) Phase of Establishment of UUEs and AUD

Nine UUEs and AUD will be established in this phase at the same time with the organization, guidance and training of beneficiaries of each irrigation block. The guidance and training to be carried out in this phase will cover such issues as operation of UUE, water use, collection of water charge, etc.

c) Phase of Training and Strengthening of UUEs and AUD

Guidance on operational means and methods as well as in-situ training on O&M of facilities and O&M equipment will be provided for the boards and members of UUEs and AUD.

The seminars and workshops proposed above will be held 120 times in total. Besides, domestic and overseas training courses will be provided to representatives of AUD and UUEs. Following is a brief description of these courses:

Domestic training course

Visits and practical courses will be organized for representatives of the nine UUEs in the areas where irrigated agriculture is well developed such as Boghé and Kaédi located upstream of the Senegal river valley. Assuming that each UUE will attend three courses, a total of 27 such training courses will be provided.

Overseas training course

Visits and practical courses will be organized for representatives of the nine UUEs at the sites of similar irrigated agriculture development projects in Africa and Asia. The number of overseas trainees will be limited to 20.

The expenses for training courses are included in the Project costs. The training courses will be conducted by SONADER using mainly the facilities of the Demonstration Farm. To this end, it is necessary to strengthen the capability of SONADER's personnel. This can be achieved through participation of SONADER's personnel in training courses, employment of permanent or temporary competent instructors, and with assistance of foreign cooperation institutions. The expenses for SONADER's personnel strengthening are not included in the Project costs.

(2) Handing-over of Project Operation and Maintenance to AUD

SONADER will start providing guidance and training to AUD in O&M of the Project facilities at first in the irrigation blocks where the construction works have been completed. The guidance and training period will last five 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 nine years, i.e. from the 4th year to the 12th year of the Project implementation. These costs are included in the Project costs. Upon completion of guidance and training on Project O&M, SONADER will hand over all the Project facilities and O&M equipment to AUD.

CHAPTER 6
ESTIMATE OF PROJECT COSTS

6.1 Conditions for Cost Estimate

The Project costs were estimated according to the following conditions:

a) The exchange rate of US$ 1.00 = UM 150.2 = ¥ 124.2 effective in February 1997 is applied.

b) The construction works will be executed under a contractual basis by contractors selected through competitive bidding. Necessary construction machinery and equipment will be provided by the contractors themselves. The cost for engineering services for detailed design and construction supervision is included in the Project costs.

c) The unit prices are divided into a local currency portion and a foreign currency portion as follows:

Local currency portion

- Personnel cost
- Cost of materials purchased in Mauritania
- Fuel cost
- Land transport cost
- Indirect cost of contractors

Foreign currency portion

- Expatriate personnel cost
- Cost of imported materials
- Cost of construction machinery and equipment
- Indirect cost of contractors

d) The unit prices of works are estimated on the basis of personnel cost, fuel cost, and costs of main construction materials obtained from a local price survey conducted in September 1996, and taking into consideration the contract prices of similar construction works executed in the vicinity of the Project area. These base prices and unit prices are shown in Table 6.1.1.

e) Physical contingency is calculated at 10% of the costs of construction and procurement of machinery and equipment. The cost of engineering services is estimated at 10% of the direct construction cost. Price contingency is calculated assuming an annual price escalation of 5% for the local currency portion and 2.5% for the foreign currency portion.

f) Considering the fact that all lands are State property, no cost for land acquisition for construction of facilities is included in the Project costs.

