# COMPARATIVE ANALYSIS OF CAPITAL INTENSIVE AND LABOR INTENSIVE RICE IRRIGATED PERIMETERS IN THE SENEGAL RIVER VALLEY



by

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## ABSTRACT

Senegal is heavily dependent on imported food, particularly rice. During the late sixties and early seventies the Sahelian drought made the country painfully aware how dependent its agriculture is on rainfall.

Irrigation and full water control systems along the major rivers became the "priority of priorities" in the recent Senegalese national plans. In the Senegal River Valley two major types of irrigation schemes had been implemented along the river valley since 1973: large scale and small scale irrigated perimeters. The objectives are to increase rice production and reduce dependence on foreign imports of rice.

This paper analyzes the two types of irrigation schemes in the Senegal River Valley and compares the financial and economic cost of producing rice in each of them with the average CIF price of rice delivered to the capital city Dakar.

The analysis shows that for large irrigated perimeters the economic and financial cost of locally produced rice delivered to Dakar range from 132 to 233 percent of the economic and financial average CIF price, respectively.

For small perimeters the economic and financial costs are, respectively, 140 and 125 percent of the CIF prices.

Costs for both large scale and small scale perimeters are relatively high for the following reasons:

a) Senegal rice imports consist of broken milled rice from Southeast Asia which is the least expensive quality of rice on the world market.

b) Managerial problems which can be significantly improved if more consistent policies toward irrigated rice production are defined and applied, and if the land development agency concerned with the Senegal River Valley is reorganized.

# CHAPTER 1

## INTRODUCTION

Senegal is primarily an agricultural country. Agriculture accounted for 28 percent of GDP in 1976 but provided employment for 80 percent of the economically active population. The most important agricultural product in Senegal is peanuts, the mainstay of the economy. Other important agricultural products are millet, paddy rice, maize and sorghum.

Cereal production in Senegal is not sufficient to meet consumption, leaving a deficit of about 200,000 tons of food grains each year. For decades the country has exported groundnuts and imported rice to cover its food deficit. During the late sixties and early seventies the rapid growth of urban areas, the failure of food production to grow apace, the disruption in peanut production, the instability of world prices, and the Sahelian drought made the country painfully aware of its dependence on imported food, mostly rice. Since 1977, Senegal has confirmed how dependent its agriculture is on rainfall, as it had to import more than 600,000 tons of cereal in 1977/1978; total cereal production in this crop year covered only 43 percent of the country's needs versus 60 percent in normal years. Domestic rice production covered only 15 percent of the domestic consumption versus a more normal 30 percent.

Senegal's food dependence is worsened by its rural exodus: the countryside can no longer feed the towns and the urban population is growing at a

high rate of 2.2 percent per annum. Urban areas are large consumers of rice, wheat and sugar and these crops can only be grown in Senegal using irrigation.

Because of the economic instability arising from the combined factors of heavy dependence on imported food and unstable rainfall, irrigation and full water control systems along the major rivers have become the "priority of priorities" in recent Senegalese national development plans. The 5th Plan (1977-1981) allocates half of the total budget for agriculture to irrigated farming and preparation for installing a large dam to regulate the flow of the Senegal River.

The river region, which contains the Senegal River accounts for 70 percent of the total investment in irrigated farming and 30 percent of domestic production of rice. A governmental land development agency, the SAED, is in charge of developing irrigated farming along this valley. Two major types of irrigation schemes had been implemented along the river valley since 1973: large scale and small scale irrigated perimeters. The large scale irrigated perimeters have high capital costs, usually borne by foreign aid, and large recurrent costs which must be supported by the government budget. There is less peasant participation in perimeter establishment and operating agricultural equipment relative to the small scale perimeters. The small scale irrigated perimeters, also called village irrigated perimeters, use traditional tools and less machinery. This requires greater peasant participation in perimeter establishment and farm management. In terms of their importance, large perimeters account for 70 percent of all rice produced in the Senegal River Valley. They account for an even greater proportion of marketed sales of rice, around 90 percent, since a substantial

proportion of rice produced on small perimeters is consumed by the producing households.

The purpose of this paper is to compare the financial and economic costs of these two types of irrigation schemes, both in relation to each other and in relation to imported rice delivered to Dakar. Financial costs are calculated both from the point of view of the land development agency, SAED, and from the point of view of participating farmers. Economic costs reflect the cost of the two alternatives to the national economy. In comparing these two approaches we calculate investment, operating, administration and marketing costs, and determine for a number of selected perimeters the financial and economic cost of producing one kilogramme of milled rice. The results of these computations are then compared with the estimated CIF price of rice delivered to Dakar. The paper also identifies some major obstacles to increasing paddy rice production in irrigated perimeters and concludes with a discussion of the policy implications of the results.

## CHAPTER II

## PRESENTATION OF THE RIVER REGION, THE TECHNOLOGICAL AND POLICY CONTEXT

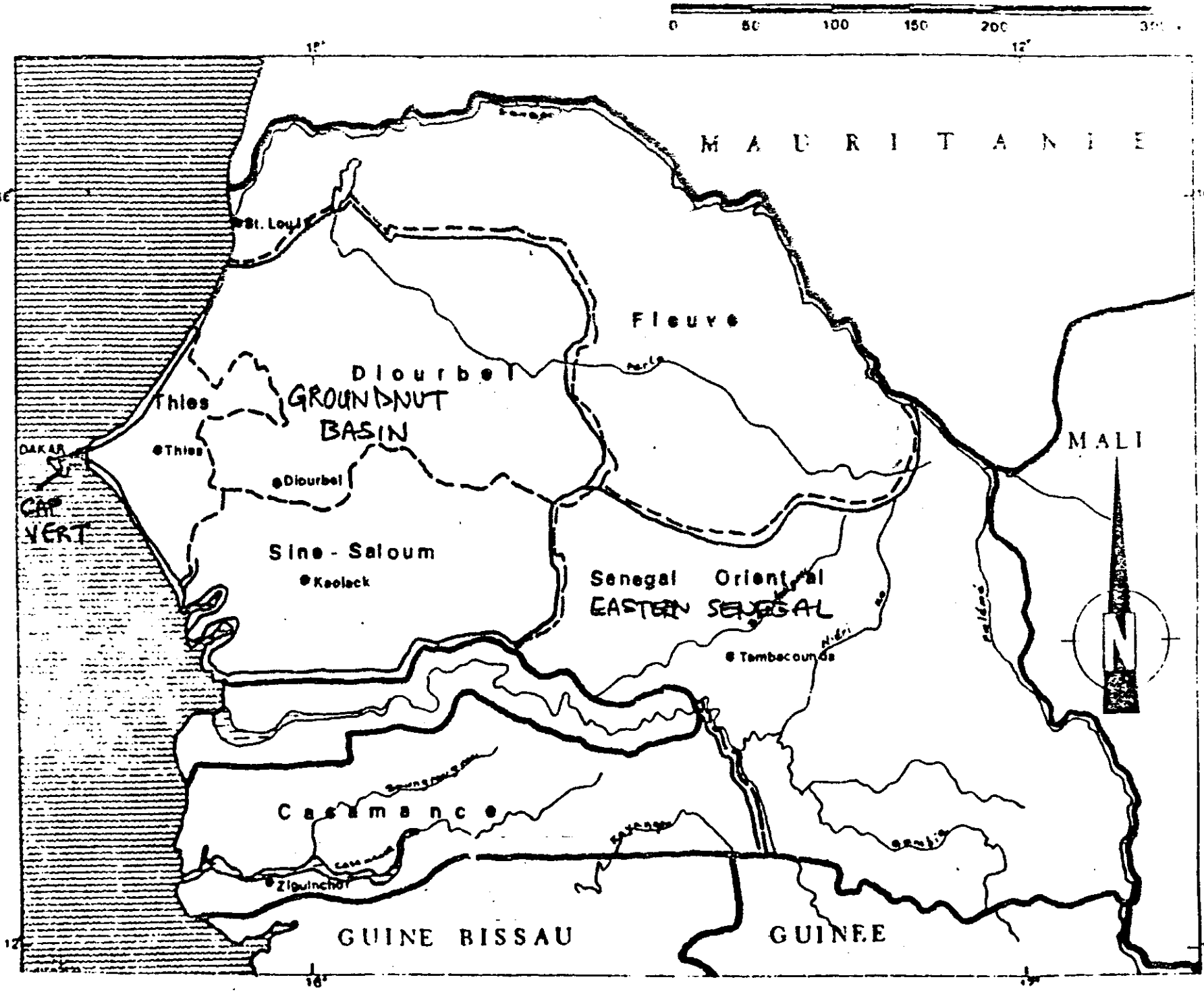
### A. Geography

The Senegal River Region is the northern-most region of the country and offers the largest potential for irrigated agriculture in Senegal (see Map I). The climate of the region is tropical with two well defined seasons: a dry season from November to June and a rainy season from July to October. Rainfall is very irregular from one year to another and declines from East to West. The annual average rainfall in the West at St. Louis is 300mm while it is 600mm in the East at Bakel.

This difference in the amount of rainfall explains differences in agricultural production patterns between the northern and the southern part of the region. In the North (Delta, Dagana, and Nianga) rainfed millet, sorghum and peanuts were grown by farmers before the establishment of irrigated perimeters. In the South (Matam and Bakel) farmers were growing maize, sorghum and rice. Up to the present large scale irrigated perimeters have been established in the northern part of the region while the South has become the domain of small village irrigated perimeters.

### B. Population

The river region has a population of 498,000 inhabitants (approximately ten percent of the Senegalese population) which is expanding at a rate of 2.2 percent per annum. In ethnic terms the population consists


0 50 100 150 200
MAURITANIE
MALI
Fleuve
Diourbel
GROUNDNUT BASIN
Thies
DAKAR
CAP VERT
Sine - Saloum
Kaolack
Senegal Oriental
EASTERN SENEGAL
Tambacounda
Casamance
Ziguinchor
GUINE BISSAU
GUINEE
St. Louis

MAP I

primarily of Toucouleur and Ouolofs with a smattering of other groups as is indicated in Table 2.1. The largest groups, Toucouleur and Ouolof are more oriented toward irrigated farming, while the Soninke migrate to large cities, particularly in France. Peulh and Maure devote themselves more to animal husbandry and other activities. The population density is very low in the Delta and the "Dieri."[1] This creates an important labor bottleneck during the peak season. Efforts are being made by the Senegalese government to bring people from the highly populated peanut basin into resettlement villages established in the Delta.

## C. Agriculture

Agriculture is the most important activity of the region. Agricultural production is diversified as shown in Table 2.2. Millet and sorghum, rice, maize, peanuts and vegetables constitute the main food crops in the river region, with millet and sorghum occupying first place in volume. The preeminence of millet and sorghum is evidenced by the large portion of total cultivated area devoted to this crop. Rice, however, is becoming progressively the more important crop in the region with the establishment of new irrigated perimeters.

## D. History of Rice Cultivation in the Senegal River Valley

Irrigated rice cultivation was first introduced into the Senegal River Valley by the colonial governor Le Baron Roger in 1824. An experimental irrigated farm was established at Richard Toll along the river. The main objectives of the farm were the development and extension of different fruits

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[1] "Dieri" is dryland which can be cultivated only under rainfall.

TABLE 2.1
ETHNIC COMPOSITION OF THE HUMAN POPULATION
OF THE RIVER REGION OF SENEGAL, 1975

| Ethnic Group | Population | Percent of the Total Regional Population |
|---|---|---|
| Toucouleur | 310,000 | 62 |
| Ouolof | 125,000 | 25 |
| Soninke | 25,000 | 5 |
| Maure | 10,000 | 2 |
| Peulh | 20,000 | 4 |
| Bambara | 5,000 | 1 |
| Sarakholle | 3,000 | 1 |

Source: SCET International/ SAED, 1975 Program d'action a court et Moyen term - Plan Directeur d'Amenagement de la Valley du Fleuve Senegal.

TABLE 2.2
AREA AND PRODUCTION OF MAJOR CROPS IN
THE RIVER REGION OF SENEGAL, 1978

| | Rice (Paddy) | Millet/Sorghum | Maize | Peanuts | Vegetables |
|---|---|---|---|---|---|
| Area (hectares) | 12,200 | 104,300 | 9,100 | 12,300 | 2,100 |
| Production (tons) | 22,500 | 45,000 | 5,700 | 2,400 | 10,700 |

Source: SCET International/SAED, 1975 Program d'action a court et Moyen term - Plan Directeur d'Amenagement de la Valley du Fleuve Senegal.

and cereal varieties and the promotion of rice cultivation for local consumption. However, the lack of knowledge about the characteristics of Sahelian agriculture, ignorance of the soil structure, and poor climate conditions led to the failure of the project shortly after it began. Peanut production for export was developed all over the region. However, as peanut production increased, cereal production progressively dropped. During the first quarter of the 20$^{th}$ century, the cultivation of groundnuts reduced the food reserves of the country considerably. The resulting food shortages called for a reconsideration of the possibilities of rice cultivation in the Senegal River Valley.

In 1935, France created the "Mission d'Etude du Fleuve Senegal" which was replaced three years later by the "Mission d'Amenagement du Senegal" (MAS). The MAS was in charge of conducting studies (Hydrology, Pedology, Topography, Agronomy, etc.), necessary to the assessment of the region's potentials.

In 1938, the MAS implemented its first perimeters at Guede (1,000 hectares), Diorbivol (100 hectares), and Demette (100 hectares), along the river. The smaller perimeters of Diorbivol and Demette were experimental and soon abandoned. The perimeter of Guede had a pumping station and required the participation of local farmers. From 1938 to 1960 when Senegal attained independence, the Guede perimeter was the only irrigated perimeter in the country being exploited. After independence the new government decided to put a high priority on developing the Senegal River Valley for irrigated rice production.

Since 1960, all rice production along the Senegal River Valley has been under the supervision of Parastatal agencies. The OAV (Organization autonome de la Vallée) supervised irrigated projects in the river valley

from 1960 to 1964. The SAED (Societe d'amenagement et d'exploitation du Delta) replaced the OAV in 1965. Since that time SAED has been providing extension services, machinery services, seed, chemical fertilizer, insecticides and herbicides on credit to the rice farmers in the Senegal River Valley.

## E. Rice Production Technologies

During the sixties two types of rice irrigation systems were developed along the valley, one of which eventually supplanted the other.

### 1. The Primary Polders with Partial Water Control

This was the initial irrigation system used in much of the valley. This partial water control technique comes from Asia (Indus Valley). It was introduced during the colonial period by the French, first in 1930 along the Niger River with the creation of the Office du Niger and secondly, in 1960, in the Senegal River delta by the MAS. The system was further developed and adapted to local conditions during the late sixties by the SAED. The technique itself results in only a minor improvement in natural conditions. Protecting the polders against the eroding forces of the river and maintaining within the polder a water level different from that of the flooded river have proved to be major problems. In these primary polders, yields vary between 500 and 1,200 kg/ha depending on the rainfall, the flood and the salinity of the soil.

In bad years, no polder is secure because of salt water incursion upstream. About 75 percent of the Senegal River's total annual flow of 25 billion cubic meters ($m^3$) occurs during the three months of the rainy season. Thereafter, the flow tapers off and reaches ten cubic meters per second ($m^3/s$) or less in April/May. This results in the drawing of saline ocean waters 200 km upstream. Such incursions of salt water render dry

season cropping in the Delta impossible. A minimum flow of about 100 $m^3/s$ is required to repulse the saline incursion in the high flow period. Due to large inter-annual variations, the date at which river flow is sufficient to push back the ocean water and to permit pumping in the Delta varies significantly. In years of bad floods, important delays occur in the planting of the rice crop in the Delta polders. In consecutive drought periods, salinization and acidification of soils become added problems.

In 1965 SAED began the improvement of the primary polders in the Delta by adding a pumping station and an improved canal network within the polder. These were called secondary polders. In the absence of leveling, water depth varies greatly throughout the fields and dwarf, high yielding varieties cannot be used. By leveling and adding an improved canal network we get a tertiary polder with full water control.

