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FARM LEVEL STUDY OF THE RICE PRODUCTION SYSTEM AT THE OFFICE DU NIGER IN MALI: AN ECONOMIC ANALYSIS

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FARM LEVEL STUDY OF THE RICE PRODUCTION SYSTEM AT THE OFFICE DU NIGER IN MALI: AN ECONOMIC ANALYSIS

By

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ABSTRACT

FARM LEVEL STUDY OF THE RICE PRODUCTION SYSTEM AT THE OFFICE DU NIGER IN MALI: AN ECONOMIC ANALYSIS

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The study was designed to provide information on the economics of rice and livestock production in the Office du Niger settlement in Mali. Currently 5,000 settlers produce 70 percent of the marketable surplus of rice in Mali on this gravity irrigation scheme. The objectives were to describe the socio-economic environment, estimate incomes and expenditures of the settlers, evaluate farm labor use, develop models of improved rice farming and study the special problem of undercapitalization of settlers.

The results of the survey revealed that there was substantial heterogeneity in the natural resource endowments and rice yields in the three representative zones, i.e. Kolodogou, Sahel and Kolongo. The average yield of sample farmers was 1.7 mt per hectare, approximately 30 percent lower than official estimates. The survey also revealed that the gross income per man-equivalent was 42,300 MF in Kolongo and 100,800 MF in Kolodogou and Sahel. The real cost of producing one kilo of paddy was 25 percent higher than the official farm gate price. This explains why settlers sell rice in black markets. Off-farm revenues were higher than on-farm revenues, particularly for Kolongo settlers. Gross cash income from livestock averaged 31,000 MF per farm. Analysis of labor utilization showed that 55 percent of the total labor inputs in rice production was contributed by

adult males and 27 percent by adult females but females provided one-half the labor for harvest. Peak season demand for labor was found to be a constraint on increasing rice production.

A linear programming model was developed to test the profitability of improved practices. The results suggest that the optimum farm size was 3 to 7 hectares and that farm incomes could be increased if row-seeding and mechanical weeding were adopted by farmers. However, these innovations will require the support of an expanded credit program.

The policy recommendations stress the need (1) for the government to increase the farmgate price of rice from the present 60 MF per kilo to 90 MF, (2) invest in land improvements in Kolongo, (3) initiate on-farm research to test improved technologies, (4) replace interest-free loans with loans reflecting the opportunity cost of capital, (5) expand the credit program, (6) replace the fixed land tax per hectare with a variable land tax which reflects the differences in yield potential of land and (7) develop special incentives to assist the impoverished farmers in the Kolongo zone.

To my family, for the painful separation we
had to endure as this work was being completed

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GLOSSARY OF FARM MANAGEMENT CONCEPTS

This glossary contains definitions of some farm management concepts used in this thesis.

Capital turn over ratio: financial test ratio calculated by dividing total gross income by the average value of farm capital.

Decision tree: a diagrammatic representation in tree form of a risky decision problem.

Family earnings (total household net income): equal net farm earnings plus other household income; it represents the total income available to the farm family for all purposes.

Farm cash flow: farm payments or receipts in the form of cash (including transactions conducted through a bank); farm net cash flow - if adjusted for loan received and interest and principal payments.

Fixed ratio: financial test ratio calculated by dividing total fixed costs by the gross income.

Gross farm income (gross farm returns, revenues or earnings): the value of total output of a farm over some accounting period.

Gross margin: gross income minus the variable expenses attributable to that enterprise or farm.

Gross ratio: financial test ratio calculated by dividing total expenses (fixed plus variable) by the gross income.

Income, revenues or earnings: represent value of output in general terms. Terms used interchangeably.

Input-output coefficients: technical coefficients specifying the quantity of some particular input per unit of output or the amount of output produced per unit of input.

Labor budget: a budget comparing labor requirements with labor available, constructed on a seasonal basis.

Labor profile: the seasonal pattern of labor requirements for a given activity.