The Project costs comprise direct construction cost including procurement cost, and the Project administration cost. Following are the components of the Project cost:

(1) Direct Construction Cost

a) Civil Works and Rural Infrastructure

- Main and secondary canals and related structures of irrigation and drainage systems, including the drainage pumping station;
- Rehabilitation and new construction of tertiary irrigation and drainage canals for existing paddy fields including those of the Demonstration Farm;
- Development of lands and construction of tertiary canals for paddy fields and pastures to be newly developed;
- Installation of electric fences for pasture lands;
- Rural roads;
- Water supply facilities;
- Rehabilitation of intake canals for existing fields in the northern part of the Project area; and
- Rehabilitation of the intake structure of the Tifaji irrigation area.
- Protective works for desertification
- Model market facility for WID

b) Demonstration Farm

- Buildings such as office, laboratories, and houses;
- Farm machinery; and
- Experimentation and observation equipment.

c) Cost for Engineering Services

d) Procurement of O&M machinery and equipment

(2) Administration Cost

a) Administration cost of SONADER for construction of the Project

b) Administration cost of SONADER for operation of the Project

c) Administration cost of SONADER for the Demonstration Farm

d) Cost for establishment and strengthening of AUD and UUEs

6.2 Estimate of Project Costs

6.2.1 Direct Construction Cost

Considering that the Project is aimed essentially at increasing productivity and improving the living conditions of farmers, the Project construction costs were estimated by dividing into two components, one to be financed by the public sector and the other by the private sector, according to the following principles:

a) All main and secondary canals, and intakes for tertiary canals are constructed by the public investment.

b) Rural roads and maintenance roads along main and secondary canals are constructed by the public investment.

c) Rehabilitation and new construction of tertiary canals for paddy fields belonging to local residents in the Project area are financed by public investment .

d) Assuming that the newly developed paddy fields and pasture lands will be distributed to farm cooperatives established by local residents in the Project area, the costs for land leveling and construction of tertiary canals in these areas will be financed by public investment.

e) Rehabilitation and new construction of tertiary canals for paddy fields belonging to individual farms are financed by private investment.

Tables 6.2.1 and 6.2.2 show the estimated direct construction costs including the cost for equipment and their annual disbursement schedule, respectively. Table 6.2.3 gives the breakdown of cost of procurement of O&M equipment. The total direct construction cost was estimated to be 6,414 million UM, including 5,429 million UM to be financed by public investment and 985 million UM by private investment.

6.2.2 Administration Cost for Project Execution and Operation of Demonstration Farm

Three kinds of administration costs for Project execution and operation were calculated based on the Project implementation and operation plan discussed in sub-section 5.1.3, including the operation of the Demonstration Farm. The Project operation cost comprises the O&M cost (water charge) which will be borne by SONADER during the period of guidance and training of AUD mentioned in sub-section 5.2.3. The administration costs for execution of the Project and operation of the Demonstration Farm are shown in Tables 6.2.4 and 6.2.5 respectively, and their disbursement schedule is indicated in Table 6.2.2. The total administration cost was estimated to be 438 million UM.

6.2.3 Project Costs

All the Project costs including physical contingency and price contingency are summarized in the following table:

Description	Total Project Cost			Public Financing			Private Financing		
	F.C.	L.C.	Total	F.C.	L.C	Total	F.C.	L.C.	Total
1. Civil Works	1,847	1,124	2,971	1,364	908	2,272	483	216	699
2. Rural Infrastructure	135	398	533	135	397	532	0	1	1
3. Demonstration Farm	149	101	250	149	101	250	0	0	0
4. O&M Equipment	272	30	302	272	30	302	0	0	0
5. Engineering Services	263	113	375	214	92	305	49	21	70
Cost (Direct Con. Cost)	(2,666)	(1,765)	(4,431)	(2,134)	(1,527)	(3,661)	(532)	(238)	(770)
6. Administration Cost	0	212	212	0	212	212	0	0	0
7. Operation Cost of Demonstration Farm	0	226	226	0	226	226	0	0	0
8. Physical Contingency	267	220	487	213	196	409	54	24	78
9. Price Contingency	338	719	1,057	267	653	920	71	66	137
Total	3,271	3,143	6,414	2,614	2,815	5,429	657	328	985

Note: F.C.: Foreign Currency; L.C.: Local Currency

6.3 Operation and Maintenance Cost

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. A breakdown of these costs is given in Table 6.3.1. According to the estimate, these costs would amount to 90.8 million UM per year, corresponding to 19,200 UM/ha/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.