## 2. Polder with Full Water Control

Between 1965 and 1970 the large inter-annual variation of the flood in the river, coupled with the Sahelian drought, led to a failure of the secondary polders of the Delta.

In order to secure rice cultivation along the river, the SAED began in 1971 to develop a new system of polder with full water control. The objectives were:

1. to disassociate the irrigation canal network and the drainage canal network.

2. to level the land to a maximum slope of five percent.

3. to divide the polder into irrigated blocks of 100 hectares and into fields of three to five hectares each.

4. to associate farmers in the supply and control of water and in the maintenance of the irrigation network and the fields.

These measures would permit double cropping and intensive cultivation of high yielding varieties of rice.

Since 1972, all polders developed for rice cultivation have been built for full water control. The development of full water control perimeters involves a new organization and management of the fields. Two types of full water control perimeters are being implemented.

1. large scale irrigated perimeters with high capital investment and less peasant participation in implementation;

2. small scale irrigated perimeters with low capital investment and large participation of peasants in implementing and operating the farm.

In both systems the introduction of high yielding varieties of rice, wheat and tomatoes have resulted in increased agricultural productivity and higher income for the peasants.

a. Large Scale Irrigated Perimeters

Large scale irrigated perimeters are characterized by:

1. areas of 100 to 10,000 hectares
2. large pumping stations (more than 240 hp)
3. heavy equipment (tractors, combines)
4. large number of peasants
5. large number of extension agents and extension services

The perimeter is divided in holdings of .5 to 3 hectares each and is fed by a feeder canal capable of irrigating ten hectares. This permits better irrigation and use of heavy pumping machines. A mutual guarantee group of 15 to 20 farmers are put in charge of water distribution and maintenance of the feeder canals.

At the present time there are three different large scale perimeters in the valley:

1. Delta Perimeter (Boumdoum)
2. Dagana Perimeter
3. Nianga Perimeter

1. The Delta Perimeter

The tertiary perimeter of Boumdoum is a result of several different improvements. The primary perimeter of 1964 became a secondary perimeter in 1966 and a tertiary perimeter in 1972. The average holding per farmer is about 2.5 hectares. Crop decisions are made by SAED which also provides inputs, machinery pumping and extension services.

Seeding is done mechanically with seeders. Fairly high seeding rates are required due to the low germination rates in the saline soils of the Delta. Land preparation and threshing are done with motorized equipment.

The major problems confronting the Delta perimeter are water insecurity, the presence of salt, and the high cost of polder development. Farmers face the additional financial risk of being liable for machinery service charges and cash inputs without adequate production security.

2. The Dagana Perimeter

The project is located in the lower river valley near the city of Dagana. The project was financed jointly by the Senegalese government and the IDA. Total project cost was estimated at US $7.4 million (CFA F 752 million) or 40 percent of the total cost. Irrigation work started in late 1973 because of excessive delays in preparing contracts. Two conditions were required by the IDA before the project could start:

1. signature of a financial agreement between government and SAED satisfactory to IDA, and

2. establishment of a contract between SAED and farmers or a farmer's group, satisfactory to the association.

The Dagana perimeter comprises three sectors: Sector A (600 hectares), Sector B (1700 hectares), Sector C (700 hectares). Each sector has its own pumping station. The estimated completion date for the three sectors at the time of appraisal was February 1976. Late availability of governmental financing has led to frequent work stoppages, however, delaying completion of Sector A and B by one and one-half years and Sector C by three years.

The major constraints on the Dagana perimeter are the presence of salt and heavy soil which requires heavy equipment and the low production security for farmers. Moreover, farmers are from different ethnic groups which affects the organization of farming groups and mutual guarantee groups. The average holding per farmer is about one hectare. As in other large perimeters, machinery services, crop decisions and extension services are made by the SAED.

3. The Nianga Perimeter

The Nianga perimeter is located near the city of Podor in the middle river valley. It was financed under the "1071/SE" convention between the Senegalese government and the European Development Fund (FED) in 1974. The total cost of the project was estimated at 1.7 million CFA francs to implement 860 hectares. The final design of the perimeter calls for 10,000 hectares under cultivation. However, completion will depend on greater availability of water through the regulation of the Senegal River. Until an upstream storage facility is constructed, the off-take of river water for dry season irrigation will remain seriously constrained. Because Nianga does not experience salt water incursion, farmers can practice

double-cropping if sufficient water is available. They grow rice during the rainy season and tomatoes and maize during the dry season. Total investment costs are about 1,250,000 CFA francs per hectare. Individual parcels average about one hectare. Mutual guarantee groups of 15 to 20 farmers are put in charge of water distribution and maintenance of feeder canals. The pumping station and primary irrigation network are maintained by SAED, which also decides on the crop to be planted, the varieties to be grown, and the agricultural calendar [Tuluy, 1978].

Land preparation, seeding and threshing are done mechanically. Land preparation requires deep plowing every three to four years and offset and cross-harrowing in intervening years. Seeding is done with a tractor drawn seeder. Potassium chloride is applied at seeding, and during the crop cycle complex fertilizers and urea are manually applied. Weeding is done by hand in conjunction with chemical herbicides. Harvesting is manual, using a sickle, and a mechanical thresher. In addition to the same problems encountered at Dagana, the Nianga perimeter is confronted with a scarcity of labor during the peak periods of the year.

b. Small Scale Village Irrigated Perimeters

These perimeters are characterized by:

1. small areas of 15 to 50 hectares with an average area of 20 hectares per perimeter;

2. one mutual guarantee group of farmers (GP) per village perimeter (15 to 20 farmers per groupement de producteurs);

3. one motor pump per perimeter;

4. one extension agent for two or three villages;

5. use of traditional tools.

The main objective of small village perimeters is to lower costs to farmers. Before this kind of perimeter is set up, the village must ensure that there are about 20 hectares of land available which are not subject to flooding but are close enough to the river for pumping, that land tenure problems are settled, and that a village level committee for perimeter management and operation is established. SAED helps choose an appropriate site and lays out the design of the major network. Clearing, stumping and canal construction are then done collectively by farmers using traditional tools. Individual parcels in the polder are allocated by SAED lottery to polder members who have been chosen by the village. SAED occasionally limits the number who can join to assure that at least .20 hectares are allotted per household. Each individual is responsible for the leveling and construction of his own plot. The polder pump is installed by SAED and operated by the villagers, while a SAED mechanic remains responsible for major maintenance.

Land preparation is done in June with a traditional hand hoe or shovel and without the benefit of pre-irrigation rains to soften the soil. A collective nursery is prepared in mid-June while the river level is still low. Farmers use a short-cycle, high yielding variety of rice (IKONG PAO) which is purchased from SAED and renewed every three years. Seedlings are transplanted three weeks later when sufficient field water becomes available.

Fertilization rates on small perimeters are high. Weeding is done manually or with a traditional hand hoe though weeds are not generally a problem because the rice is transplanted and individual plots are small. Paddy is sickle-harvested by all family members from October through December and left to dry in the field for about two days. It is

then taken to a threshing floor on or near the perimeter and threshed over a barrel by women. Transport to on-farm storage sites varies considerably depending on the distance between the perimeter and the farmer's village. It may be done by renting, borrowing, or using one's own animal-drawn cart or by canoe or head carrying.

In addition to hand tools, fertilizers and improved seed, farmers use pump and extension services furnished by SAED. Pump repair is done by SAED mechanics, and peasants pay for any spare parts required. Peasants are supposed to maintain an amortization fund out of which major repairs and pump replacement are paid.

The major constraint on expansion of this system is the availability of suitable land. In addition, if expansion increases the size of individual holdings and there is no change in the technique used, labor could become a big constraint. Finally, the effectiveness of the village committees in assuring pump maintenance and replacement has yet to be tested.

## F. Agriculture Policies in Senegal Relating to the Rice Sector

Since the 1968-73 drought and the high world rice prices in 1974, the Senegalese government has clearly defined its intentions to encourage irrigated farming and particularly rice production. The main objective of greater rice production is long-term self sufficiency in cereals leading to enhanced national food security. In order to develop the country's rice sector, the government, through public land development agencies, has pursued four major policies with respect to investment, input supply, prices and trade, and land use.

### 1. Investment Policies

Because of its importance to the Senegalese diet, recent Senegalese rice policy has aimed at expanding domestic production under conditions of

more secure water availability. In an unstable climate, the only secure systems of food production are those that can assure the availability and distribution of water when needed. The need to control water is the main rationale behind the government's investments in irrigation systems for rice.

### 2. Input Supply Policies

Generally, agricultural inputs such as fertilizers, seeds, pesticides, equipment, and machinery are subsidized. SAED provides to each farmer a leveled parcel of land with full water control and free extension services since by law all land under irrigation belongs to the national government. In addition, the input distribution system both subsidizes the delivery of inputs to the farm, and finances the working capital required for their purchase.

Mechanical services such as deep plowing and water supply are charged to farmers at cost or slightly less. Almost all goods destined for the agricultural sector are exempt from import duties.

### 3. Prices and Trade Policies

Since independence, the government has continuously been adjusting consumer and producer prices. While working to expand rice production, the government remains committed to maintaining adequate cereal supplies at stable consumer prices through its rice import policy. Through heavy price controls, the conflict is temporarily solved to the advantage of urban consumers and the disadvantage of rural farmers.

a. Consumer Prices

Since 1960 the government has made an effort to stabilize consumer prices by adopting an official price of rice which it has defended with large quantities of imports. Between 1960 and 1968 large increases in the world price of rice were passed on to the consumers, while smaller, temporary fluctuations were absorbed by government taxes or subsidies. To generate revenues for the rice stabilization fund, consumer prices were usually set above the CIF import price. In addition, because the cost of producing local rice was higher than the average CIF price, the higher retail price afforded protection to domestic rice producers.

The 1968 drought occurred at a time of rising world food prices. The domestic production short-fall had to be made up with imports as the price rose 40 percent. In 1971, when import prices fell, the government decided to lower consumer prices. In 1973 import prices shot up and the government again subsidized consumers. In 1974 CIF rice prices were so high that the government was no longer able to subsidize consumers. The estimated subsidy on rice, sugar, and oils (2.7 billion CFA) was larger than the entire development budget of Senegal. Pressure to revise prices began in November 1974 when the government totally eliminated the subsidy on rice imports. The retail price of rice was raised from 60 to 100 francs. Since then the retail price has been equal to or above the CIF price for imported rice.

b. Producer Prices

Senegalese price policy has strongly affected domestic rice production.

The effect can be divided into two parts: trade protection and domestic producer price supports. Trade protection leads to quantitative import restrictions which may have caused the local market price to stay significantly above the world price in some years. The competitiveness of local production is hampered because Senegal usually imports inexpensive qualities of rice. Even with international shipping tariffs included, it is difficult for Senegalese rice to compete with 80 to 100 percent broken rice from Southeast Asia which is the quality that is most frequently imported. Consequently, government policy to purchase large quantities of 100 percent broken rice which is only lightly taxed creates little incentive for local production to replace imports.

### 4. Land Use Policies

Land under irrigation is owned by the State government according to the law on the National Domain of June 1964. The law eliminated all payments made to landholders under the traditional system. Since this law effectively established public ownership of unregistered land there is no market for agricultural land in the valley. The National Domain as defined by the law consists of four zones: (1) Zones urbaines, (2) Zones classees, (3) Zone Terroirs, and (4) Zones pionnieres. In the Senegal River Valley we are concerned with the Zones pionnieres.

The Zones pionnieres are uninhabited areas which have been targeted by the state for eventual development. Such development must proceed according to a well defined national plan. A state designated agency (SAED in the case of the Senegal River Valley) is in charge of this development. The land thus improved for modern agriculture is then entrusted to officially recognized farmer cooperatives or producer groups (GP) on a

contractual basis. The cooperatives or GP organize their members to cultivate the land. At the same time, these groups are contractually bound to market all their harvest, except for a small portion retained for home consumption by individual members, to the SAED.

# CHAPTER III

# METHODOLOGY

## A. Calculating Economic Costs and Benefits

This chapter essentially presents the methodology for evaluating the economic costs and benefits of the four selected perimeters. However, before presenting the methodology, we will outline the main differences between a financial and an economic analysis.

Financial analysis presents the costs and benefits to the participants in a project. Prevailing prices are used to measure the costs and benefits. Financial analysis permits the analyst to examine the levels and distribution of project benefits among participants and to assess the attractiveness of the project to participants. Economic analysis, on the other hand, measures the costs and benefits of a project which accrue to the nation as a whole. For example, income transfers such as government subsidies and export taxes are excluded in an economic analysis. In addition shadow prices are used to remove distortions which may exist in the prices of foreign exchange, inputs and outputs [Gittinger, 1972].

Shadow pricing is a technique whereby observed prices are corrected so as to reflect the true cost of inputs and the true value of outputs in face of distorted markets. Shadow prices have no real existence. They are nothing more than theoretical constructs, and as such, have no existence outside of the analytical framework in which they are derived. Squire

and Van des Tak [1979] give an excellent statement of the kinds of distortions shadow prices are used to correct.

> Shadow prices are defined as the value of the contribution to the country's basic socio-economic objectives made by any marginal change in the availability of commodities or factors of production. Thus, shadow prices will depend on both the fundamental objectives of the country and the environment in which the marginal changes occur. The economic environment typically will be determined by the physical constraints on resources and by various constraints that limit the government's control over economic development. Any changes in objectives or constraints will therefore necessitate a change in the estimated shadow prices. [p. 26]

Two points should be made about this definition of shadow prices. First, these prices relate to an economic environment in which distortions may be expected to persist: they are not the equilibrium prices that would prevail in a distortion free economy. This should not be interpreted, however, as a passive acceptance of existing distortions; in fact, the estimation of (second best) shadow prices supplies important information that can be used as a basis for designing policies to remove the distortion. Second, those conducting the economic analysis should have a clear definition of the socio-economic goals of the government's development policy [p. 27].

Clearly, defining correct shadow prices is not possible without reference to politically determined national objectives. To the extent possible, the shadow prices derived below are calculated from economic data and the author's interpretation of long term political objectives of the Senegalese government. These political objectives do not result from any such direct process. The objectives are inferred from project decisions in the past and the present, from tax structures, national plans, etc.

Since the country attained independence in 1960, the government has given favored tax status to investments which generate new employment. It

has also followed an evolutionary rather than revolutionary development policy. It seems appropriate therefore to use market clearing prices for valuing inputs and outputs. For unskilled labor this has the effect of treating increase in consumption arising from wage levels above the opportunity cost of labor as a benefit consistent with government policies aimed at helping low income wage earners.

### 1. Shadow Exchange Rate

The shadow exchange rate (SER) in Senegal reflects the domestic value of one unit of foreign exchange on the assumption of relatively unrestricted flow of capital between Senegal and countries outside the franc zone. Most developing countries suffer from extreme fluctuations in the prices of their exports. Foreign exchange scarcity is often a major problem. A decrease in available foreign exchange following a decline in export prices can compromise the development plans of a country highly dependent upon imported goods. However, in the Senegalese case such problems concerning foreign exchange are considerably reduced by the country's ties with France and other members of the franc zone. In effect, access to foreign exchange is controlled by controlling domestic money supply rather than through direct controls on foreign exchange.