Management income: the residual return after all fixed factors are compensated at their opportunity cost.

Man-day: a unit of measurement of labor input, assumed to represent the work accomplished by an adult worker in eight hours.

Net farm income, net enterprise income: gross income minus the variable and fixed costs attributable that enterprise or farm. It represents the reward to the farm family for their labor and management together with the return on all the capital invested in the farm or enterprise, whether borrowed or owned.

Operating ratio: financial test ratio calculated by dividing total operating (or variable) costs by the gross income.

Returns to family labor: net farm income minus an imputed interest charge on farm equity capital.

CHAPTER 1

INTRODUCTION

Background

The principal objective of the Malian government cereals policy in the 1970s has been to regain self-sufficiency and to maintain it against crop failures. Rice has remained for a long time the basis of cereals policy for one main reason: its production in irrigated and flooded zones is more secure against subnormal rainfall and drought than is the rainfed cultivation of millet and sorghum. Recent orientation of the Malian government toward increased investments in the Office du Niger (O.N.) has to be examined in light of this objective.

The Office du Niger remains the largest rice production scheme with full water control in West Africa. It currently irrigates some 40,000 hectares (ha) of improved land and realizes an average yield of 2.2 metric tons (mt) per hectare. The Office contributes 40 percent to the domestic production of paddy (rough rice) and provides 60 to 70 percent of the volume of milled rice marketed through Malian official channels. Originally designed to serve all the countries of the Niger River "loop", the O.N. has at least remained the basis of Mali's comparative advantage in domestic rice production as a substitute for imports and also for export to other West African countries.

The Office is also a settlement for nearly 5,000 farm families who make their living planting rice and delivering the harvest to the scheme management. They also keep productive animals and some cultivate small plots for the production of vegetable and dryland crops.

For the Office to continue to increase productivity and contribute to the accomplishment of the national objective of food security, the Malian government had to choose in recent years between intensification and extension of cultivated areas to utilize more fully the existing irrigation network. The first option has been retained, partly in view of the fact that the Office major development costs are sunk and that aid donors are now willing to pay for the rehabilitation projects.

This study looks at the Office production system from a farm level perspective. It was conceived as part of the preliminary phase of the intensification program now being implemented. Its broad objective was to fill in some important gaps in the present knowledge base in the Office. First, Mali's economic standing and the role of rice in the agricultural economy are briefly reviewed; second, the specific objectives of the study are outlined.

1.1 Mali's Past and Current Economic Standing

Mali, former French Soudan, is the largest country in Sahel with a total area of about 1,204,000 square kilometers. According to the 1976 census, its population was to 6.3 million, 90 percent of which lives in the southern half. As much of the territory is flat, Mali has a natural advantage in the utilization of water resources embedded in the meanders of the Niger and Senegal Rivers.

Mali's mineral reserves are still being assessed and principally include phosphates, bauxites, manganese, iron-ore and natural gas [Platon, 1979]. Oil and uranium have also been traced. However their full exploitation depends on important infrastructural investments which would allow cheap transportation and a low-cost supply of energy to its land locked territory (Figure 1). Comparatively Mali experienced a very low economic growth (0.5 percent per year) during the first decade after its independence in 1960. From 1972 to 1979, however, its Gross National Product (GNP) sustained a remarkable upward trend which averaged 4.3 percent annually [Platon, 1979].[1]

The main thrust of economic policy of Mali has remained its adherence to development plans to achieve a number of economic objectives. Between 1961 and 1979 the Government of Mali enacted four economic development Plans or Programs. Table 1-1 summarizes the main features of three of the major Plans.

The first Plan was prepared in 1960-61. The objectives were to intensify agricultural production, improve Mali's export potential, build processing industries and achieve an effective state control of the economy. As Jones [1976] points out, however, the first Plan failed to match planned and actual expenditures because prescribed investments and support policies did not succeed in generating the output the planners had expected.