In view of the drainage pump's effect, the project area is largely divided into three development areas; paddy fields above EL. 1.25 m, pasturage between EL. 0.75 - 1.25 m, and the Awlig block located in the north - east of the project area. Those respective area are 3,660 ha, 590 ha and 480 ha. Drainage water from the Awlig block flows into the north depression of the Gouère area, and thus is beyond the duty of drainage pump at Dioup. The pump's capacity required for paddy fields is 1.5 m^3/sec, while it is increased to 4.0 m^3/sec when the development of pasturage is added. These facts may differentiate the O&M charge cost on the farmers depending upon the kinds of development area. The provisional estimate gives that the unit O&M costs for the above three development areas are; 16,100 UM/ha/year for the paddy fields, 43,300 UM/ha/year for the pasturage, and 12,800 UM/ha/year for the Awlig block. However, this estimate is reference only, and such O&M charge to be collected from the farmers should be decided by the Government in due consideration of social factors and on the basis of mutual agreement with the project beneficiaries.

CHAPTER 7
PROJECT EVALUATION

7.1 Economic and Financial Evaluations

7.1.1 Basic Conditions for Evaluation

The following basic conditions were applied in the economic and financial evaluations of the project:

a) Economic Life : In the economic evaluation, the useful life of the Project is assumed to be 50 years

b) Conversion Rate : A standard conversion factor of 0.85 is applied to the domestic market prices to convert financial costs to economic costs in the calculation of all costs and benefits in the local currency portion.

c) Economic Prices : Economic prices of imported agricultural products (rice) and inputs (urea, triple super-phosphate, potassium sulfate) are estimated on the basis of long-term international market prices forecast by the World Bank for 2005 based on 1990 constant prices, after converting them to the 1997 price level. Prices of other local agricultural products (subsistence products, vegetables, etc.) and inputs (seeds, manure, etc.) are calculated by multiplying local market prices by the standard conversion factor of 0.85. Transfer elements such tax on contracts, subsidies, interests, etc. are deducted from the Project costs because these are considered as a moving of local money that does not affect production.

7.1.2 Economic Benefits

The economic output per ha of crops under irrigated conditions was estimated for two 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:

(Unit: UM/ha)

Description	Rice Cultivation		Pasture
	Mechanized Work	Manual Work	Mechanized Work
"Without Project" Case			
- Total production	79,800	79,800	
- Production cost	65,310	78,920	
- Benefit	14,490	880	
"With Project" Case			
- Total production	169,800		108,000
- Production cost	83,130		75,800
- Profit	86,670		32,200

Note: See Tables 7.1.1 to 7.1.3 for more details

The net benefit in the cases of "Without Project" and "With Project" was calculated on the basis of the unit output mentioned above and the cultivated areas. The annual

irrigation benefit is the difference between agricultural production under "Without Project" and "With Project" conditions. The calculation was based on prices at the time of completion of the Project. The irrigation benefit thus calculated is as follows:

(Unit : UM 1,000)

Description	Rice Cultivation		Pasture	Total
	Rainy Season	Dry Season		
Development Area:	3,940 ha		790 ha	4,730 ha
"Without Project" Case				
- Cultivated area (ha)	770 ha			770 ha
- Total production	61,450.6			61,450.6
- Production cost	53,691.2			53,691.2
- Benefit	7,759.4			7,759.4
"With Project" Case				
- Cultivated area (ha)	3,940 ha	3,940 ha	790 ha	8,670 ha
- Total production	669,012.0	669,012.0	85,320.0	1,423,344.0
- Production cost	327,532.2	327,532.2	59,882.0	714,946.4
- Benefit	341,479.8	341,479.8	25,438.0	708,397.6
Irrigation Benefit				
"Without Project" Case	3,170 ha	3,940 ha	790 ha	7,900 ha
- Cultivated area (ha)	607,561.4	669,012.0	85,320.0	1,361,893.4
- Total production	273,841.0	327,532.2	59,882.0	661,255.2
- Production cost	333,720.4	341,479.8	25,438.0	700,638.2
- Benefit				
Unit benefit per ha (UM/ha)	84,700.6	86,670.0	32,200.0	148,126.5

After the completion of construction works, the irrigation benefit from incremental agricultural production will increase progressively to attain the anticipated benefit after a certain time. In the Project evaluation process, it is estimated that the production target will be reached within a period of five years in each field, by assuming increase rates of 50% in the 1st year, 60% in the 2nd year, 70% in the 3rd year, 80% in the 4th year, and 100% in the 5th year.