Under the circumstances just described the shadow exchange rate expressed as a percent of the existing rate is given by the foreign exchange premium (FEP), calculated in the following way:

$$FEP = \frac{\text{Imports} + \text{Import Taxes} - \text{Import Subsidies} + \text{Exports} - \text{Export Taxes} + \text{Export Subsidies}}{\text{Imports} + \text{Exports}}$$

Table 3.1 gives values for the FEP for the period of 1967-1976. We have simply used the average of these annual values (1.134) as the shadow

TABLE 3.1
CALCULATION OF THE SHADOW EXCHANGE RATE
(Value (in million dollars)

| Year | (1) M=Imports | (2) X=Exports | (3) Imports + Import Taxes | (4) Exports - Export Taxes | (5) Col (1) + Col (2) | (6) Col (3) + Col (4) | FEP |
|---|---|---|---|---|---|---|---|
| 75/76 | 123,540 | 98,726 | 151,540 | 95,776 | 222,266 | 247,316 | 1.113 |
| 74/75 | 119,382 | 93,983 | 145,082 | 92,138 | 213,365 | 237,220 | 1.112 |
| 73/74 | 79,766 | 43,237 | 98,886 | 41,937 | 122,003 | 140,823 | 1.154 |
| 72/73 | 70,551 | 54,412 | 88,551 | 52,612 | 124,963 | 141,163 | 1.129 |
| 71/72 | 60,561 | 34,707 | 76,511 | 33,442 | 95,268 | 109,553 | 1.149 |
| 70/71 | 53,587 | 42,182 | 69,350 | 40,575 | 95,769 | 109,925 | 1.147 |
| 69/70 | 51,294 | 31,907 | 65,290 | 30,068 | 83,201 | 95,358 | 1.146 |
| 68/69 | 44,527 | 37,369 | 57,748 | 34,587 | 81,896 | 92,335 | 1.127 |
| 67/68 | 38,898 | 33,890 | 53,351 | 31,213 | 72,788 | 84,564 | 1.161 |
| 66/67 | 38,283 | 36,764 | 52,359 | 33,901 | 75,047 | 82,260 | 1.096 |
| 1966-75 average | | | | | | | 1.134 |

Source: U.N. Yearbook of International Trade Statistics and Calculations.

exchange rate expressed as a percent of the nominal exchange rate. Over this period import and export subsidies were insignificant and are, therefore left out of the table and the calculation of the FEP.

## 2. Shadow Wage Rate

### a. Unskilled Labor

Conventionally the shadow wage rate (SWR) for unskilled labor is taken to be the opportunity cost of a worker removed from agricultural production in the traditional sector plus the cost to the economy of any increase in consumption occurring as a result of his higher wage. The opportunity cost in production has been estimated at approximately 45,000 CFA francs per year.[1] This represents 20 percent of the minimum wage for the lowest wage category (ouvrier 1$^{ere}$ category) in the modern sector.

Assuming a very high marginal propensity to consume or zero saving among low income people in poor countries such as Senegal and given that about fifteen percent of the minimum wage represents transfers paid by workers (social security and other taxes), eighty five percent of the wage is used for consumption. The increase in consumption resulting from Formal Public Sector employment created with the establishment of irrigated perimeters can be calculated as follows:

| [Salary of the Lowest Category] | - | [Transfers and Taxes] | + | [Production Foregone] | = | Net Increase in Consumption |
|---|---|---|---|---|---|---|
| [231529][2] | - | [34730 | + | 45000] | = | 151.799 |

---

[1]SONED Etude sur la commercialisation et le stockage des cereales aux Senegal, Juillet 1978.

[2]SAED, Division du Personnel, Bareme des Salaires, Juin 1978.

This net increase in consumption can be considered as a benefit or a cost to the economy depending on the value a government gives to increases in consumption for low income wage earners.

For all developing countries in the world, the fight against hunger and malnutrition is becoming one of the major concerns of our time. Particularly in Senegal, food self-sufficiency is the "priority of the priorities" as expressed in recent development plans. The government of Senegal has always been concerned with adequately feeding its population and heavy subsidies of consumer goods, agricultural inputs and food production policies attest to that concern. For these reasons, we assume that any increase in consumption by unskilled workers is a benefit to the Senegalese economy. Consequently, the shadow wage for unskilled labor simply equals the opportunity cost of a worker removed from agricultural production in the traditional sector. We assume this to be 20 percent of wages paid to unskilled labor.

b. Skilled Labor

In most developing countries such as Senegal wages for skilled workers are fixed by the government and are lower than the opportunity cost of such labor, even including taxes and transfers. For this reason and given that overvaluation of foreign exchange is offset by undervaluation of unskilled labor in domestically produced consumption we assume that the (SWR) for skilled labor is equal to the actual wage rate.

### 3. Domestically Produced Goods

Domestic goods are valued at market prices for convenience on the assumption that the higher shadow rate for foreign exchange more or less offsets the lower shadow wage for unskilled labor.

4. Division of Costs Into Foreign Exchange, Unskilled Labor, Skilled Labor and Domestic Goods Components

Table 3.2 gives the cost components (foreign exchange, unskilled labor and skilled labor/domestic goods) for each category of cost taken into consideration in this study. For all goods and services used in the construction and operating of the perimeters, the economic costs were calculated by subtracting government taxes from and adding subsidies to the financial costs.

$$\text{Economic Cost} = [\text{Financial Cost} - \text{Taxes} + \text{Subsidies}] \times [(FEX \times SER) + (UNSKL \times SWR) + DOM]$$

SER = shadow exchange rate = 1.13

SWR = shadow wage rate for unskilled workers = .20

FEX = foreign exchange component

UNSKL = unskilled labor component

DOM = skilled labor/domestic cost component

Example of Calculating Economic Costs for a Tractor

Assumption:

| | |
|---|---|
| Acquisition Cost | 3.5 million CFA francs |
| Foreign Component | 87% (Table 3.2) |
| Domestic Component | 13% (Table 3.2) |
| SER | 1.13 (Table 3.1) |
| No Taxes | |

Calculations:

Adjusted Foreign Exchange

3.50 x .87 x 1.13 = 3.44

Domestic Component

3.5 x .13 x 1 = .45

Economic Cost 3.89 million CFA francs

TABLE 3.2
FOREIGN EXCHANGE, UNSKILLED LABOR AND DOMESTIC
COST COMPONENTS USED FOR ECONOMIC ANALYSIS

| | Foreign Exchange % | Unskilled Labor % | Other Skilled Labor Domestic Comp-% |
|---|---|---|---|
| Adjustment Factors | SER=1.13 | SWR=.20 | 1 |
| 1. INVESTMENT COSTS | | | |
| Dikes | 32 | 15 | 53 |
| Earth work | 23 | 25 | 52 |
| Leveling | 32 | 15 | 53 |
| Equipment and installation | 69 | 3 | 28 |
| Furniture and Office Equipment | 70 | -- | 30 |
| Masonry | 23 | 25 | 52 |
| Farm machinery | 87 | -- | 13 |
| Auto, trucks | 70 | -- | 30 |
| Consultant-services | 90 | -- | 10 |
| SAED services | 20 | -- | 80 |
| Family labor[a] | -- | -- | 100 |
| Small perimeter establishment | 20 | -- | 80 |
| 2. OPERATING COSTS | | | |
| Seed | -- | -- | 100 |
| Fertilizer | 81 | -- | 19 |
| Insecticides | 72 | -- | 28 |
| Fuel | 65 | -- | 35 |
| Maintenance | 68 | 10 | 22 |
| Supplies and material | 40 | -- | 60 |
| Personnel | -- | 21 | 79 |
| Family labor[a] | -- | -- | 100 |
| Insurance | -- | -- | 100 |
| Transport | 60 | -- | 40 |
| Small equipment and tools | 20 | -- | 80 |

Source: Edward M. Weiler, "Social Cost Benefit Analysis of the Nianga Pilot Project." Masters Thesis, Purdue University, May 1979.
-estimations made by the author.

[a]This is unskilled labor but this unskilled labor is paid its opportunity cost rather than the minimum wage. Therefore, the full value of wages are counted in economic costs.

## B. Computational Simplifications

The basic concept underlying Benefit/Cost analysis is to compare the costs and the benefits for alternative projects over time. If a project lasts more than one year, future cost and benefits streams are discounted to reflect their present value.

There are three discounted measures commonly used for agricultural projects: the Benefit-cost ratio, the net present worth and the internal rate of return. However, in this paper none of these conventional measures have been used to compare the irrigation alternatives. Rather, because of limited data we did a static comparison of cost and benefits in an average year.

Data for the year 1978 were selected for this analysis since it is the $4^{th}$ year of operation of the tertiary irrigation projects. By the fourth year annual costs and benefits are expected to reflect long term patterns. Also by 1978, the fourth year after the 1968-73 drought, the economic situation of the country had regained its normal trend. Moreover sufficient time series data were not available for other years to conduct expost economic evaluation of the projects. We assume that the behavior of per hectare costs and benefits for the fourth year in the irrigated perimeters of the Senegal River Valley reflects long term averages and can yield reliable comparisons. A final reason underlying the choice of this method is its simplicity and ease of understanding for decision-makers.

### 1. Investment Costs and the Opportunity Cost of Capital

A large amount of the funds invested for irrigation projects are provided by donor agencies through the Senegalese government as grants or loans.

The rate at which the Senegalese government must pay for loans is very low, one or two percent per year during the life of the project.

For this reason we use two percent as the interest rate on capital for the financial analysis. However, for the economic analysis we assume 12 percent to be the opportunity cost of capital funds to the economy, regardless of how they are acquired, since this more accurately reflects the productive potential of investment resources.

In computing the annual fixed costs we use annualized depreciation, interest charges on the average annual investment, and annual maintenance costs. In the case of irrigation projects we consider maintenance and repair of the physical plant as a fixed cost since these are important components of project cost and since annual repairs on water gates, leveling and dikes are necessary to maintain the income generating capacity of the project.

Because we are not aware of the procedures used in repaying the invested funds and we do not know the successive annuities. Instead we calculate the average annual investment and compute the annual interest on it. The interest paid annually on the average investment is included in the analysis as a fixed cost because it is a real and permanent cost during the life of the project regardless of the level of activity of the perimeters.

The average investment on the basis of which interest costs are calculated is computed as follows:

$$\frac{\text{Acquisition} + \text{Salvage Value}}{2}$$

This gives the mean annual value of capital invested over the life of the project.

Computing interest charges on the average annual investment in this way does not incorporate the effect of differences between investments in the flow of investment, returns and accumulated opportunity costs of invested capital. Such a procedure underestimates interest costs for projects with a larger proportion of their investment costs up front, as is the case with the large perimeters, relative to projects with a more dispersed pattern of investment. However, the data at our disposal were not of sufficient quality to warrant the much greater work involved in constructing a time series of benefits and costs. Consequently, the reader should keep in mind that real fixed costs of the large perimeters have been underestimated relative to the large perimeters.

Depreciation is an annual fixed cost which in effect, represents the annual repayment of the invested funds. It measures the amount of an asset consumed in executing a project. Depreciation in this analysis is calculated in the following way:

$$\frac{\text{Acquisition or Initial Investment} - \text{Salvage Value}}{\text{Life of Asset}}$$

linear formula

This gives the mean annual depreciation over the life of the asset.

# CHAPTER IV

## COMPARATIVE COSTS OF RICE PRODUCTION IN LARGE AND SMALL SCALE IRRIGATED PERIMETERS IN THE SENEGAL RIVER VALLEY

### A. Procedures and Source of Data

In comparing the two major types of perimeters along the Senegal River Valley we divide costs for each type of the four selected perimeters into fixed and operating costs. Fixed costs for each perimeter are broken into establishment costs, agricultural equipment and building costs. For each fixed cost component we calculate average annual depreciation, interest on invested capital and maintenance costs. These are calculated on a per hectare basis for each of the four perimeters. Of the three categories of costs, only maintenance costs contain charges for labor.

Operating costs for the perimeters are divided into: agricultural inputs (seeds, fertilizers, pesticides, fuel,water), personnel and general administration costs. The general administration costs of the SAED are divided among perimeters for each category of cost according to the number of hectares cultivated in relation to the total number of hectares for which SAED is responsible.

Each year the SAED double crops rice with other crops such as tomatoes, wheat, maize or vegetables. During the rainy season from June to November only rice is cultivated on the land. During the dry season from December to May in all perimeters except the Delta half of the land is

occupied by another crop. In the Delta, from January until June the river contains salted water coming from the sea and this makes dry season irrigation impossible. Poor water availability permits cultivation of only one-third of the land during that season. For these reasons we allocate investment, personnel and general administration costs to each enterprise in each perimeter according to the total area planted. For all perimeters rice bears the largest part of these costs per hectare. Two-thirds of investment, personnel and general administration costs per hectare will be imputed to the rice component for Dagana, Nianga and Matam. For the Delta rice bears three-fourths of these costs.

We calculate the gross revenue per hectare in each perimeter based on the average yield reported from surveys carried out by the SAED. We then determine the net revenue per hectare by deducting fixed and operating costs from the gross revenue. Finally, we deduct marketing and rice processing costs for each perimeter before directly comparing the alternative production systems.

Most of the data used in this paper were collected by the SAED. Each year its Office for Studies and Programming collects and keeps detailed records of farm operations as they are performed. Enumerators visit farmers regularly and record their activities. Each year output is estimated by harvesting yield plot samples. In addition, the size of all fields farmed by producers is measured. Complementary data were found in official Senegalese documents (Ministere du development rural, Direction Nationale de la Statistique), in the documents of international donors (USAID, World Bank, FAC, etc.) and in studies done by university scholars. The critique of SAED managerial problems, farmers' behaviors and general rice policies are based on my own four years experience as a SAED economist.

## B. Fixed Costs

### 1. Perimeter Establishment

Tables 4.1 and 4.2 show the capital investment required for establishing one hectare of land on large and small scale irrigated perimeters, respectively, as recorded for 1978. Table 4.2 outlines the life of investments and maintenance rates assumed for large and small perimeters. Tables 4.3 and 4.5 summarize fixed costs for each of the perimeters given their respective capital investment costs, depreciation and maintenance rates. As indicated in the first section of this chapter investment costs are divided between rice and other crops. The total fixed cost in the tables is allocated between rice and other crops. Fixed costs for rice are given in both tables.

Comparing Tables 4.3 and 4.5 shows that wide differences in perimeter establishment costs exist between large and small perimeters. Financial and economic costs per hectare for Dagana, which has the lowest cost among large perimeters, are eleven times higher than those for small perimeters. These wide cost differences can be explained by a higher capital investment required for dike construction, earthwork and pumping stations in large perimeters. These items are constructed by companies using highly qualified personnel and sophisticated machinery. Unit prices fixed by the companies for perimeter establishment are relatively high. Small perimeters on the other hand are entirely built by local personnel with the help of farmers. Fixed cost for large perimeters are also high because of the annual maintenance and repairs required to keep the perimeters operating. Table 4.4 shows that farmers participation represents about ten percent of the economic and financial costs per hectare whereas in large perimeters farmers make no contribution to perimeter establishment costs.

TABLE 4.1
CAPITAL INVESTMENT PER HECTARE FOR ESTABLISHING
LARGE SCALE PERIMETERS IN THE
SENEGAL RIVER VALLEY, 1978
(Thousand F CFA)

| Investment Category | Delta | | Dagana | | Nianga | |
|---|---|---|---|---|---|---|
| | Fin | Econ[a] | Fin | Econ | Fin | Econ |
| 1. Dikes | | | | | | |
| FEX | 58 | 66 | 11 | 12 | 15 | 17 |
| UNSKL | 27 | 5 | 5 | 1 | 7 | 1 |
| Other | 97 | 97 | 18 | 18 | 24 | 24 |
| TOTAL | 182 | 168 | 34 | 31 | 46 | 42 |
| 2. Earth Work | | | | | | |
| FEX | 148 | 167 | 148 | 167 | 237 | 192 |
| UNSKL | 160 | 32 | 161 | 32 | 111 | 37 |
| Other | 333 | 333 | 334 | 334 | 392 | 385 |
| TOTAL | 641 | 532 | 643 | 533 | 740 | 614 |
| 3. Leveling | | | | | | |
| FEX | 22 | 25 | 40 | 45 | 43 | 49 |
| UNSKL | 11 | 2 | 19 | 4 | 20 | 4 |
| Other | 37 | 37 | 66 | 66 | 72 | 72 |
| TOTAL | 70 | 64 | 125 | 115 | 135 | 125 |
| 4. TOTAL | 893 | 765 | 802 | 679 | 921 | 781 |

Source: (A) Plan Directeur d'Amenagement de la valley du Fleuve Senegal. Bureau d'etude SAED and SCET International (France) 1979.
(B) author calculations.

[a]Economic costs are calculated by determining the cost component of each investment category using Table 3.2 and then multiplying the foreign exchange portion of the financial cost by the estimated foreign exchange preminum of 1.13 and the unskilled labor component by the shadow wage rate of .20.