The 1970-73 "Program of Economic and Financial Rehabilitation" was aimed at correcting a disastrous economic situation. The main economic indicators over this Plan's period reveal a less spectacular improvement

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[1]The most comprehensive study to date of Mali's past and current economic performances is presented by Pierre Platon in the December 21, 1979 issue of Marchés Tropicaux et Méditerranéens. This 100 page paper contains useful details concerning the trend in macro-economic aggregates.

Republic of Mali: Administrative Division

FIGURE 1

TABLE 1-1. Mali's Economic Development Planning 1961-1978

Plan Demonination	Enactment Period	Initial Distribution of Planned Expenditures					Achievements
		(billion of Malian francs)[a]					
1st Five Year Plan	1961-66	Primary Sector	Industry	Infrastructure	Social Services	Others	Ratio: Actual/planned expenditures: 60% % variation in agricultural production (quantity):
		16.4	4	36.5	7.4	0.7	Rice (-13.8), millet/sorghum (-12.5) maize (+289), groundnuts (-40) cotton (+62.2)
		(billion MF)					
Economic and Financial Rehabilitation Program	1970-73	Primary Sector	Secondary Sector	Infrastruc. & Transport	Social Services	Others	Ratio: 1) Actual/planned expenditures: 51% 2) Actual/acquired financing: 63%
		26.5	30.3	36.1	15.3	5.6	Secondary sector achieved an increase of 45.7% (cotton)
		Breakdown of investments (billion MF) (updated June 76)					
3rd Five Year Plan	1974-78	Rural Economy	Mining, power Industry	Communication Tourism Housing	Social Sector		% variation energy production: +90 (1972-78) Cereal production: near self-sufficiency levels
		269.3	241.6	319.8	59.1		Cotton expansion

Source: Adapted from P. Platton [1979] (pp. 3529-3532).

[a]The Malian franc was at parity with the CFA franc until the 1967 devaluation which led to a rate of 1CFAF = 2MF. In the late 70's the exchange rate was approximately 420 to 440 MF for USA $1 (or 210-220 CFAF).

in the primary sector. Food crop production declined because of the Sahelian drought of the early 70's. However cotton production increased by 75 percent during this period.

The Five Year Plan (1974-78) emphasized self-reliance and agricultural income generation processes more or less free from the vagaries of the weather. Although aggregate economic indicators are not available, it is possible to expect actual spending to remain below its projected level as the annual inflation rate increased to 9.6 percent over the second half of the 70's and because foreign aid remains so large a share in the total planned expenditures. However Platon [1979] has reported that energy production has increased by 90 percent over its 1972 level, and Mali has almost achieved self-sufficiency in cereal production.

1.2 The Agricultural Sector

Agriculture is the mainstay of the Malian economy and contributed 45 to 50 percent to the GNP over the last two decades [CILSS, 1977]. Crop land estimated at 1.8 percent of total area and 18 percent of the arable land is limited to the southern half of the country where rainfall is relatively higher (600 to 1,300 mm) and irrigation is possible from the floods of the Niger, Bani and Senegal Rivers.

Major food grains (rice, millet and sorghum) occupy 80 percent of cultivated land. Peanuts and cotton respectively use up 13 and 6 percent of it [CRED, 1976]. On a national average, crop production and animal husbandry provide 46 and 45 percent of the agricultural income, respectively. The evolution of agricultural land use and major crop production is shown in Table 1-2. The wide adoption of animal traction, the