7.1.3 Economic Costs

The economic costs are calculated by multiplying the Project costs estimated in section 6.2 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	Amount
Cost of Construction Works	4,552.7
Cost of Replacement of Drainage Pumps and Gates	170.0
Annual O&M and Repair Cost	64.9

7.1.4 Economic Evaluation

The Project is evaluated economically in terms of Economic Internal Rate of Return (EIRR), Benefit-Cost Ratio (B/C), and Benefit minus Cost (B-C), based on the economic benefits and costs estimated above and assuming a discount rate of 10%. The costs of the whole Project are evaluated as Case-1 and the costs of irrigation and drainage facilities, and costs of construction and operation of the Demonstration Farm, except the construction cost of water supply facilities and rural roads, as Case-2. The evaluation results are as follows:

Description	Case-1	Case-2
EIRR	9.4%	10.4%
B/C	0.93	1.03
B-C	- 220	92

According to the evaluation results, EIRR is 9.4% and 10.4%, which demonstrates that the Project is justified.

A sensitivity analysis was conducted by assuming eventual fluctuations of the Project costs and benefits as follows:

(1) Increase of construction cost by 20%

(2) Decrease of benefit by 20%

(3) Simultaneous occurrence of (1) and (2), above

The analysis results are as follows:

	Project	Case (1)	Case (2)	Case (3)
EIRR	9.4%	7.9%	7.6%	6.2%

With a EIRR value of 9.4% in normal case and even 6.2% in the case of 20% increase in construction cost and 20% decrease in benefit at the same time, as estimated above, the Project can be considered economically feasible.

7.1.5 Financial Evaluation

To examine the Project viability in terms of farm economy, the Study Team conducted an economic analysis of medium-size farms benefiting from irrigation and traditional farms (rice cultivation+stock farming, and rice cultivation only) located in the Project area, in the future "With Project" condition. The payment capacity of beneficiary farmers is evaluated to see whether the surplus from farm income, which is the balance of total farm income minus production cost and living expenses, can cover the O&M cost of irrigation facilities in each plot, calculated according to the irrigation requirement. The farm budget and results of payment capacity analysis of each farm category are shown in the tables below:

Farm Budget

	Medium-size Farm		Small-size Farms			
			Rice Cultiv.	+ Stock Farming	Rice Cultivation only	
Cultivated Area	9.5	22.8	2.0	5.0	2.0	4.0
Paddy Rainy Season	8.2	10.9	2.0	2.0	2.0	2.0
Dry Season	1.3	10.9		2.0		2.0
Pasture		1.0		1.0		
Gross Income (1,000 UM)						
- Farm income	919.8	4,616.8	193.6	950.0	193.6	824.0
- Non farm income	485.0	0.0	382.1	87.7	382.1	72.4
Total	1,404.8	4,616.8	575.7	1,037.7	575.7	896.4
Family Size * (people)	8.5	8.5	6.4	6.4	6.4	6.4
Gross Expenses (1,000 UM)						
- Production cost	779.5	2,206.6	109.2	391.0	109.2	315.9
- Living expenses	616.4	739.7	464.1	464.1	464.1	510.6
Total	1,359.9	2,946.3	573.3	573.3	573.3	826.5
Net Surplus (1,000 UM)	8.9	1,670.5	2.4	2.4	2.4	69.9

Note *: Farm Economy Study, JICA, 1996

Capacity to Pay Costs for O&M and Management of Facilities

	Medium-size Farm	Traditional Farm	
		Rice Cult.+Stock F.	Rice Cultivation only
Development Area (ha)			
Paddy field	10.9	2.0	2.0
Pasture	1.0	1.0	
Cost for O&M and management of facilities (UM/year)			
19,200 UM/ha	228,480	57,600	38,440
Net Farm Income (UM)	2,410,200	303,300	508,100
Ratio	9.5%	19.0%	7.6%
Net Surplus (UM)	1,670,500	136,200	69,900
Ratio	13.7%	42.3%	55.0%

As shown in the above table, 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 traditional 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 a sufficient capacity to pay the cost for O&M and management of the facilities.