TABLE 4.2
COEFFICIENTS ASSUMED FOR ESTIMATING DEPRECIATION AND MAINTENANCE COSTS FOR LARGE AND SMALL IRRIGATED PERIMETERS IN THE SENEGAL RIVER VALLEY

| Investment | Estimated Life | Estimated Maintenance/Year |
|---|---|---|
| A. Large Perimeters | | |
| Dikes | 50 | 2% |
| Earth work | 50 | 2% |
| Leveling | 20 | 4% |
| Pumping Station | 15 | 10% |
| Tractors | 5[a] | 15% |
| Farm equipment | 7 | 5% |
| Mower | 5[a] | 15% |
| Threshing machine | 5[a] | 10% |
| Combine | 5[a] | 15% |
| B. Small Perimeters | | |
| Oxen | 5[c] | 0 |
| Plow and accessories | 10 | 2% |
| Pump and pumping equipment | 10 | 5% |
| Construction and perimeters | 20 | 2% |

Source: Programme d'Extension des Perimetres d'Irrigation Villageois Dans les Departements de Podor et Matam, SATEC, Paris, 1976 and unpublished documents from the Bureau d'Etude, SAED.

[a]According to SAED's accounting procedures, the estimated life of farm equipment is ten years. Experience proves that this is too high for moving material not well adapted to local conditions. We have used five years for tractors, mowers, threshing machines and the combine which we think are more reliable.

[b]Annual maintenance costs for leveling are estimated by SAED to equal two percent of the initial investment. We find this also too low. Since 1975 leveling was corrected on several plots and water-gates repaired many times. As a result, we have used four percent instead of two percent.

[c]The pair of oxen has a salvage of 90,000 CFA francs after five years. (The pair is bought when it is three and sold five years later.) We assume that the labor costs for maintaining oxen is offset by other income from the oxen such as transportion and use on other crops. Moreover, animal fodder is provided by crop residues with zero sale value.

TABLE 4.3
TOTAL FIXED COSTS PER HECTARE FOR ESTABLISHING
LARGE SCALE IRRIGATED PERIMETERS IN THE
SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Cost Component | Delta | | Dagana | | Nianga | |
|---|---|---|---|---|---|---|
| | Fin | Econ | Fin | Econ | Fin | Econ |
| Depreciation | 20 | 17 | 20 | 17 | 22 | 19 |
| Maintenance | 19 | 17 | 19 | 16 | 21 | 18 |
| Interest on invested capital[a] | 9 | 46 | 8 | 41 | 9 | 47 |
| TOTAL cost all crops | 48 | 80 | 47 | 74 | 52 | 84 |
| Rice component | 36 | 60 | 31 | 49 | 35 | 56 |

Source: Table 4.1 and 4.2.

[a]The capital invested in irrigation is loaned by international donors for 30 to 50 years at an interest rate of one to two percent. A large part of it is given as a grant by foreign donors such as FED (Fond European de Development) and FAC (Fond d'aide et de Cooperation). In computing financial cost we use two percent as the annual interest on invested capital. However, we use twelve percent as the economic cost.

In our calculations we use average investment over the life of the project calculated as follows:

$$\frac{\text{investment cost + salvage value}}{2}$$

Here we assume salvage value of zero for all capital investments.

TABLE 4.4
CAPITAL INVESTMENT REQUIRED FOR ESTABLISHING A PERIMETER OF 20 HECTARES IN THE MATAM ZONE OF THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Category of Investment | Total Investment | | Investment Per Hectare | |
|---|---|---|---|---|
| | Farmers | SAED | | |
| | Group Work[a] | Participation | Fin | Econ |
| Studies | -- | 90 | 5 | 5 |
| Land clearing | 75 | -- | 4 | 4 |
| Deep ploughing | -- | 160 | 8 | 9 |
| Principal canal | -- | 60 | 3 | 3 |
| Dikes | 17 | -- | 1 | 1 |
| Engineering | -- | 350 | 18 | 18 |
| Drainage | -- | 250 | 13 | 13 |
| TOTAL | 92 | 910 | 52 | 53 |

Source: SAED/SATEC Paris 1976

[a]Number of man-days times 250 CFA francs the assumed opportunity cost of labor in the river valley during the period of the year when the work takes place.

TABLE 4.5
TOTAL FIXED COSTS PER HECTARE FOR ESTABLISHING A SMALL SCALE IRRIGATED PERIMETER IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| | Financial | Economic |
|---|---|---|
| Depreciation[a] | 2.5 | 2.5 |
| Maintenance | 1.0 | 1.0 |
| Interest on investment capital[b] | .5 | 3.1 |
| TOTAL cost all crops | 4.0 | 6.6 |
| Rice component | 2.7 | 4.4 |

Source: Tables 4.2 and 4.4.

[a]We do not have good estimates of expected life and maintenance cost per hectare for the necessary capital investments. The actual life of the investment is variable from one perimeter to another depending upon the nature of floods, some of which may destroy the dikes and the perimeter. Moreover, some perimeters are destroyed when the government replaces them with large perimeters. In order to facilitate calculations we assume a 20 year estimated life with zero salvage value and two percent annual maintenance for all cost components for constructing small perimeters as listed in Table 4.2.

[b]The interest on invested capital is 12 percent for the economic costs and two percent for the financial costs. The use of these numbers was explained under Table 4.3.

Perimeter establishment costs for large scale irrigated perimeters along the Senegal River Valley varied considerably between 1970 and 1978. During the early seventies the financial cost of perimeter establishment was around four hundred thousand CFA francs. By 1978 that cost had doubled on the Senegalese side of the river and tripled on the Mauritanian side. Costs are growing very fast because of a continuous increase in the prices fixed by the three major companies implementing perimeters in the valley which act as an oligopoly. Some control over prices fixed by these foreign companies is very important for the future of irrigation in the valley.

### 2. Agricultural Equipment

All agricultural equipment for large scale perimeters belongs to the SAED. In small perimeters agricultural equipment belongs to the farmers, though SAED maintains and repairs irrigation pumps. Table 4.6 shows the agricultural equipment required for exploiting one hectare of irrigated land on large scale perimeters in the Senegal River Valley. The table gives the estimated life of the equipment, its salvage value, field capacity and average capital investment in equipment per hectare.

Financial and economic capital investments per hectare for farm machinery on large scale irrigated perimeters are, respectively, 344 and 383 thousand CFA francs in 1978. This is twice as high as on small perimeters as shown in Table 4.7. Table 4.8 gives the economic and financial costs of annual depreciation maintenance and interest on invested capital for agricultural equipment for each perimeter. Table 4.8 also allocates those costs between rice and other crops in each perimeter.

As shown in Table 4.8 the financial and economic cost of agricultural equipment required for small perimeters is 17 percent, 19 percent of that of large perimeters. Small perimeters are more labor intensive and are too small

TABLE 4.6
AGRICULTURAL EQUIPMENT REQUIRED FOR LARGE SCALE PERIMETERS IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Equipment | Acquisition Cost | Estimated Life | Salvage Value | Field Capacity | Capital Investment Per Hectare | |
|---|---|---|---|---|---|---|
| | | | | | Fin | Econ |
| Crawler Tractor 80 hp | 4,500 | 5 | 315 | 60 | 75 | 83 |
| Small Tractor 45 hp | 3,500 | 5 | 245 | 60 | 58 | 65 |
| Other equipment (seedmill, plough, remorque, etc.) | 4,000 | 7 | 200 | 60 | 67 | 75 |
| Plough for ridge | 1,500 | 7 | 105 | 60 | 25 | 28 |
| Combine | 4,500 | 5 | 315 | 60 | 75 | 83 |
| Threshing machine | 4,000 | 5 | 280 | 90 | 44 | 49 |
| | | | | | 344 | 383 |

Source: SAED Rapport de Campagne, 1978.
Diallo, Budgets et comptes financiers de la SAED, 1975-78.

[a]There are no rules in estimating the salvage value of agricultural equipment in the river valley. The value depends on the conditions of the equipment and the number of buyers in the public sales. Experience proves that the salvage value of the equipment is rarely above ten percent and not often below five percent of its acquisition cost. We use seven percent of the acquisition cost as the salvage value for the tractor, combine and threshing machine and five percent for the other equipment. Economic salvage values is assumed to bear the same relationships to financial salvage value as economic investments cost to financial investment costs.

TABLE 4.7
AGRICULTURAL AND PUMPING EQUIPMENT REQUIRED FOR A SMALL SCALE IRRIGATED PERIMETER IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Equipment | Acquisition Cost | Estimated Life | Salvage Value[a] | Field Capacity (ha) | Capital Investment Per Hectare | |
|---|---|---|---|---|---|---|
| | | | | | Fin | Econ[b] |
| 1. Agricultural Equipment | | | | | | |
| Pair of Oxen[c] | 50 | 5 | 90 | 2 | 25 | 25 |
| CART | 35 | 10 | 0 | 2 | 18 | 19 |
| UCF plow | 22 | 10 | 0 | 4 | 6 | 6 |
| Super eco seeder | 27 | 10 | 0 | 4 | 7 | 7 |
| Sine hoe | 18 | 10 | 0 | 4 | 5 | 5 |
| Accessories | 8 | 10 | 0 | 4 | 2 | 2 |
| SUBTOTAL | 160 | | | | 63 | 64 |
| 2. Pumping Equipment[d] | | | | | | |
| Motor Lister HR2 | 700 | 10 | 0 | 20 | 35 | 36 |
| Spare parts | 150 | 10 | 0 | 20 | 8 | 8 |
| Pump | 280 | 10 | 0 | 20 | 14 | 14 |
| Spare parts | 50 | 10 | 0 | 20 | 3 | 3 |
| Floating ferry | 475 | 10 | 0 | 20 | 24 | 25 |
| Flexible pipe | 200 | 10 | 0 | 20 | 10 | 10 |
| Aluminum tubs | 275 | 10 | 0 | 20 | 14 | 14 |
| Joinings | 100 | 10 | 0 | 20 | 5 | 5 |
| Accessories | 150 | 10 | 0 | 20 | 8 | 8 |
| SUBTOTAL | 2,380 | | | | 121 | 123 |
| TOTAL | 2,540 | | | | 184 | 187 |

Source: SATEC (France) Etude d'amenagement des perimetres villageois de Matam, July 1978.
J.P. Rigoulot Plan B research paper, Michigan State University, 1980.

[a]The salvage value for equipment is zero according to the estimates of SATEC experts on irrigation. We do not see any reason to change it.

[b]Except for oxen economic costs are treated as small equipment and tools in Table 3.2.

[c]The higher salvage value than acquisition cost for oxen reflects their appreciation in value as the animal matures. Economic and financial costs are the same.

[d]Pumping equipment for large scale irrigated perimeters are included in perimeter establishment costs.

TABLE 4.8
PER HECTARE ECONOMIC AND FINANCIAL FIXED COSTS
OF AGRICULTURAL EQUIPMENT FOR THE SAED
IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| | Large Perimeters | | Small Perimeters | |
|---|---|---|---|---|
| | Financial | Economic | Financial | Economic |
| Depreciation | 59 | 66 | 9 | 9 |
| Maintenance[a] | 40 | 44 | 7 | 7 |
| Interest | 3 | 23 | 4 | 22 |
| Total cost for all crops | 102 | 133 | 20 | 38 |
| Rice component | | | | |
| Delta | 77 | 100 | -- | -- |
| Dagana | 68 | 89 | -- | -- |
| Nianga | 68 | 89 | -- | -- |
| Matam | -- | -- | 13 | 25 |

Source: Table 4.6 and 4.7.

[a]Assuming annual maintenance rates as listed in Table 4.2 for large and small perimeters.

for the use of tractors. On the other hand, the soils in large perimeters are heavy and cannot be cultivated easily with traditional tools. These factors combine to cause these large differences in agricultural equipment costs.

### 3. Building Costs

Four types of buildings exist in each perimeter: (1) administrative buildings, (2) personnel buildings, (3) parking and storage facilities, and (4) pumping stations.

Free housing is provided by each perimeter to the staff. Depreciation, maintenance costs are supported by the perimeter. The estimated life of each building is 20 years and their maintenance cost is five percent. The estimated cost of building on a per hectare basis was 50.000 CFA francs for large perimeters and 25.000 CFA francs for small perimeters in 1978 [SONED, 1978].

According to these figures and using the same methodology as for equipment, the annual cost per hectare is detailed in Table 4.9.

### 4. Summary of Investment Costs

Table 4.10 summarizes the financial and economic capital investment required to establish one hectare of irrigated land in the Senegal River Valley. These costs are, respectively, around 260 thousand francs for small perimeters and 1200 thousand for large perimeters. Thus, required capital investment is almost five times higher in large perimeters than in small perimeters. Table 4.11 compares the annual fixed costs per hectare in large and small perimeters without regard to differences in cropping intensity. The table also indicates a similar difference in fixed costs between the two types of perimeters. This confirms that small perimeters

TABLE 4.9
PER HECTARE ECONOMIC AND FINANCIAL FIXED COSTS
FOR BUILDINGS IN LARGE AND SMALL PERIMETERS
IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| | Large Perimeters | | Small Perimeters | |
|---|---|---|---|---|
| | Financial | Economic | Financial | Economic |
| Depreciation[a] | 2.50 | 2.06 | 1.25 | 1.03 |
| Maintenance | 2.50 | 2.50 | 1.25 | 1.25 |
| Interest on capital invested[b] | .50 | 3.00 | .25 | 1.50 |
| Total for all crops | 5.50 | 7.56 | 2.75 | 3.78 |
| Rice component | | | | |
| Delta | 4.12 | 5.67 | -- | -- |
| Dagana | 3.66 | 5.04 | -- | -- |
| Nianga | 3.66 | 5.04 | -- | -- |
| Matam | -- | -- | 1.83 | 2.52 |

Source: SONED Rapport diagnostic sur la SAED, July 1978 and author calculations.

[a] Assuming zero salvage value.

[b] Based on average investment over the life of project, i.e., $\frac{\text{acquisition cost + salvage value}}{2}$

TABLE 4.10
SUMMARY OF THE FINANCIAL AND ECONOMIC CAPITAL INVESTMENT
REQUIRED FOR ONE HECTARE OF IRRIGATED LAND
IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| | Delta | | Dagana | | Nianga | | Matam | |
|---|---|---|---|---|---|---|---|---|
| | Fin | Econ | Fin | Econ | Fin | Econ | Fin | Econ |
| 1. Perimeter establishment | | | | | | | | |
| Dikes | 182 | 168 | 34 | 31 | 46 | 42 | -- | -- |
| Earth work | 641 | 532 | 643 | 533 | 740 | 614 | 52 | 53 |
| Leveling | 70 | 64 | 125 | 115 | 135 | 125 | -- | -- |
| Sub-total | 893 | 765 | 802 | 679 | 921 | 781 | 52 | 53 |
| 2. Agricultural equipment | 344 | 383 | 344 | 383 | 344 | 383 | 184 | 187 |
| 3. Buildings | 50 | 42 | 50 | 42 | 50 | 42 | 25 | 21 |
| Total for all crops | 1287 | 1190 | 1196 | 1104 | 1315 | 1206 | 261 | 261 |
| Rice component | 965 | 892 | 797 | 736 | 876 | 804 | 174 | 174 |

Source: Table 4.1, 4.6, 4.7 and 4.9.