TABLE 1-2. Area Planted, Yields and Production of Major Crops

Year[1]	Rice			Peanuts			Millet and Sorghum			Cotton		
	Area (000 ha)	Yields (mt/ha)	Production (000 mt)	Area (000 ha)	Yields (mt/ha)	Production (000 mt)	Area (000 ha)	Yields (mt/ha)	Production (000 mt)	Area (000 ha)	Yields (mt/ha)	Production (000 mt)
1961	170	1.09	185	n.a.		122	n.a.		850	n.a.		n.a.
1962	182	1.02	185	n.a.		138	n.a.		820	n.a.		n.a.
1963	200	0.95	190	n.a.		167	n.a.		870	n.a.		n.a.
1964	123	1.34	165	n.a.		182	n.a.		865	n.a.		n.a.
1965	159	0.99	158	144	1.03	148	859	0.79	678	89	0.37	33
1966	169	0.96	162	122	1.25	153	830	0.87	721	76	0.24	18
1967	178	0.89	158	129	1.23	159	910	0.81	737	62	0.45	28
1968	198	0.87	172	140	0.85	119	1035	0.80	830	76	0.49	37
1969	162	0.83	135	129	0.74	96	932	0.60	557	91	0.60	55
1970	133	1.22	162	118	1.15	136	745	0.81	603	76	0.61	46
1971	172	0.95	163	162	0.96	156	725	0.99	715	75	0.76	57
1972	169	1.15	195	174	0.87	152	1258	0.57	715	79	0.90	71
1973	167	0.60	100	160	0.84	135	900	0.69	623	86	0.85	73
1974	185	0.49	90	n.a.		132	n.a.		660	69	0.80	55
1975	198	1.09	215	n.a.		188	n.a.		850	68	1.04	71
1976	224	1.16	260	240	0.85	205	1220	0.71	865	87	1.15	100
1977	n.a.		350	n.a.		160	n.a.		1050	107	1.11	119
1978	n.a.		220	n.a.		113	n.a.		820	100	1.14	114
1979	n.a.		270	n.a.		160	n.a.		910	114	1.12	128

Source: West Africa Rice Development Association (WARDA), Rice Statistics Yearbook 1976, Mali Agricultural Sector Assessment, Final Report; CRED, University of Michigan, December 1976; and Marchés Tropicaux, December 1979.

[1]Ending year of the agricultural season.

increasing trend in the use of fertilizer and other modern techniques and recent efforts in the intensification of agricultural extension services are evidences of the potential of Malian land and labor. Beginning in 1974-75 the trend in food crop production has brought Mali to the edge of self-sufficiency in cereals with no substantial increases in the cultivated area. However, to sustain higher levels of cereals production, adequate price policies need to be adopted. In 1977-78 only 4 percent of the production of coarse cereals was marketed through the official channels [Platon, 1979]. However the 1977 CILSS study (Marketing, Price Policy and Storage of Food Grains in the Sahel) showed no clear indication that the agricultural sector in Mali has had typically poor or declining terms of trade with the rest of the economy up until the mid 1970's (pp. 141-147). The government extraction of an economic surplus from the primary sector through lower producer prices to provide investment funds for industry has certainly become a heavy burden.

Successive increases in the official producer price of major cereals since the mid 1970's seemed to have lagged behind an inflationary pressure that had already eroded farmers' incomes. Other issues of concern in the Malian agricultural sector are discussed at length in the 1976 CRED report and many studies are now available on grain marketing and price policy in Mali.[2]

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[2]Most recent in the series are the two volumes on "Marketing, Price Policy and Storage of Food Grains in the Sahel [CILSS/CLUB du SAHEL, 1977] and "Reforming Grain Marketing System in West Africa: A Case Study of Mali" by Eliot Berg [1978]. The latter paper examines the food grain marketing problems in Mali and analyzes why numerous proposals for reform have proven infeasible or too difficult to implement.

Rice in Malian Economy

Although millet and sorghum remain the staple food of most Malians, rice consumption has been increasing much faster than its rate of production particularly during the last decade. Rice contributes only 2.2 percent to the GNP and 5 percent of the total value of agricultural product [IBRD, 1976]; it provides 15 percent of the national supply of calories and its consumption rate is estimated at 3 percent annually [West Africa Rice Development Association (WARDA), 1980]. However, the per capita average of 20 kg per year conceals such striking regional disparities as 90 and 170 kg per capita in Bamako and the Office du Niger zone, respectively. The trend in rice consumption and availability is depicted in Table 1-3. Rice imports were eliminated over the 18 year period shown only twice: first, from 1966 to 1968 and second, after 1976 when the total production of paddy crossed the 200,000 metric tons mark. Imports peaked during the drought years of 1972 to 1974.