In case of adopting the different O&M costs to the paddy fields (beyond EL. 1.25 m) and pasturage (EL. 0.75 - 1.25 m) in view of drainage pump's effect, the ratio of annual O&M costs is 13.1% for medium-size farms, 55.0% for traditional farms practicing rice cultivation and stock farming, and 46.0% for farms growing only rice. This result, for a purpose of reference only, shows that the farmers will a sufficient capacity to pay.

7.2 Indirect Benefits and Project Impacts

In addition to the direct benefits mentioned in the above economic evaluation, it is expected that Project will generate secondary benefits and socio-economic impacts. The main socio-economic impacts are the following:

(1) Security of Food Production

In the Project area, many traditional farms are forming agricultural cooperatives and cultivating paddy in common fields. These farms, however, are suffering from low income due to moderate production as a result of the lack of operation fund and rice cultivation techniques. Stable irrigation water supply, improvement of drainage, and introduction of farming techniques through the Demonstration Farm will allow these farmers to increase production and have stable living conditions by reducing seasonal work for non farm income. Furthermore, Mauritania imports 50,000 - 70,000 tons of rice annually. The Project once implemented will secure an annual paddy production of 39,400 tons. A production surplus estimated at 38,000 tons by deducting the local consumption amount (11,080 inhabitants x 71 kg/year x 1/0.65 = 1,210 tons) from total production, 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 Project contemplates the construction of irrigation and drainage systems, development of farmlands, creation of an experimentation and demonstration farm (100 ha) and a pilot model area (810 ha) where a pilot production program will be implemented by members of farm cooperatives. This program covers such activities

as trials, demonstration and training on rice cultivation, fodder and fruit and vegetable cultivation, as well as production of seeds. The demonstration and extension effects of this program 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 Project area is facing the problems of aggravated degradation of pasture lands and decrease of productivity due to poor drainage and free grazing of cattle. 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. At present, the transport of these goods is interrupted in the rainy season.

(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.

7.3 Project Effect Monitoring Plan

It is scheduled that the Project implementation would take more than 10 years from the commencement of construction of facilities to the establishment of the O&M and management system for the said facilities and the materialization of target production. The Project monitoring plan will be carried out to evaluate the Project effects by collecting and analyzing data concerning the progress of works and financial supervision of the Project, as well as on agricultural activities, production, and farm economy after the commissioning of the Project facilities.

The monitoring work will be done by the Monitoring Section of SONADER Rosso Office which, during the work execution, will periodically gather and arrange data coming from the Project Construction Office. For the UUE blocks where the construction of facilities has been completed, the Section will prepare a schedule of investigation for collection of data and surveys of farms on agricultural statistics. The farm surveys will consist of analysis and evaluation of the Project effects through periodical monitoring of the farms selected based on the analysis of the farm economy survey conducted at the stage of development studies. The results will be

used for confirmation of the status of attainment of the Project objectives, and as references when providing instructions to beneficiary farmers.

The main factors to be examined and evaluation criteria are as follows:

Level	Data	References
A	Project progress and financial supervision	Recording of data (construction supervision)
B	Farming pattern	Farming pattern, cultivated area
	Rice cropping ratio	Annual rice cropping ratio, status of introduction of double rice cropping
	Water management	Irrigation installation and effect
C	Agricultural development area	Yields and production
	Land ownership	Total work quantity
	Agricultural support	Familial work quantity
	Agricultural production cost	
	Yields and production	
	Agricultural inputs	
D	Prices of products	Amount of agricultural production
	Income from farm products	Agricultural production cost
	Benefit from farm products	Farm gross income and net benefit
	Farm income	Work quantity and cost
		Gross income and net benefit from agricultural activities

CHAPTER 8
ENVIRONMENTAL CONSERVATION PLAN

8.1 Chott Boul and PND Ecological Areas

The Delta is recognized to be the most sensitive and important area in the valley from the biodiversity viewpoint. Probably 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 considered as an annexed part of PND in view of its location in proximity to PND. Chott Boul's isolated location is favorable for rest, reproduction and forage of birds. When PND dries up, the birds leave this place and go to Chott Boul for forage and repose.