TABLE 4.11
ANNUAL FIXED COSTS PER HECTARE: A COMPARISON
BETWEEN LARGE AND SMALL IRRIGATED PERIMETERS
IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| | Large Perimeters | | | | | | Small Perimeters | |
|---|---|---|---|---|---|---|---|---|
| | Delta | | Dagana | | Nianga | | Financial | Economic |
| | Fin | Econ | Fin | Econ | Fin | Econ | | |
| 1. Perimeter Establishment | | | | | | | | |
| Depreciation | 20 | 17 | 20 | 17 | 22 | 19 | 3 | 3 |
| Maintenance | 19 | 17 | 19 | 16 | 21 | 18 | 1 | 1 |
| Interest | 0 | 46 | 8 | 41 | 9 | 47 | 1 | 3 |
| Sub-total | 48 | 80 | 47 | 74 | 52 | 84 | 5 | 7 |
| 2. Equipment | | | | | | | | |
| Depreciation | 59 | 66 | 59 | 66 | 59 | 66 | 9 | 9 |
| Maintenance | 40 | 44 | 40 | 44 | 40 | 44 | 7 | 7 |
| Interest | 3 | 23 | 3 | 23 | 3 | 23 | 4 | 22 |
| Sub-total | 102 | 133 | 102 | 133 | 102 | 133 | 20 | 38 |
| 3. Buildings | | | | | | | | |
| Depreciation | 3 | 2 | 3 | 2 | 3 | 2 | 1 | 1 |
| Maintenance | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 |
| Interest | 1 | 3 | 1 | 3 | 1 | 3 | 0 | 2 |
| Sub-total[a] | 6 | 8 | 6 | 8 | 6 | 8 | 3 | 4 |
| TOTAL for all crops | 156 | 221 | 155 | 215 | 160 | 225 | 28 | 49 |
| Rice component | 117 | 166 | 104 | 143 | 106 | 150 | 19 | 33 |

Source: Tables 4.3, 4.5, 4.8 and 4.9.

[a]Column totals may not add exactly due to rounding errors.

with substantial peasant participation require far less investment than large, more centrally controlled perimeters.

## C. Operating Costs

Operating costs concern only rice production and are divided into the following cost categories:

1. Fertilizer
2. Seed
3. Pesticides
4. Fuel for machinery
5. Machinery service charges to farmers
6. Fuel for water supply
7. Water supply charges to farmers

### 1. Fertilizer

In order to encourage production, all agricultural inputs used on rice are subsidized by the government. Fertilizer is subsidized nationally through direct transfers from the government to domestic fertilizer manufacturers. For the irrigated perimeters it is further subsidized through absorption of distribution costs by the SAED. In the financial analysis subsidies raise no problems. Subsidies on fertilizer are in effect transfer payments to the farmers. The subsidy on fertilizer reduces its cost to the farmer and thereby increases his income. This may well be justified on grounds of increasing incentives to adopt new technology or perhaps even on income distribution grounds. In the financial analysis we merely attribute to each entity that part of the total cost which it actually pays.

For the economic analysis we must adjust market prices to reflect the amount of subsidies. This is necessary to compare agricultural projects with alternative investments available to the economy in an unbiased way.

In calculating the financial and economic cost of fertilizer we have included national government subsidies in financial costs and treated fertilizer costs and distribution cost components separately according to the proportions in Table 3.2. The subsidized prices of fertilizer are shown in Table 4.12. The delivered cost to farmers and the quantities used per hectare and per perimeter are also given. In addition, the table includes total costs for all types of fertilizer for each of the perimeters. From Table 4.12, we see that farmers pay only about 28 percent of the economic delivered cost to the farm.

### 2. Seed

Seed is produced in two ways: (1) by the SAED seed multiplication farms at Savoigne, or (2) by the pilot farmers who sell seed after harvest to the SAED. There is no difference in the quality of seed produced by the two suppliers.

SAED buys seed at 41.5 CFA francs per kilogramme and sells it to farmers for 70 CFA francs per kilogramme. The difference covers storage and cleaning costs. Table 4.13 indicates the cost of seed per hectare is slightly higher in small perimeters because of a higher delivery cost. Since seed is a locally produced input with a shadow price of unity, financial and economic costs are the same.

### 3. Insecticides and Herbicides

Table 4.14 shows quantities and the financial cost of insecticides and herbicides used per hectare in four perimeters in the Senegal River Valley. There are wide fluctuations in use of insecticides and herbicides from one year to the next and from one perimeter to the other. The products are applied not preventively, but as a curative. The recommended dosages made by

TABLE 4.12
QUANTITIES AND SUBSIDIZED COSTS OF FERTILIZER PER KILOGRAMME AND PER HECTARE IN THE SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| | Delta | Dagana | Nianga | Matam |
|---|---|---|---|---|
| A. Subsidized cost ex factory | | | | |
| KCL | 25 | 25 | 25 | 25 |
| NPK | 25 | 25 | 25 | 25 |
| UREA | 35 | 35 | 35 | 35 |
| B. Manufacturing subsidy | | | | |
| KCL | 17 | 17 | 17 | 17 |
| NPK | 17 | 17 | 17 | 17 |
| UREA | 24 | 24 | 24 | 24 |
| C. Cost of transportation and distribution borne by SAED | | | | |
| KCL | -- | -- | 14.5 | -- |
| NPK | 42 | 42 | 42 | 44 |
| UREA | 49 | 48 | 48 | 51 |
| D. Unsubsidized cost of fertilizer (1 + 2 + 3) | | | | |
| KCL | -- | -- | 56.5 | -- |
| NPK | 84 | 84 | 84 | 86 |
| UREA | 108 | 107 | 107 | 110 |
| E. Prices paid by farmers | | | | |
| KCL and NPK | 25 | 25 | 25 | 25 |
| UREA | 35 | 35 | 35 | 35 |
| F. Kilograms used per hectare | | | | |
| KCL | -- | -- | 34 | -- |
| NPK | 150 | 150 | 195 | 200 |
| UREA | 100 | 200 | 96.5 | 200 |
| G. Total cost per hectare to farmers (E x F) | 7,250 | 10,750 | 9,102 | 12,000 |
| H. Total cost per hectare to SAED (C x F) | 11,200 | 15,900 | 13,315 | 19,000 |
| I. Governmental subsidy (B x F) | 4,950 | 7,350 | 6,209 | 8,200 |
| J. Economic cost | 23,400 | 34,000 | 28,626 | 39,200 |

Source: SAED Rapport de Campagne, 1978.
Standford - WARDA Project, 1978.

TABLE 4.14
QUANTITIES AND FINANCIAL COST OF INSECTICIDES AND HERBICIDES USED PER HECTARE IN FOUR PERIMETERS IN THE SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| | Farm Cost Per Unit | Financial Cost Per Unit | Delta | | Dagana | | Nianga | | Matam | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q | Cost | Q | Cost | Q | Cost | Q | Cost |
| Basudin (kg) | 680 | 685 | 1 | 685 | 1 | 685 | .5 | 343 | 10 | 6,850 |
| STAM F34 | 1250 | 1252 | 7.5 | 9,390 | 9.5 | 11,894 | 9.7 | 12,144 | -- | -- |
| HCH (kg) | 118 | 118 | 20 | 2,360 | -- | -- | -- | -- | 5 | 590 |
| Total financial cost | | | | 12,435 | | 12,579 | | 12,487 | | 7,440 |

Source: Diallo. Budgets et comptes financiers de la SAED, 1975-78.
Craven, Kathryn and Hansan A.Tuluy, Rice Policy in Senegal, 1979.

the SAED are not followed by farmers who find that insecticides and herbicides cost too much. Farmers did not quite pay the full financial cost to SAED of insecticides and herbicides, paying only 680 CFA francs per kilogramme for BASUDIN, 1250 CFA francs per liter for STAM F34 and 115 CFA francs per kilogramme for HCH. The remaining cost was paid by SAED.

Insecticides and herbicides like other agricultural inputs, are subsidized. In 1978, the subsidy amounted to 40 percent of the actual financial cost of insecticides and herbicides delivered to farmers. Prices in the economic analysis are adjusted to reflect these subsidies.

### 4. Fuel for Machinery

In large scale perimeters, land preparation, seeding and threshing are done mechanically. Land preparation requires deep plowing every three to four years and offset and cross-harrowing in intervening years. Seeding is done with a tractor-drawn seeder. Harvesting and threshing are done both manually and with a combine, with about one-third of the total area in large perimeters being harvested and threshed manually.

Maintenance, spare parts and personnel costs associated with use of machinery on the large scale perimeters are counted elsewhere. In this section we deal only with fuel costs. The delivered price paid for fuel by the SAED was 60 CFA francs for heavy fuel and 85 CFA francs for light fuel. The oil companies insure the delivery and pay 33 percent annual tax (taxe sur le chiffre d'affaire) on gasoline, light diesel, heavy diesel and lubricants. In financial analysis, these taxes are treated as a cost. In economic analysis, they are not. Table 4.16 gives the economic and financial cost of fuel required for exploiting one hectare of irrigated land on large scale irrigated perimeters. Fuel prices in 1978 are given in Table 4.15.

TABLE 4.15
FUEL PRICES AND TAXES IN SENEGAL, 1978
(CFA Francs)

| | Financial Cost (CFA/liter) | | | | Economic Cost | | |
|---|---|---|---|---|---|---|---|
| | Price | Delivery | Tax | Total | FEX | Other | Total[a] |
| Gasoline | 68 | 8 | 24 | 100 | 55.4 | 27.0 | 82.4 |
| Light diesel (gasoil) | 58 | 8 | 19 | 85 | 48.0 | 23.5 | 71.5 |
| Heavy diesel | 41 | 8 | 11 | 60 | 35.5 | 17.6 | 53.1 |
| Lubricants | 238 | 8 | 104 | 350 | 180.6 | 86.1 | 266.7 |

Source: [a]SAED, Note Sur les Prix des Facons Culturales a'la SAED, 1977 and unpublished documents from SAED's Financial Division.

TABLE 4.16
ECONOMIC AND FINANCIAL COST TO SAED OF FUEL USED
FOR RICE CULTIVATION ON A PER HECTARE BASIS
ON LARGE SCALE PERIMETERS, 1978
(CFA Francs)

| | Per Hour Consumption (liter) | Time per Hectare (minutes) | Consumption per Hectare (liters) | Fuel Cost per Hectare | |
|---|---|---|---|---|---|
| | | | | Financial | Economic |
| Crawler tractor 80 hp[a] | 9.6 | 102 | 16.32 | 1,387 | 1,168 |
| Small tractor 45 hp[b] | 4.5 | 12 | .90 | 77 | 64 |
| Tractor + remorque | 4.5 | 7 | .52 | 44 | 38 |
| Threshing machine | 6.1 | 386 | 18.9 | 1,110 | 1,004 |
| Combine | 3.2 | 180 | 9.60 | 816 | 687 |
| Total | | | | 3,434 | 2,961 |

Source: Edward M. Weiler, Social Cost-Benefit Analysis of the Nianga Pilot Project, Senegal Masters Thesis, Purdue, 1979. SAED Division Industrielle, unpublished documents, Memento de l'Agronome, Ministere de la Cooperation (France). Table 4.15 Fuel Prices.

[a]Soil preparation for rice consists of two passes with the offset disk per hectare.

[b]The small tractor runs .11 hours for every hour of operation of the crawler tractor.

[c]The threshing machine uses heavy fuel, all other equipment uses light fuel.

5. Machinery Services Charges to Farmers

In large scale perimeters machinery services are provided to farmers by the SAED. The SAED owns all the agricultural equipment, runs it and insures its maintenance. The farmers buy services from SAED at the following subsidized prices:

1. Deep plowing with crawler tractors is done every third year at a fee of 8,000 CFA francs/hectare.

2. Offset and cross-harrowing each year at a fee of 5,000 CFA francs each.

3. Seeding at 3,500 CFA francs per hectare.

4. Threshing at 10,000 CFA francs per hectare.

The average subsidy amount is 40 percent of the cost to SAED for providing these services. Since the economic cost of operating SAED is itself greater than the financial cost, a further adjustment in SAED's own costs is required in order to arrive at the economic cost of these machinery services. Since the breakdown of costs used in the analysis is not conducive to any direct calculation of these costs, perhaps the best approximation to the difference between economic and financial costs for the SAED itself are reflected in the figure in Table 4.24. That table summarizes the SAED costs both from the financial and economic point of view. It reflects differential of 150 percent between economic and financial costs of producing rice in the four perimeters. Economic costs listed in Table 4.17, therefore reflect both the 40 percent subsidy by SAED of its own costs, plus 50 percent greater economic as opposed to financial cost for providing machinery services.

6. Fuel for Water Supply

Table 4.18 gives the cost of fuel for pumping in large and small scale irrigated perimeters. For small perimeters, fuel and oil consumption were

TABLE 4.17
COST OF MACHINERY SERVICES FOR FARMERS
IN LARGE SCALE PERIMETERS
PER HECTARE PER YEAR

| | Financial | Economic |
|---|---|---|
| Deep Ploughing[a] | 2,667 | 6,668 |
| Offset harrowing | 5,000 | 12,500 |
| Cross-harrowing | 5,000 | 12,500 |
| Seeding | 3,500 | 8,750 |
| Harvesting & threshing[b] | 6,666 | 16,665 |
| Total | 22,833 | 57,083 |

Source: SAED Budget Previsionnel 1977/78.
Annual Publication of SAED's Provisional Budget 1977.

[a]The cost of deep ploughing is divided by three since deep ploughing is done only once every three years.

[b]The cost of harvesting is multiplied by two-thirds because farmers harvest at least one-third of their fields themselves.

TABLE 4.18
COST OF FUEL FOR PUMPING WATER IN IRRIGATED PERIMETERS
IN THE SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| | Delta | | Dagana | | Nianga | | Matam | |
|---|---|---|---|---|---|---|---|---|
| | Fin | Econ | Fin | Econ | Fin | Econ | Fin | Econ |
| Cost per $m^3$ | .70 | --- | .62 | | .58 | | --- | --- |
| Cost per hectare | 10,500 | 8,841 | 9,300 | 7,830 | 8,700 | 7,325 | 42,000 | 34,861 |

Source: SAED Cout d'Irrigation de Nianga, Hivernage 1976.
Unpublished documents, 1978.

recorded at Matam for the year 1978. Since the majority of pumps in use at Matam and Bakel are GORMAN HR2s, data for this pump were taken for this study--1400 liters of gas-oil (fuel) and 60 liters of oil were used for two hectares of rice (rainy season) and three hectares of maize (dry season) in 1978. Sixty percent of the total annual cost are charged to rice while the remaining 40 percent are charged to maize in accordance with their estimated relative water consumption. For rice on small perimeters, the financial cost per hectare for oil and fuel are:

$$\frac{1400 \text{ liters} \times 85 \text{ francs} \times .60}{2 \text{ hectares}} + \frac{60 \text{ liters} \times 350 \text{ francs} \times .60}{2 \text{ hectares}} = 42000 \text{ CFA francs}$$

The economic costs are:

$$\frac{1400 \times 71.57 \times .60}{2} + \frac{60 \times 266.78 \times .60}{2} = 34861 \text{ CFA francs}$$

For large perimeters the cost of fuel given in Table 4.18 is for rice only.

### 7. Water Supply Charges to Farmers

A flat fee of 25,000 CFA francs per hectare of rice crop is levied on farmers in large perimeters to cover the cost of water supplied by SAED. This is again a subsidized price. The actual financial cost of water supply as computed by the SAED's Office of Research and Studies was 37,200 CFA francs per hectare in 1978. Thus SAED's subsidy to farmers amounts to 33 percent of the total cost of supplying water. We consider 25,000 CFA francs per hectare as the financial cost paid by farmers and 37,200 CFA francs per hectare as the unsubsidized financial cost of water supply for farmers in large scale irrigated perimeters.

## D. SAED's Personnel

The personnel in large and small scale irrigated perimeters carry out the following functions:

1. general administration
2. extension services and training
3. maintenance and repairs
4. marketing and inputs distribution

There are three types of personnel working in the perimeters:

1. permanent workers
2. temporary workers, and
3. foreign technical assistants.

### 1. Permanent Workers

They are civil servants sent by the Senegalese government to the SAED or employees recruited by the SAED. The former receive their salaries directly from the government while the latter are paid from the SAED budget. Civil servants receive an indemnity each month from the SAED. The economic and financial costs of permanent workers are the same since they are considered to be skilled workers. Cost figures are presented in Table 4.19. Generally, large and small perimeters require the same type of permanent workers to staff one hectare. However, wide differences may exist among perimeters because of their size. Table 4.19 gives an exhaustive list of the cost of permanent workers needed in each of the four perimeters in the Senegal River Valley.