Higher rates of consumption of rice are expected to be sustained through the year 1990 with an estimated 4.5 percent annual growth [WARDA, 1980]. This is because rice is becoming an exceptional grain in the urban consumer diet particularly for its cooking characteristics and good taste relative to coarse cereals. In recent years, however, government policies may have contributed to the increase in the demand for rice. For instance during the drought years of the early 70's, rice prices at the consumer level were kept unchanged in the face of soaring world prices. As a result this induced at least in the urban centers a substitution of the relatively cheap imported rice for the domestic low-values coarse cereals [WARDA, 1977].

TABLE 1-3. Rice Availability and Consumption (in 1000 Metric Tons)

Year[a]	Availability					Consumption per Capita[f] (kg)
	Production[b]	Changes in Stock[c]	Seeds and Losses[d]	Net Imports	Net Availability[e]	
1961	120	n.a.	-21	-13	86	19
1962	120	n.a.	-24	-15	81	18
1963	124	n.a.	-26	-5	93	22
1964	107	n.a.	-19	-1	87	16
1965	103	n.a.	-21	-4	78	17
1966	105	n.a.	-22	0	83	16
1967	103	n.a.	-22	0	81	17
1968	112	n.a.	-24	0	88	17
1969	88	n.a.	-19	20	89	18
1970	105	n.a.	-19	15	101	18
1971	106	n.a.	-22	15	99	20
1972	127	n.a.	-24	31	134	15
1973	65	n.a.	-17	46	94	20
1974	59	-18	-18	71	94	14
1975	140	-23	-27	20	110	23
1976	169	10	-31	0	148	24
1977	228	n.a.	-28[g]	11	211	33
1978	143	n.a.	n.a.	n.a.	n.a.	n.a.
1979	176	n.a.	n.a.	n.a.	n.a.	n.a.
1980	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: WARDA Rice Statistics Yearbook, 1976; Marchés Tropicaux, December 1979.

[a]Ending year of the agricultural season.

[b]Paddy has been converted to rice at a milling rate of 0.65.

[c]Changes in stocks represent stocks at the end of the indicated year minus stocks at the beginning of the same year. Figures for 1961-73 are not available but are believed to be negligible.

[d]Assuming a seeding rate of 100 kg per hectare. Losses are assumed to be 10 percent of the gross yield before seeds are subtracted. Data on area planted are from Table 1.2. Seeds and losses are finally converted to rice equivalent at the 0.65 milling rate.

[e]Net availability is defined as production minus seeds and losses, minus changes in stocks plus net imports.

[f]Population each year was calculated by extrapolating from the 1976 census figure of 6,300,000 at an annual growth rate of 2.5 percent.

[g]The area planted to rice for 1977 was calculated as the average of the three preceeding years, before deriving estimates of seeds and losses.

Recent projections of the per capita rice consumption for 1983, 1990 and the year 2000 were shown to be 48, 79 and 92 kg respectively [Platon, 1979]. This calls for production requirements of 646, 1214 and 1987 thousand metric tons of paddy. Thus for self-sufficiency to be maintained through the year 2000 assuming a total population of 10.2 million[3] average paddy yields for Mali as a whole will have to pass the 2.2 mt per hectare mark.

Several types of rice cultivation are found in Mali, however, as described in Table 1-4, four main types can be distinguished. The oldest type is the traditional flooded production system practiced along the flood plains of the Niger toward Segou, the Bani River toward San and around Mopti. Individual holdings average 1.5 hectares with yields of 0.5 to 0.7 mt per hectare. Practically no water control exists except in some cases where small earth dikes are constructed along river banks. The use of animal traction in the traditional flooded system is also very limited.