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. The dynamics of the area makes it exceptionally rich in invertebrates and fish, possibly contributing to the improvement of the social environment of villages located near PND. These villages, in particular those located in the Ziré and Birette sand dunes, have a long history of fisheries. Fishing activities however have been limited by the creation of PND which reduced the working area of fishermen. In DEAR Study in 1985, Chott Boul was included in PND area and proposed to be developed for facilitating fishing activities of the said villages.

Today PND has become the only protected site by the Ramsar Convention in the area. Chott Boul has not yet been granted any protection status but is included in the list of internationally important wetlands submitted by DEAR to Ramsar.

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.

According to the results of Initial Environmental Evaluation (IEE), the alternative of draining waters from the Project area towards Chott Boul via the N'Diadier canal will probably have harmful effects on the environment of the Chott Boul area. These effects, which have been discussed in previous sections of this Report, can be detailed as follows:

(1) Effect of Water Level Fluctuations in Ponds and Backwaters in the Area

Water level fluctuations caused by the additional inflow from the Project may cause flooding on a rather large scale. Prolonged water saturation of soils in submerged areas may asphyxiate the vegetation, thus reducing the herbaceous and ligneous cover, and affect the habitats and spaces for migratory birds living in the area.

(2) Effect of Contamination of Waters by Plant Protection Products (Pesticides and Fungicides)

Considering the nature of these products (to kill viruses, bacteria, insects), it is obvious that an uncontrolled application of such products will have a serious impact on the environment. As the products are soluble in water, they may contaminate it

with heavy concentrations and thus imperil the fauna in contact with this water, especially fish, and also birds that feed on these fish and consume this water.

(3) Fertilizer-related Effect

Unlike toxic products such as pesticides and fungicides, fertilizers are intrinsically not dangerous to the environment. Their impact is rather indirect due to their double effect of benefiting not only the cultivated plants but also other plants, algae, and birds feeding on algae. A high concentration of fertilizers may lead to proliferation of algae coupled with a large oxygen consumption, which results in reduced clarity and transparency of water through the eutrophication process. This condition will affect the development of certain animal species and kill fish, and particularly harm birds which need to see their preys through water to catch them.

Taking the above into consideration, and in view of the concern of DEAR authorities about the need of conservation and protection of nature in the area, the drainage alternative mentioned above should not be applied.

Activities relating to the conservation of the areas concerned and PND must be emphasized and strengthened. Simultaneously, studies and arrangements for granting of protection status to other areas of the Delta and its vicinity (Chott Boul area) should be pursued. The environmental conservation in the whole valley should be focused on specific targets: The "gonakié" planted areas, various ichtyo-fauna components, remaining population of mammals should be covered by a program of monitoring and concerted conservation efforts by DEAR.

8.2 Sanding and Desertification

(1) Desertification Control

Sanding, which causes big losses of productive lands (pasture and cropping lands), represents the number one environmental problem in Mauritania. Considerable experience has been acquired in Mauritania in the field of fixation of drifting sands both around housing areas and along roads. Many sand fixation projects are under execution, with most of which being under management of NGOs.

Among all the areas covered by the sanding prevention program along the Saharian edge, the techniques acquired by Mauritania are exemplary. A combination of two techniques is adopted in Mauritania for fixation of drifting sands: Mechanical fixation and biological fixation. The mechanical fixation method is to construct protection counter-dunes or to install fixing wattles made of tree branches, palm-tree rachises or leaves, or synthetic material along sand dunes. The second technique is to afforest the area with appropriate tree varieties having rapid growth and being tolerant of drought.