### 2. Temporary Workers

Unskilled laborers and tractor drivers are seasonally recruited to reduce the labor bottleneck in the perimeters. They are paid by the SAED. The total salaries paid to temporary workers in 1978 were equal to one-third of the total expenses for permanent workers. Half of the total payments to temporary workers went to unskilled labor. The remainder paid tractor

TABLE 4.19
COST OF PERMANENT WORKERS FOR FOUR IRRIGATED PERIMETERS
IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Personnel | Annual Cost per Individual | Large Perimeters | | | Small Perimeters |
|---|---|---|---|---|---|
| | | Delta | Dagana | Nianga | Matam |
| 1. Management | | | | | |
| Head of Perimeter | 3.500 | 1 | 1 | 1 | 1 |
| Deputy | 2.920 | 1 | 1 | 1 | 1 |
| Intendant | 1.160 | 2 | 1 | 1 | 1 |
| Head of Zone | 1.170 | 3 | 3 | 1 | 4 |
| Intendant Zone | .540 | 2 | 2 | 2 | 3 |
| Mechanics Zone | 1,080 | 2 | 3 | 2 | 4 |
| Head of Sector | .720 | 5 | 4 | 2 | 4 |
| 2. Perimeter Establishment | | | | | |
| Assistant Engineer | 1.210 | - | - | - | 1 |
| Head Brigade Topo | 1.010 | - | - | - | 1 |
| Operator | .790 | - | - | - | 1 |
| Others | .680 | - | - | - | 2 |
| 3. Extension Services | | | | | |
| Extension Agent-rice | 1.490 | 13 | 8 | 6 | 1 |
| Extension Agent-vegetables | 1.020 | 12 | 5 | 5 | 1 |
| Extension Agent-animal traction | 1.050 | 1 | 2 | 2 | 1 |
| Operator Audio Visual | .690 | - | 2 | 1 | 3 |
| Monitor | .810 | 3 | 2 | 3 | 1 |
| Enumerators | .780 | 5 | 4 | 2 | 2 |
| 4. Maintenance and Repairs | | | | | |
| Head Maintenance | 1.380 | 1 | 1 | 1 | 1 |
| Diesel Mechanics | 1.050 | 1 | 2 | 1 | 1 |
| Vehicle Mechanics | .780 | 1 | 1 | 1 | 1 |
| Assistant Mechanics | .410 | 2 | 3 | 2 | 1 |
| Pumpist | .410 | 3 | - | - | 1 |
| Truck Drivers | .670 | 1 | 5 | 4 | 2 |
| Car Drivers | .670 | 5 | 3 | 3 | 5 |
| 5. Administration | | | | | |
| Accountant | 1.380 | 1 | 1 | 1 | 1 |
| Assistant | 1.050 | 2 | 2 | 3 | 1 |
| Storage Man | .540 | 1 | 2 | 1 | 1 |
| Secretary | .690 | 1 | 3 | 2 | 1 |
| Administrative Agent | .870 | 1 | 1 | 1 | 1 |
| Guard | .350 | 1 | 2 | 1 | 1 |
| Mason | .580 | 2 | 1 | 1 | 1 |
| Unskilled Workman | .320 | 3 | 3 | 4 | 2 |
| 6. Agricultural Services | | | | | |
| Head Tractor Column | .780 | 4 | 3 | 2 | - |
| Tractor Drivers | .670 | 32 | 18 | 10 | - |
| Assistants | .410 | 10 | 5 | 4 | - |
| Unskilled Workers | .320 | 3 | 3 | 2 | - |
| Medical Aid | .810 | 1 | 1 | 1 | 1 |
| Assistant | .670 | 2 | 2 | 2 | 1 |
| TOTAL Annual Cost | | 100,310 | 93,320 | 65,190 | 48,410 |
| Area (hectares) | | .2102 | .1080 | 406 | 500 |
| Cost per Hectare of Perimeter | | 47.72 | 86.40 | 160.56 | 96.82 |

Source: SAED Personnel Budget, 1978.

TABLE 4.20
ECONOMIC AND FINANCIAL COST OF PERSONNEL ON A PER HECTARE BASIS
IN FOUR PERIMETERS OF THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| | Delta | | Dagana | | Nianga | | Matam | |
|---|---|---|---|---|---|---|---|---|
| | Fin | Econ | Fin | Econ | Fin | Econ | Fin | Econ |
| Permanent Workers | 47.72 | 47.72 | 86.40 | 86.40 | 160.56 | 160.56 | 96.82 | 96.82 |
| Temporary Workers | 15.90 | 9.54 | 28.80 | 17.28 | 53.52 | 32.11 | 32.27 | 19.33 |
| Technical Assistants | 2.85 | 13.32 | 2.77 | 12.96 | 14.77 | 68.96 | 6.0 | 28.0 |
| Total All Crops | 66.47 | 70.58 | 117.97 | 116.64 | 228.85 | 261.63 | 135.09 | 144.15 |
| Cost per Hectare Rice Component | 49.85 | 52.93 | 78.64 | 77.76 | 152.56 | 174.42 | 90.06 | 96.10 |

drivers and other skilled labor. Table 4.20 summarizes the economic and financial cost of temporary labor in the large scale irrigated perimeters in 1978.

### 3. Technical Assistant

Foreign technicians are sent by donor agencies or recruited by the SAED to do specialized jobs for which there are no qualified Senegalese available. Their work is to insure the control and supervision of perimeter establishment. The economic and financial costs of technical assistants are given in Table 4.20 as well. The annual cost of a technical assistant includes salaries, transportation, indemnities, housing, etc., which are paid by the Senegalese government or the donor agencies. The financial cost represents only the indemnities and housing provided by the SAED.

### 4. Summary of Personnel

Table 4.20 summarizes the cost of personnel per hectare in the four selected perimeters. As indicated in previous sections the personnel cost is allocated between rice and other crops. The large difference in personnel cost among perimeters can be explained by the large differences in area cropped and the cropping intensity within each perimeter. The Delta perimeter with 2102 hectares has the lowest cost figures while the Nianga perimeter, the least developed perimeter, with the smallest area cropped, 406 hectares, has the highest. It is expected that personnel cost per hectare at Nianga will diminish with the establishment of new parcels. In addition, training Senegalese technicians and engineers will overcome the high cost of technical assistants. In reality, for the same qualifications, a technical assistant costs four to five times as much as a Senegalese engineer.

TABLE 4.21
OPERATING COST PER HECTARE FOR FOUR PERIMETERS
IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Operating Cost | Delta | | | | Dagana | | | | Nianga | | | | Matam | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total Cost | | | | Total Cost | | | | Total Cost | | | | Total Cost | |
| | Farmer Share | SAED Share | Fin | Econ | Farmer Share | SAED Share | Fin | Econ | Farmer Share | SAED Share | Fin | Econ | Farmer Share | SAED Share | Fin | Econ |
| Fertilizer | 7.25 | 11.2 | 18.45 | 23.40 | 10.75 | 15.90 | 26.65 | 34.00 | 9.10 | 13.51 | 22.61 | 31.33 | 12.00 | 19.00 | 31.00 | 39.80 |
| Seeds | 8.40 | 1.56 | 9.96 | 10.08 | 8.40 | 1.56 | 9.96 | 10.08 | 8.40 | 1.56 | 9.96 | 10.08 | 8.40 | 1.68 | 10.08 | 10.21 |
| Insecticides | 12.35 | .08 | 12.43 | 17.41 | 12.56 | .02 | 12.57 | 17.61 | 12.46 | .02 | 12.48 | 17.47 | 7.38 | .60 | 7.44 | 10.42 |
| Fuel for Machinery | - | 3.43 | 3.43 | 2.96 | - | 3.43 | 3.43 | 2.96 | - | 3.43 | 3.43 | 2.96 | - | - | - | - |
| Fuel for Pumps | - | 10.50 | 10.50 | 8.84 | - | 9.30 | 9.30 | 7.83 | - | 8.70 | 8.70 | 7.33 | 42.00 | - | 42.00 | 34.86 |
| Machinery Services[a] | 22.83 | - | -[a] | -[a] | 22.83 | - | - | - | 22.83 | - | - | - | - | - | - | - |
| Water Supply[a] | 25.00 | - | -[a] | -[a] | 25.00 | - | - | - | 25.00 | - | - | - | - | - | - | - |
| Personnel | - | 49.85 | 49.85 | 52.93 | - | 78.64 | 78.64 | 77.76 | - | 152.56 | 152.56 | 174.42 | - | 90.06 | 90.06 | 96.10 |
| SUBTOTAL | 75.83 | 76.62 | 104.62 | 115.02 | 79.54 | 108.85 | 140.56 | 142.64 | 77.79 | 179.78 | 209.74 | 240.28 | 69.78 | 110.80 | 180.58 | 190.79 |
| ADJUSTED TOTALS[b] | 75.83 | 28.79 | 104.62 | 115.02 | 72.54 | 61.02 | 140.56 | 149.64 | 77.79 | 131.95 | 209.74 | 240.28 | 69.78 | 110.80 | 180.58 | 190.79 |

Source: Tables, Chapter IV, Section C.

[a]These are farmer payments to SAED. Total financial and economic costs for this item are divided between SAED cost categories.

[b]Total excluding farmer payments to SAED for machinery services and water supply - farmer payments include a share of investment costs paid by SAED and counted elsewhere.

## E. Summary of Operating Costs

Table 4.21 summarizes the operating costs per hectare for the four selected perimeters. The total financial cost per hectare and per perimeter varies between 105 and 210 thousand CFA francs, a ratio of one to two. The cost at Nianga is twice as high as the cost in the Delta. This wide difference is explained by the large differences in area cropped in 1978 (2102 hectares in the Delta versus 406 hectares at Nianga), and related high personnel cost per hectare at Nianga. Farmers' cost per hectare in large scale perimeters are similar, varying between 75 and 80 thousand CFA francs per hectare and per year. Farmers' costs as a percent of total financial costs per hectare are the following: 72 percent in the Delta, 57 percent at Dagana, 37 percent at Nianga and 39 percent at Matam. This indicates that as the area cropped in a perimeter increases, the proportion of operating costs supported by the farmer also increases. The lower percentage for the small perimeters of Matam can be explained by the fact that farmers do not use SAED machinery or water supply services, instead using family labor and buying their own fuel to run the pumps.

## F. General Administration Costs

The general administration costs of the SAED were presented as follows in the 1978 budget:

| | Millions CFA francs |
|---|---|
| Personnel | 407.8 |
| Supplies and Materials | 117.5 |
| Services | 154.9 |
| All other costs | 112.7 |
| Total | 792.9 |

Source: SAED Budget Recapitule' Gestion 1977-1978.

These costs include all the operating expenses of the central services (management, accounting, personnel, studies and programs, etc.) at St. Louis and Dakar. The costs do not include the investments, maintenance and operating costs of the perimeters which we have already discussed. In 1978 the SAED was supervising 8,881 hectares under a full water control system. Dividing the total cost by the number of hectares cultivated, we have the following average cost per hectare for SAED administration expenses:

$$\text{Cost per hectare:} \quad \frac{792.9 \text{ million}}{8{,}881 \text{ hectares}} = 89{,}280 \text{ CFA francs}$$

As explained in Section A, multiple cropping leads us to allocate two-thirds of this cost to the rice component for Dagana, Nianga and Matam. Three quarters of this cost is allocated to the rice component in the Delta. Therefore, the general administration costs per hectare of rice are 59,520 CFA francs for Dagana, Nianga and Matam, and 66,960 for the Delta.

## G. Family Labor

Farm labor in the Senegal River Valley essentially consists of family labor. Some farmers with large farms and/or small families employ hired laborers during the peak seasons (weeding and harvesting, threshing and winnowing) for 300 CFA francs per day. Labor during other periods is assumed to be valued at 150 CFA francs per day. Because of this variation in the daily wage we will assume for the entire rainy season an average wage of 250 CFA francs per day to facilitate calculations. Experience proves that this figure works well in practice.

Labor inputs in the study are expressed in man-days. For both adult males and females working in the field we assume an equal weight for labor. A child's day of work is assumed equal to .5 man-days. Birdcaring is essentially done by children. The details on labor input per hectare for large and small scale irrigated perimeters are shown in Table 4.22.

TABLE 4.22
FAMILY LABOR INPUT FOR RICE CULTIVATION IN LARGE AND SMALL SCALE IRRIGATED PERIMETERS IN THE SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| | | Large Perimeters | | Small Perimeters | |
|---|---|---|---|---|---|
| Activities | Period | Man-days | Financial Cost | Man-days[a] | Financial Cost |
| Land Preparation | June | 1 | 250 | 30 | 7,500 |
| Mech-Fertilizing | July | 2 | 500 | -- | -- |
| Direct Seeding | July | 2 | 500 | -- | -- |
| Nursery | -- | - | -- | 10 | 2,500 |
| Transplanting | -- | - | -- | 60 | 15,000 |
| Irrigation | -- | 14 | 3,500 | 14 | 3,500 |
| Fertilizing | -- | - | -- | 10 | 2,500 |
| Herbicides Application | -- | 10 | 2,500 | -- | -- |
| Weeding | Aug-Sept | 5 | 1,250 | 40 | 10,000 |
| Birdcaring[b] | Sept-Oct | - | -- | 32 | 8,000 |
| Harvesting | Nov-Dec | 35 | 8,750 | 64 | 16,000 |
| Threshing & Winnowing | Dec | 6 | 1,500 | 22 | 5,500 |
| TOTAL | | 75 | 18,750 | 282 | 70,500 |
| Economic Cost | | - | 18,750 | -- | 70,500 |

Source: SAED Bureau d'etudes et de programmation. Diallo = Estimations based on data found in the Gambian project and the Bakel project (MSU Working Paper No. 28).

[a]For small scale irrigated perimeters the family labor input does not include perimeter establishment costs (land clearing, canal construction, and deep plowing). These were computed under investment costs. It includes levelling and preparation of the soil for the new crop, in addition to crop production labor.

[b]Birdcaring is done by children, the number of man-days has been divided by two.

Table 4.22 points out the wide difference in labor input between large scale perimeters and small scale perimeters. In large scale perimeters, land preparation, seeding and threshing are done mechanically. The majority of harvesting is also done mechanically. Weeding is done by herbicides.

In small scale perimeters, land preparation begins earlier, in June, with traditional tools (hand hoe) or, in a few cases, with an oxen and plow. Seeding, weeding, harvesting and threshing are done manually. Rice is transplanted by hand in individual small plots. Paddy is sickle-harvested by all family members from October through December and left to dry in the field for two days before threshing. Threshing is done over a barrel by women, who also winnow the grain.

The economic and financial cost of farm labor are assumed to be the same because the wage used to value it is its opportunity cost rather than the minimum wage for agricultural labor.

## H. Summary of Farm Level Production Costs

Table 4.23 summarizes the financial and economic cost of producing paddy rice on a per hectare basis in the Senegal River Valley. Table 4.24 gives the distribution of the financial costs between the SAED and the farmers.

The financial cost per hectare in large perimeters varies from 307 to 394 thousand CFA francs per hectare as compared to 329,000 CFA francs in small perimeters.

In large perimeters capital investment is essentially made by the SAED. In small perimeters farmers participate in land clearing, dikes and canal construction. The farmers participation in the overall financial cost per hectare varies from 95 to 140 thousand CFA francs.