One of the essential determining factors to ensure the success of a project is the extent of participation of the local population. Experience obtained in Mauritania demonstrates that the success of sand fixation projects sensibly increases where the local population is directly involved in the design, construction, and maintenance of the projects.

Efforts to promote participation and motivation of local people (protection of their irrigated lands in downstream areas, income from felling of trees, land appropriation) in such sand fixation projects have been successful in many instances. The participation of villagers in such efforts of preventing environmental deterioration would be strengthened through the activities of the Pilot Farm proposed under the Project. The Farm can assist in production and planting of plants or ensure technology transfer to villagers through trials and demonstrations performed in the

Farm. The Farm will have a function of research on conservation and monitoring of soil erosion and will recommend conservation methods aimed at reducing the costs and optimizing the integration of new development projects.

(2) Protection Works for Desertification

The Project will include the protection works for desertification in order to protect the project facilities including the farm lands, canals and farm roads. The afforestation method, which is prevailing in the vicinity area, will be adopted to the protection works. 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.

8.3 Environmental Monitoring System

(1) Monitoring of Resources

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 work should be performed as far as possible with the participation of the Project beneficiaries. To this end, it is recommended that the monitoring system be integrated into the Pilot Farm mentioned above, of which functions include research, soil conservation, resource monitoring, evaluation of protection measures, extension, production and supply of seedlings to farmers.

The monitoring includes inventory of quality and quantity of resources in order to examine their dynamics. Inventory will be conducted at regular intervals of time and will cover the parameters indicating the evolution of resources and the environment. These parameters will be selected among representative samples of different categories of resources.

(2) Monitoring Items

a) Soil and Water

The quality of soil and its evolution should be monitored as regularly as the farming practices are intensified. Soil analysis should be conducted at the end of each cropping season or according to the frequency recommended by the Soil Expert as discussed in the Chapter on Soils in this Report. The monitoring should enable:

- to detect eventual phenomena of salinization, alkalinization, or modification of structure; and
- to calculate accurately the nutritive elements required to be provided for the next cropping season and to inform the same to producers

As to the water in the Project area, a progressive quality deterioration was observed. This can be explained by the following conditions:

- absence of drainage measures; and

- absence of action to make the population sensitive to the problem of water sanitation and better utilization of wells.

SONADER shall continue monitoring water quality after the completion of the Project. Monitoring activities will include water quality analysis twice a year, in mid-July (at the period corresponding to the end of harvest of out-of-season crops and the beginning of rainy season cropping) and in mid-December (at the time of harvest of most winter crops). The locations and elements to be tested will be as follows:

- on the river upstream of Ibrahima: pH, EC, and salinity

The salinity of irrigation water for rice cultivation should be less than 2,000 ppm in order to avoid the problems of toxicity and decrease in output.

- in the wells of water for consumption: pH, EC, NO_3, salinity, bacteria, and E. Coli.

Accumulation of nitrates and number of bacteria and E. Coli should be monitored.

- in areas downstream of the future drainage canal: NO_3, P, plant protection products; and

- in the Gungala depression where drainage waters will be discharged: NO_3, P, plant protection products.

Table 8.5.1 (referring to ADOUR-GARONNE Basin Agency) shows a multi-purpose pattern indicating the criteria for overall evaluation of water quality. This pattern specifies five quality classes depending on the purpose of use of the river water. Each class groups the values of many parameters. Since international standards are adopted in preparing this pattern, it can be used as a valid tool for water quality monitoring in Mauritania.

Monitoring will also include water quality control through:

- observation of piezometric level of groundwater during the rainy season and during the periods of intensive irrigation; and

- maintenance and flushing of drains so as to facilitate the flow of drainage waters and to avoid their contact with groundwater.

b) Sanding and Desertification

Even after application of protection measures to the affected areas, problems may arise due to the lack of adequate monitoring. Therefore, continuous monitoring will be required until the trees attain maturity and replace the wattle-work, then periodical monitoring may be necessary thereafter. The latter work will consist of guarding against straying of cattle, maintenance of fences (repairs, removal of sand), and monitoring the height of trees in order to strengthen effectiveness of windscreens.

c) Health and Epidemiology

A better utilization of statistical means will allow a better knowledge of evolution of different affections. Therefore, epidemiological indicators of morbidity, i.e. ratio of prevalence, ratio of attack by age group will enable to better determine health measures for prevention and treatment during the monitoring of diseases. The improvement of this health tool can be materialized only with a perfect collaboration of health officials.