TABLE 4.23
COST OF PRODUCING PADDY RICE ON A PER HECTARE BASIS IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Cost Categories | Delta | | Dagana | | Nianga | | Matam | |
|---|---|---|---|---|---|---|---|---|
| | Fin | Econ | Fin | Econ | Fin | Econ | Fin | Econ |
| 1. Fixed Costs | | | | | | | | |
| Perimeter establishment | 48.00 | 80.00 | 47.00 | 74.00 | 52.00 | 84.00 | 5.00 | 7.00 |
| Equipment | 102.00 | 133.00 | 102.00 | 133.00 | 102.00 | 133.00 | 20.00 | 38.00 |
| Building | 6.00 | 8.00 | 6.00 | 8.00 | 6.00 | 8.00 | 3.00 | 4.00 |
| Subtotal: all crops | 156.00 | 221.00 | 155.00 | 215.00 | 160.00 | 225.00 | 28.00 | 49.00 |
| Rice Component | 117.00 | 166.00 | 104.00 | 143.00 | 106.00 | 150.00 | 19.00 | 33.00 |
| 2. Operating Costs | | | | | | | | |
| Fertilizer | 18.45 | 23.40 | 26.65 | 34.00 | 22.61 | 28.62 | 31.00 | 39.20 |
| Seeds | 9.96 | 10.08 | 9.96 | 10.08 | 9.96 | 10.08 | 10.08 | 10.21 |
| Insecticides | 12.42 | 17.41 | 12.57 | 17.61 | 12.48 | 17.47 | 7.44 | 10.42 |
| Fuel for Machinery | 3.43 | 2.96 | 3.43 | 2.69 | 3.43 | 2.69 | - | - |
| Fuel for Pumps | 10.50 | 8.84 | 9.30 | 7.83 | 8.70 | 7.33 | 42.00 | 34.86 |
| Personnel | 42.85 | 52.93 | 78.64 | 77.76 | 152.56 | 174.42 | 90.06 | 96.10 |
| SUBTOTAL (Rice Component) | 104.62 | 115.02 | 140.56 | 149.64 | 209.74 | 240.28 | 180.58 | 190.79 |
| 3. General Administration (Rice Component) | 66.96 | 66.96 | 59.52 | 59.52 | 59.52 | 59.52 | 59.52 | 59.52 |
| 4. Family Labor (Rice Component) | 18.75 | 18.75 | 18.75 | 18.75 | 18.75 | 18.75 | 70.50 | 70.50 |
| Total Cost Per Hectare (Rice Component) | 307.33 | 366.73 | 322.83 | 370.91 | 394.01 | 468.55 | 329.60 | 353.81 |

TABLE 4.24
DISTRIBUTION OF THE FINANCIAL COST OF PRODUCING PADDY RICE BETWEEN FARMERS AND THE SAED, 1978
(Thousand CFA Francs)

| Cost Category | Delta | | | | Dagana | | | | Niänga | | | | Matam | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Financial Cost | | | Econ | Financial Cost | | | Econ | Financial Cost | | | Econ | Financial Cost | | | Econ |
| | Farmer | SAED | Total | Cost | Farmer | SAED | Total | Cost | Farmer | SAED | Total | Cost | Farmer | SAED | Total | Cost |
| Investment | - | 117.00 | 117.00 | 166.00 | - | 104.00 | 104.00 | 143.00 | - | 106.00 | 106.00 | 150.00 | - | 19.00 | 19.00 | 33.00 |
| Operating[a] | 75.83 | 28.79 | 104.62 | 115.02 | 79.54 | 61.02 | 140.56 | 149.64 | 77.79 | 131.95 | 209.74 | 240.28 | 69.78 | 110.80 | 180.58 | 190.79 |
| Administration[a] | - | 66.96 | 66.96 | 66.96 | - | 59.52 | 59.52 | 59.52 | - | 59.52 | 59.52 | 59.52 | - | 59.52 | 59.52 | 59.52 |
| Family Labor | 18.75 | - | 18.75 | 18.75 | 18.75 | - | 18.75 | 18.75 | 18.75 | - | 18.75 | 18.75 | 70.50 | - | 70.50 | 70.50 |
| TOTAL | 94.58 | 212.75 | 307.33 | 366.73 | 98.29 | 224.54 | 322.83 | 370.91 | 96.54 | 297.47 | 394.01 | 468.55 | 140.28 | 189.32 | 329.60 | 353.81 |

Source: Table 4.11, 4.21, and 4.23.

[a]Economic and financial cost of administration costs and family labor are assumed to be the same. The former are domestic elements for which the shadow price is estimated equal to one and the latter is the opportunity cost in the agricultural sector.

The proportion of financial costs per hectare by perimeter as divided between farmers and the SAED, net of payments from farmers to SAED, is given in Table 4.25. From this table it is clear that cost per hectare is lower in small perimeters, but farmers bear a larger portion of the total cost.

TABLE 4.25
PROPORTION OF THE FINANCIAL COST OF PRODUCING RICE BORNE BY FARMERS AND SAED IN FOUR IRRIGATED PERIMETERS IN THE SENEGAL RIVER VALLEY, 1978
(Thousand CFA Francs)

| Perimeters | Cost Per Hectare | Farmer Share | | SAED Share[a] | |
|---|---|---|---|---|---|
| | | Value | % | Value | % |
| Delta | 307 | 95 | 31 | 212 | 69 |
| Dagana | 323 | 98 | 30 | 225 | 70 |
| Nianga | 394 | 97 | 25 | 297 | 75 |
| Matam | 330 | 140 | 42 | 190 | 58 |

Source: Table 4.24.

[a]Net of the amount of farmer payments made to SAED for machinery services and water supply.

# CHAPTER V

## COMPARATIVE RETURNS OF LARGE AND SMALL SCALE IRRIGATED PERIMETERS

### A. Average Yields Per Hectare

In Table 5.1, statistics for paddy field by country is given for two contrasting periods. One is the five year base period 1961-1965 when yields were rather constant and before the popularly termed "green revolution" had begun. The other is 1971-1975, which includes the drought year of 1972 as well as the generally good years 1973 and 1975. The data for 1971-1975 reflect the progress that followed the introduction of modern rice varieties on a large scale and the increased use of fertilizer and other inputs. Worldwide average rice yields increased 14 percent over this period.

There are abundant opportunities for increasing tropical rice yields on irrigated land using methods and techniques now at hand. Increases in yield, even under conditions of good water control can be realized only if adequate fertilizer is applied, weeds are controlled, and severe damage from insects and other pests, such as rodents and birds, is prevented. In the United States and Europe, the high yields (5 t/ha) reflect the response to good management and control of insects and disease. [Chandler, 1979] In the Senegal River Valley data on rice yields are available from SAED's annual yield estimates.

TABLE 5.1
AVERAGE ANNUAL AREA AND YIELD
OF RICE BY COUNTRY

| | 1961 - 1965 | | 1971 - 1975 | | Change % |
|---|---|---|---|---|---|
| | Area (Thousand ha) | Yield (t/ha) | Area (Thousand ha) | Yield (t/ha) | Yield |
| Bengladesh | 8,955 | 1.68 | 9,737 | 1.71 | 2.0 |
| Burma | 4,741 | 1.64 | 4,840 | 1.73 | 5.6 |
| China | 30,180 | 2.74 | 34,137 | 3.17 | 15.2 |
| India | 35,626 | 1.48 | 37,460 | 1.72 | 16.2 |
| Indonesia | 7,036 | 2.04 | 8,326 | 2.54 | 24.4 |
| Japan | 3,281 | 5.01 | 2,690 | 5.83 | 16.3 |
| Philippines | 3,147 | 1.26 | 3,451 | 1.59 | 26.3 |
| Vietnam | 4,813 | 2.00 | 4,921 | 2.23 | 11.7 |
| Egypt | 348 | 5.30 | 456 | 5.26 | -0.7 |
| Guinea | 277 | 1.00 | 411 | .89 | -11.0 |
| Ivory Coast | 249 | .89 | 307 | 1.25 | 40.5 |
| Madagascar | 843 | 1.85 | 1,026 | 1.77 | -4.6 |
| Brazil | 3,809 | 1.61 | 4,743 | 1.46 | -9.4 |
| United States | 705 | 4.37 | 902 | 5.07 | 15.9 |
| Europe | 326 | 4.66 | 395 | 4.57 | -1.4 |
| USSR | 158 | 2.46 | 454 | 3.86 | 56.7 |
| WORLD TOTAL | 123,278 | 2.06 | 135,065 | 2.36 | 14.4 |

Table 5.2 shows that the average yield per hectare is widely variable from one perimeter to the other. The low yield in the Delta can be explained by several factors. The presence of salt and other difficulties related to the cultivation of heavy soils are perhaps the most important. Heavy soils need more water and heavy equipment but farmers depend on SAED for machinery services, water supply and other inputs which the agency is not able to provide on time. Moreover, the Delta perimeters were implemented without serious technical studies (soil, agronomy, sociology, etc.).

The farmers in the Delta are settlers brought from different regions of the country to cultivate the empty land of the Delta. The lack of homogeneity among the new settlers make the organization of mutual guarantee groups very difficult. Also in the other perimeters (Dagana, Nianga and Matam) high yielding varieties are used, whereas in the Delta these varieties cannot be grown successfully. The non-availability of high yielding varieties adapted to the saline soils of the Delta remains a constraint for increasing yields there.

The higher yields in the small perimeters can be explained by the practice of transplanting, the total absence of salt and the smaller size of the plots. Rice is transplanted and carefully inspected by the farmer who spends a considerable amount of time in his field. High yielding varieties such as JAYA (9 to 10 tons per hectare in experimental plots) are used. Farmers are also more enthusiastic when working in their own plots. They do not face the financial risk of being liable for machinery service charges and cash inputs over which they have no control.

TABLE 5.2
YIELD PER HECTARE FOR FOUR IRRIGATED PERIMETERS
IN THE SENEGAL RIVER VALLEY, 1978
(Kilograms)

| Perimeter | Average Yield | Adjusted Yield (25%)[a] |
|---|---|---|
| Delta | 2,102 | 1,577 |
| Dagana | 4,500 | 3,375 |
| Nianga | 4,145 | 3,109 |
| Matam | 5,600 | 4,200 |

Source: Neuman, Jean Louis and Mamadou Diarra. Resultats des Sondages de Rendements. Cellule Evaluation BEP, 1978.

[a]Author's estimates.

### 1. Post-Harvest Problems and Yields

The normal sequence in handling a rice crop after it matures is harvesting, cleaning, drying, storage, milling and distribution to the market. Severe loss can occur when traditional methods of handling are used. According to Chandler, studies conducted in several South and Southeast Asian countries reveal that 13 to 34 percent of the crop is lost during harvest and post-harvest operations; during harvesting and threshing, 5 to 15 percent; in cleaning and drying, 2 to 3 percent. This represents an average of 13 percent losses on the field plot yield.

In this study we assume that crop losses amount to 25 percent in the Senegal River Valley. Table 5.2 gives the adjusted yield per hectare and per perimeter which will be used in calculating the return per hectare.

## B. Ex-Farm Cost of Paddy

To obtain the cost of one kilogramme of paddy we divide the total cost in Table 4.24 by the average yield per hectare for each perimeter (Table 5.2). Table 5.3 shows the cost of one kilogramme of paddy rice in four perimeters of the Senegal River Valley.

Table 5.3 indicates that the farmer's cost of producing one kilogramme of paddy rice varies from 29 to 60 CFA francs per kilogramme. The price of paddy fixed by the government and paid to farmers is 41.5 CFA francs per kilogramme. This means that, on the average, farmer's gain in producing rice at Dagana, Nianga and Matam while in the Delta, they lose. Table 5.4 gives the distribution, between farmers and the public sector, of the financial cost of producing paddy rice.

TABLE 5.3
EX-FARM COST OF ONE KILOGRAMME OF PADDY RICE IN FOUR PERIMETERS OF THE SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| Perimeters | Farmer | SAED | Total Financial | Economic |
|---|---|---|---|---|
| Large Perimeters | | | | |
| Delta | 59.98 | 134.90 | 194.88 | 232.54 |
| Dagana | 29.12 | 66.53 | 25.65 | 109.89 |
| Nianga | 31.05 | 25.68 | 126.73 | 150.07 |
| Small Perimeters | | | | |
| Matam | 33.40 | 45.07 | 78.47 | 84.24 |

Source: Calculated from Tables 4.24 and 5.2.

TABLE 5.4
FARMER'S PROFIT AND DIRECT AND INDIRECT PUBLIC SECTOR SUBSIDIES
PER KILOGRAMME OF PADDY RICE PRODUCED IN THE SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| Perimeter | Total Cost of Production per Kilo A | Official Prices/kg B | Farmer Cost/kg C | Farmer Profit/kg D | Direct and Indirect G.O.S. Subsidy A-C |
|---|---|---|---|---|---|
| Delta | 194.88 | 41.50 | 59.98 | -18.48 | 134.90 |
| Dagana | 95.65 | 41.50 | 29.12 | +12.38 | 66.53 |
| Nianga | 126.73 | 41.50 | 31.05 | +10.45 | 95.68 |
| Matam | 78.47 | 41.50 | 33.40 | + 8.10 | 45.07 |

Source: Calculations from Table 5.3.

The negative profit in the Delta means that the farmers cannot repay the credit received for agricultural inputs from the process of production in the Delta perimeters. This situation explains why the Senegalese government from time to time is forced to cancel farmer's debts. In effect the government is using revenue generated in other sectors of the economy to support rice farmers in all of the perimeters. In this situation, completely dominated by government regulations and controls increasing the price of paddy while giving more money to farmers, will also increase the government subsidy unless productivity increases.

## C. SAED's Marketing Costs

We distinguish three stages in computing SAED rice marketing costs:

First Stage: From the farm to the central mill.

Second Stage: Within the central mill.

Third Stage: From the mill to the consumer.

### 1. First Stage Marketing Costs

The first stage marketing costs include all the costs of moving one ton of paddy rice from the weighing center of each perimeter to the SAED central mill of Ross-Bethio. Sacks are bought by the SAED and distributed to the farmers. Handling is done by unskilled workers hired for loading and unloading the truck. The paddy sacks are transported on a 10-ton Berliet truck. The capital charges represent a 2.5 percent interest over a two month period on the money used to buy sacks and paddy rice, to rent the truck and pay the unskilled workers. The paddy is cleaned and stored in a SAED building before being processed. Collection costs are given in Table 5.5.

TABLE 5.5
THE COST OF MOVING ONE TON OF PADDY RICE FROM FOUR PERIMETERS IN THE SENEGAL RIVER VALLEY TO THE SAED'S CENTRAL MILL OF ROSS BETHIO, 1978
(CFA Francs)

| | Delta (15 km) | | Dagana (50 km) | | Nianga (175 km) | | Matam (380 km) | |
|---|---|---|---|---|---|---|---|---|
| | Fin | Econ | Fin | Econ | Fin | Econ | Fin | Econ |
| Sacks | 1,410 | 1,483 | 1,410 | 1,483 | 1,410 | 1,483 | 1,410 | 1,483 |
| Handling | 690 | 138 | 690 | 138 | 690 | 138 | 690 | 138 |
| Transportation | 130 | 140 | 420 | 453 | 1,470 | 1,585 | 3,190 | 3,439 |
| Capital charges[c] | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Storage[c] | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 |
| Total | 2,820 | 2,354 | 3,110 | 2,664 | 4,160 | 3,796 | 5,880 | 5,650 |

Source: Extracted from Tuluy, H.A. study "Comparative Resource Costs and Incentives in Rice Production," Food Research Institute, Stanford University, 1978.

[a]85 CFA francs per 65 kg sack.

[b]Paddy price plus sack handling and transportation over a two month period at 2.5 percent interest, 15 percent per year.

[c]200 CFA francs/mt/month over an average of two months duration.

### 2. Second Stage Marketing Costs

The second stage involves processing and includes all activities and costs of hulling rice within the mill. According to the mill's staff one hundred kilogrammes of paddy yields 66 kilogrammes of rice (80 percent broken rice and 20 percent whole rice). There is no distinction or separation between broken and whole grain rice. The mixture of both is delivered to the marketing board (ONCAD). Labor consists of skilled seasonal workers employed in the mill during the hulling period. Losses include the reduction of paddy weight due to moisture loss. Second stage costs are summarized in Table 5.6.

### 3. Third Stage of Marketing Costs

This stage includes all the costs of moving one ton of rice from the SAED's central mill of Ross-Bethio to the capital city Dakar. Bags are provided by the SAED. Transportation is done by ONCAD on a 10 ton Berliet truck. Unskilled workers are used for loading and unloading the truck. Rice bags are stored in ONCAD warehouses before their delivery to rice wholesalers. Table 5.7 details the delivery cost of one ton of rice from Ross-Bethio to Dakar.

Table 5.8 gives a summary of the SAED's marketing cost for a ton of rice by perimeter. The economic and financial cost of collecting, processing and distributing rice vary from 39 CFA francs per kilogramme in the Delta to 42 CFA francs per kilogramme for the more distant perimeter of Matam. Since processing and distribution costs are the same for all perimeters the only cost difference comes from the collection costs.