Epidemiological studies should be carried out every year to ensure correct monitoring and epidemiological control, as a complement to the above-mentioned measures. Reliable study of chemical resistance of certain vectors in given treatment methods; identification of mollusks responsible for urinary bilharziosis and their density, distribution and infestation; epidemiological survey on bacteria and parasites causing diarrheic and dysenteric syndromes should be conducted every year within the framework of an epidemiological inspection system. CNH can undertake the execution of these study works.

An annual survey on the quality of water for consumption of the population will provide valuable information. This will allow to anticipate indispensable preventive and curative measures to be taken.

CHAPTER 9
WOMEN IN DEVELOPMENT (WID)

9.1 WID Program Background

The present situation of activities of women from villages in the Project area shows that they are well aware of economic activities and have sufficient experience in cooperative activities. However, the conditions required for women's activities (especially in the infrastructure aspect) are not adequate for the time being and, therefore, 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, an examination of the methods used by women in cultivation and artisanal production as observed during the field study demonstrates that is still a possibility for improvement. For this purpose, there is a need to provide training and technical guidance to women.

9.2 Basic Components of WID Program

The WID Program is focused on two fundamental objectives: Development of the facilities mentioned below, and instruction on general knowledge and improvement of techniques.

- 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.

- Basic education of women as well as training and technical guidance on economic activities (artisanal production, farming).

To carry out the above activities, SONADER will formulate a basic plan for each village and give advice, taking into consideration the situation of women's activities in each village through the Union of Women Cooperatives. The Union will play the pivotal role in supply of equipment and technical guidance. 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.

CHAPTER 10
CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

(1) Although the food production potential of Mauritania is concentrated in the Senegal river valley, the present cultivated area is only 16,200 ha, corresponding to 28% of the total cultivable area of 135,410 ha. The supply of staple foods such as wheat and rice in depends on import. The country imports 50,000 to 70,000 tons of rice annually. In this context, the Government plans to secure a food self-sufficiency rate of 50% through the increase of agricultural production by incorporating the project of irrigated agriculture development in the Dioup area in the Senegal river basin as a priority project in the Integrated Irrigated Agriculture Development Program in Mauritania (PDIAIM). 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) An economic evaluation was made on the basis of the Project cost estimate including cost for construction of irrigation and drainage facilities, cost for rehabilitation and construction of farm roads, water supply facilities, etc. envisaged in the irrigated agriculture development plan, as well as on the basis of the proposed Project execution and operation plan, and the calculation of the Project benefits and impacts. The evaluation indicates that the Project's EIRR would be 9.4%. If the construction of farm roads and water supply facilities is excluded, the EIRR would increase to 10.4%. 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 components consist of rehabilitation of main and peripheral canals, construction of drainage canals and a pumping station, and rehabilitation of existing roads and construction of new farm roads, all aiming to improve productivity and prevention of salinity in existing crop fields. Since these works area similar in nature to those already executed by farmers or local contractors under supervision of SONADER in the national M'Pourié farm and Gouère area located I proximity to the Project area, 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, according to the financial analysis results, these costs will be within the payment capacity of even artisanal farms.

(5) Stock farming represents one of the main industries of Mauritania and accounts for 80% of production in the agricultural sector. The majority of local population in the Project area depend on stock farming for living and rear about 10,000 heads of bovines and ovines. The Senegal river had vast natural meadows during the flood recession periods, but these meadows disappeared after the construction of the Diama dam and the right embankment. 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 an 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".

10.2 Recommendations

Considering the fact that the Project of irrigated agriculture development in the Senegal river valley does not present any particular technical problem and will largely contribute to the increase of food production and improvement of living conditions of farmers in the Project area, 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, in parallel with the execution of works.

(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.