TABLE 5.6
THE COST OF PROCESSING ONE TON OF RICE IN SAED'S CENTRAL MILL OF ROSS BETHIO, 1978
(CFA Francs)

| Elements of Cost | Financial | Economic |
|---|---|---|
| Labor | 4,951 | 4,951 |
| Fuel and Oil | 3,181 | 3,450 |
| Interest and Depreciation | | |
| Buildings | 4,133 | 3,930 |
| Equipment | 2,941 | 3,118 |
| Maintenance and Repairs | | |
| Building[a] | 3,221 | 2,673 |
| Equipment | 6,708 | 7,149 |
| Insurance | 197 | 197 |
| Other | | |
| Losses | 3,179 | 3,179 |
| Seed Treatment | 554 | 554 |
| Total Cost per Ton of Paddy Rice | 29,066 | 28,701 |

Source: Extracted from Tuluy, H.A. "Comparative Resource Costs and Incentives in Senegalese Rice Production," Food Research Institute, Stanford University, 1978, and Table 3.2.

[a]Financial cost of building is greater than economic cost because building maintenance is entirely done by unskilled labor for which the SWR is .20.

TABLE 5.7
THE DELIVERY COST OF ONE TON OF RICE FROM THE SAED'S CENTRAL MILL OF ROSS BETHIO TO DAKAR, 1978

| Elements of Costs | Financial | Economic |
|---|---|---|
| Bags[a] | 1,418 | 1,492 |
| Handling[b] | 400 | 80 |
| Transport[c] | 2,723 | 2,935 |
| Commissions[d] | 1,000 | 1,000 |
| Capital Charges | 420 | 420 |
| Storage[e] | 800 | 800 |
| Total | 6,761 | 6,727 |

Source: Extracted from Tuluy, H.A. "Comparative Resource Costs and Incentives in Senegalese Rice Production," Food Research Institute, Stanford University, 1978; and Table 2.1.

[a]85 CFA francs/60 kg sack.

[b]200 CFA francs/mt for loading and unloading bags.

[c]Delivery to Dakar, 325 km by 10 ton berliet.

[d]ONCAD Commission of 1,000 CFA francs/mt.

[e]400 CFA francs/mt/month for an average of two months.

TABLE 5.8
ECONOMIC AND FINANCIAL COST OF COLLECTING, PROCESSING
AND DISTRIBUTING ONE TON OF RICE PRODUCED
BY EACH OF FOUR PERIMETERS IN THE
SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| | Delta | | Dagana | | Nianga | | Matam | |
|---|---|---|---|---|---|---|---|---|
| | Fin | Econ | Fin | Econ | Fin | Econ | Fin | Econ |
| Collecting | 2,820 | 2,354 | 3,110 | 2,664 | 4,160 | 3,796 | 5,880 | 5,650 |
| Processing | 29,066 | 28,701 | 29,066 | 28,701 | 29,066 | 28,701 | 29,066 | 28,701 |
| Distributing | 6,761 | 6,727 | 6,761 | 6,727 | 6,761 | 6,727 | 6,761 | 6,727 |
| Total | 38,647 | 37,782 | 38,937 | 38,092 | 39,987 | 39,224 | 41,707 | 41,078 |

Source: Table 5.5, 5.6 and 5.7.

## 4. Total Cost of Rice Delivered to Dakar

### a. Rice from the Senegal River Valley

The cost of one kilogramme of rice produced in the Senegal River Valley and transported to the capital city, Dakar, is obtained by adding total marketing cost to the cost of producing one kilogramme of paddy. These costs are summarized in Table 5.9.

### b. Imported Rice

To show whether Senegal can produce rice in the Senegal River Valley more cheaply than importing it, we will compare the economic and financial cost of rice produced in the four selected perimeters with the average CIF price of imported rice. The CIF price is an average of five consecutive years (1974-1978) following the drought of 1968-1973. The average CIF is assumed to be representative because imports during these years averaged around 200,000 tons which is the average annual volume imported in normal years since 1965. Calculation of the CIF price of rice is detailed in Table 5.10.

Financial cost of one kilogramme of rice produced in the four irrigated perimeters and transported to Dakar varies from 120 to 234 CFA francs per kilogramme versus 72 CFA francs for imported rice.

This means that domestic production of rice in irrigated perimeters cost 67 to 225 percent more than imported broken rice in financial terms. The economic costs to Senegal of producing one kilogramme of rice delivered to Dakar are, respectively, 125 francs for small perimeters and 270 CFA francs for the most costly of large perimeters versus 81 CFA francs for imported rice. Thus, rice produced in the Senegal River Valley is from 54 percent to 233 percent more than imported.

TABLE 5.9
TOTAL COST OF ONE KILOGRAMME OF RICE PRODUCED IN THE SENEGAL RIVER VALLEY AND DELIVERED AT DAKAR, 1978
(CFA Francs)

| Cost Categories | Delta | | | | Dagana | | | |
|---|---|---|---|---|---|---|---|---|
| | Financial Costs | | | Economic Cost | Financial Costs | | | Economic Cost |
| | Farmer Share | SAED Share | Total Fin | | Farmer Share | SAED Share | Total Fin | |
| Investment | - | 74.19 | 74.19 | 105.26 | - | 30.81 | 30.81 | 42.37 |
| Operating Costs | 48.08 | 18.25 | 66.33 | 72.93 | 23.57 | 18.08 | 41.65 | 44.33 |
| Administration | - | 42.46 | 42.46 | 42.46 | - | 17.63 | 17.63 | 17.63 |
| Family Labor | 11.88 | - | 11.88 | 11.88 | 5.55 | - | 5.55 | 5.55 |
| Marketing | - | 38.68 | 38.68 | 37.78 | - | 38.94 | 38.94 | 38.09 |
| Total | 59.96 | 173.58 | 233.54 | 270.31 | 29.12 | 105.46 | 134.58 | 147.97 |
| Percentage | 26 | 74 | 100 | | 22 | 78 | 100 | |
| | Nianga | | | | Matam | | | |
| Investment | - | 34.09 | 34.09 | 48.24 | - | 4.52 | 4.52 | 7.85 |
| Operating Costs | 25.02 | 42.44 | 67.46 | 77.28 | 16.61 | 26.38 | 42.99 | 45.42 |
| Administration | - | 19.14 | 19.14 | 19.14 | - | 14.17 | 14.17 | 14.17 |
| Family Labor | 6.03 | - | 6.03 | 6.03 | 16.78 | - | 16.78 | 16.78 |
| Marketing | - | 39.99 | 39.99 | 39.22 | - | 41.70 | 41.70 | 41.08 |
| Total | 31.05 | 135.66 | 166.71 | 189.91 | 33.39 | 86.77 | 120.16 | 125.30 |
| Percentage | 19 | 81 | 100 | | 28 | 72 | 100 | |

Source: Table 4.24, 5.8.

TABLE 5.10
AVERAGE CIF PRICE (DAKAR) OF ONE
KILO OF IMPORTED MILLED RICE

| | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|
| Quantity Imported (Metric Tons) | 207,181 | 102,119 | 200,000 | 218,005 | 183,700 |
| Value (1000$) | 75,105 | 28,253 | 55,500 | 60,000 | 64,000 |
| Conversion Factor | 1000 FCFA= $4.160 | 1000 FCFA= $4.670 | 1000 FCFA= $4.191 | 1000 FCFA= $4.070 | 1000 FCFA= $4.440 |
| CIF Price of One Kilo (CFA) | 87.037 | 59.243 | 66.213 | 67.620 | 78.467 |

Average CFA $= \frac{87.037 + 59.243 + 66.213 + 67.620 + 78.467}{5} = 71.716$

Source: FAO Trade Yearbook, Vol 32, pp. 20, 118.

These results detailed in Table 5.11 confirm that Senegal is producing rice at a very high cost.

TABLE 5.11
COMPARATIVE COSTS BETWEEN IMPORTED RICE AND RICE PRODUCED
IN THE SENEGAL RIVER VALLEY, 1978
(CFA Francs)

| | Financial Cost Per Kilo | % Difference With CIF Price[a] | Economic Cost Per Kilo | Financial With CIF Price[b] |
|---|---|---|---|---|
| Large Perimeters | | | | |
| Delta | 233.54 | 225 | 270.31 | 233 |
| Dagana | 134.58 | 87 | 147.97 | 82 |
| Nianga | 166.71 | 132 | 189.91 | 134 |
| Small Perimeters | | | | |
| Matam | 120.16 | 67 | 125.30 | 54 |

Source: Table 5.8 and 5.9.

Average CIF price = 71.716

[a] % Difference = $\frac{\text{Financial Cost}}{\text{CIF Price}}$

[b] % Difference = $\frac{\text{Economic Cost}}{\text{CIF x SER}}$

CIF x SER = 81.03

# CHAPTER VI

## CONSTRAINTS ON IRRIGATED FARMING IN THE SENEGAL RIVER VALLEY

### A. Physical and Technical Constraints

Senegal is a Sahelian country. As such it is subject to all the climatic uncertainties associated with this ecological zone. The climate and the soil represent important constraints for agriculture. According to the CNRA of Bambey in Senegal (The National Agronomic Research Center), 50 percent of the annual fluctuation in agricultural production is determined by rainfall levels and more importantly, by the distribution of rain over time. During the drought period 1968 to 1973 agricultural production of all crops in the country declined. Declines in production ranged from 30 to 50 percent. According to Stryker, the Sahelian countries as a group can expect 15 percent shortfall in production every five years, a 20 percent deficit one in ten years and 30 percent decline once every twenty years. This shows the importance of irrigated farming for Sahelian countries.

In the Delta of the Senegal River the major constraints on irrigated farming are the presence of salt and the heavy soils which require heavy equipment. It may take years or decades of permanent drainage to "desalt" the land. "Desalinisation" of the land requires the construction of underground permeable pipelines to absorb water containing the salt. The cost

of such an operation is very high. Large quantities of water pumped from the river are needed for such drainage operations. More water, in turn, means more fuel and oil. At the same time heavy equipment is needed to cultivate the compact soils of the Delta. Such equipment has to be imported and is very expensive. Up until now the average yield of paddy per hectare in the Delta is 2.1 tons, a very poor result when compared to the costs. An average yield of 4 tons per hectare is necessary to justify rice cultivation in the Delta.

Increasing yield per hectare in the Delta within the actual conditions can be done only by using high yielding varieties adapted to saline soil, varieties which are not yet available. At the current time investing in "desalinisation" systems is too expensive given the expected results.

## B. Relations Between SAED and Farmers

SAED has management responsibility over the perimeters. In large perimeters farmers' parcels are allocated annually by the SAED. Farmers follow instructions from the agency and have no incentive to improve or even maintain the parcels. Very often there is no long term link between the farmer and the plot he cultivates. He does not identify himself as a parcel owner but as a hired laborer to serve for a year on land belonging to the SAED.

Also the SAED has been unable to provide farmers with inputs and services on time. These problems, added to the low yields in the saline soils of the Delta, the cost of inputs and the price of rice, make farmers unenthusiastic about rice cultivation. Frequently farmers are even unable to pay their debts because of the low yields they obtain.

SAED's perimeter managers, confronted with very high operating costs, are not sensitive to farmers' difficulties. As a result coercive actions

are taken by the SAED against farmers who are unable to repay their debts. Some are expelled from their parcels. Others are suspended from receiving credit.

The very high operating cost of the perimeters results, in turn, from the poor management of resources by the SAED personnel. The excessive centralization of SAED paralyzes initiatives and dynamism at the various levels of decision-making. Decentralization of decision is an indispensable tool for reducing costs.[1]

Most extension agencies such as SAED face serious personnel management problems. There is a lack of sufficiently well-trained staff to conduct specialized work such as perimeter management, research management, perimeter establishment studies (agronomy, pedology, micro-economy, etc.). The establishment of efficient maintenance structures always takes much longer than anticipated. Many times the right person is not assigned to the right job. In the case of SAED, many key positions are under control of people with low qualifications, while well-trained and skilled personnel are overlooked. Personal relations and family alliances are important contributors to this situation.

In small perimeters farmers have more responsibilities and are more enthusiastic about farming. A socio-economic survey conducted by OMVS (Organization de mise en Valeur du Fleuve Senegal) in the Matam area shows that the majority of farmers will abandon dry land farming for irrigation

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[1] Some examples: The head of a pumping station is not authorized to stop pumping even though the flood is high enough to fill the canals. A mechanic with nothing to do refuses to repair a vehicle or a tractor until he receives orders from his own supervisor.

if the size of their plot is increased. The actual size is .25 hectares per household which is four times smaller than those in large perimeters. With such small plots farmers can barely produce enough for auto consumption and rarely can generate surpluses to improve their farm or equipment. Increasing the plot size, however, depends upon the availability of suitable land (not subject to flooding, but close enough to the river for pumping). Such land is limited in amounts and limits extension of the small perimeter program.

# CHAPTER VII

# CONCLUSIONS

The results of our calculations indicate that for large perimeters economic cost of locally produced rice delivered to Dakar is higher than the average economic CIF price. For small perimeters the economic cost is 54 percent higher than the economic CIF price. In large perimeters 74 to 81 percent of the cost is borne by SAED while only 19 to 26 percent are supported by the farmers. In small perimeters 28 percent of total costs are borne by farmers and 78 percent by government and SAED. Even though the cost of producing rice locally appears to be relatively high in Senegal, the results suggest that more participation and involvement of farmers in rice production could result in higher yields and greater return to investment.

Examining the different cost categories individually we find the following:

## A. Investment Cost

The investment cost in large perimeters is seven times higher than in small perimeters. High investment costs per hectare are attributable to oligopolistic power and a disinterest in lower costs on the part of companies engaged in constructing the irrigated perimeters. There is little competition among such companies and an absence of systematic research for solutions capable of reducing unit price.

## B. Operating Costs

Operating costs of small perimeters require a large amount of family labor. Most activities are done manually using traditional tools. The farmer is tied to his plot during the rainy season, taking care of everything himself. In large perimeters machinery services are provided to the farmer by the SAED. The farmer is a passive agent for most of the time while SAED hired workers are performing agricultural activities on his plot. The farmer is not tied to his plot as he should be. Irrigation, weeding by applying herbicides, and sometimes harvesting and threshing are the only activities the farmer does in his plot during the rainy season. This explains why some civil servants, merchants, herdsmen and other artisans own plots in large scale irrigated perimeters. They practice agriculture as a sideline activity. Obviously, these people are often absent from their plot for days or weeks. The yield on these plots are low. Despite efforts by the SAED to stop such practices, anomalies still exist in large perimeters. In small perimeters there is so much labor input involved that it is impossible for an outsider to own a plot.

Farmers in large perimeters need to be more involved in their plots. For that, SAED's role must be reduced. Farmers who own or rent agricultural equipment themselves and who perform agricultural activities themselves will feel more involved in and responsible for agricultural production. Outsiders not fully engaged in agriculture must be expelled in order to increase land available for others and hopefully raise yields and return to investment. For that, strong leadership and good management is needed at the head of each perimeter.

## C. General Administration Costs

The general administrative costs of SAED are very high in relation to the activities performed. Personal experiences of the author suggest that personnel costs can be cut in half without reducing the level of services. This can be done by eliminating drivers without cars and trucks, secretaries without typing machines, civil servants without offices and many other agents paid by the SAED who do nothing. The lack of serious controls on expenditures for supplies and material results in a misappropriation of public funds. The absence of control on SAED vehicles has resulted in larger expenditures for fuel, maintenance and repairs, electricity, water and telephone charges. This waste of resources at all levels of the agency greatly limits the hope for a better future in the Senegal River Valley.

While many people are calling for an increase in the size of SAED, a reduction in size seems more appropriate. However, there is a need to reinforce the agronomy, economics, accounting and pedology services of the perimeters.

Perimeters can be autonomous units more easy to manage. The excessive centralization of the development agency often paralyzes initiative and dynamism at the various levels of decision-making. Decentralization is an indispensable tool for success of irrigated farming in the Senegal River Valley.

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