Controlled submersion is the production system characterizing the government financed rice development Operations (at Segou and Mopti). Rice is produced on nonlevelled land or polder[4] with an inlet gate, a

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[3]Extrapolated from the 1976 census figure of 6,300,000 using a growth rate of 2.5 percent, believed to be the annual rate of growth based on comparisons with partial surveys done in 1960 and 1967 [McIntire, 1979].

[4]The term is used in Mali to describe an assemblage of a large number of small, inexpensive partial-water control works along river banks.

TABLE 1-4. Characteristics of Major Rice Production Systems in Mali

Production Technique	Area (ha)	Gross Paddy Yields mt/ha	Production (Average 1976-79) mt	Type of Water Control	Land Preparation (source of power)	Harvest (source of power)	Use of: Improved Seeds	Use of: Fertilizer	Use of: Pesticides
Traditional flooded (Delta)	110,000[a]	0.50	55,000	Unimproved flooded	Oxen and manual	Manual	Yes	No	No
Controlled flooded (Polder, Segou)	35,000	1.5[b]	38,000[b]	Partially controlled flooded	Oxen	Manual	Yes	Little	No
Controlled flooded (Polder, Mopti)	16,074[a]	1.15	18,485	Partially controlled flooded	Oxen	Manual	Yes	Little	No
Gravity irrigation (Office du Niger)	40,000	2.5[c]	95,000[c]	Diversion dam	Oxen	Manual	Yes	Yes	No
Traditional swamp and rainfed	11,000	1.2	13,200	None	Manual	Manual	No	No	No
Improved swamp and flooded (Sikasso)	4,000	1.8	7,200	Small diversion dam	Oxen	Manual	Yes	No	No

Source: WARDA/SD/79/3 "Rice Policy in Mali (J. McIntire). Office du Niger, Bureau of Economic Affairs.

[a] 1976 data.

[b] Average 1974 through 1978.

[c] Data from the 1978-79 season, BAE, Office du Niger.

unique irrigation and drainage canal[5] and delimited by an earth dike retaining the floods along the river bank. With no capacity to fill the polder when floods are late, this system is still not free from the vagaries of the weather. Yields are known to be higher than the traditional system and vary from 1.2 to 1.5 mt per hectare. Animal traction is practiced but fertilizer use is limited.

The gravity irrigation system at the Office du Niger supplies 40 percent of the doemstic production of paddy in Mali and virtually 70 percent of the quantities of milled rice marketed through government channels. The basis of the system is a diversion dam at Markala, and a main canal serving two feeder canals. Although the Markala dam cannot store water, it raises the river's level and so provides full control of water to all the rice fields. The Office is a very extensive system with average holding of 9 to 10 hectares (in the recent past). Office settlers are more specialized in rice production than are rice farmers in the adjacent Operation Riz Segou. In some sectors of the O.N. rice yields can reach 2.5 mt per hectare and above.

The fourth production system is the rainfed/swamp cultivation encountered in southern Mali where rice is grown in rotation with maize, sorghum and peanuts, and where cotton remains the main cash crop. Improved variants of the system using fertilizer and animal traction are

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[5]The unique irrigation and drainage canal was recently built only for the Operation Riz Segou to allow some level of control of the floods toward greater security. In the past partial control systems of the Rice Operations were totally at the mercy of the level to which the rivers rise. This was clearly illustrated when Operation Riz Segou harvested only 21 percent of the area sown in the drought year of 1972-73 [CRED, 1976, pp. 9-10].

represented in the zones sponsored by the Operation Riz Pluvial and Riz de Bas Fond in the Sikasso region. Yields are reported to range from 1.5 to 1.8 mt per hectare.

Rice Policy and Role of the O.N.

Historically rice has remained for a long time the basis for the Government of Mali's cereals policy. In years of deficient cereal production as millet is unavailable on the world market and imported sorghum lacks the organoleptic qualities of locally produced sorghum, rice must then be imported to make up for the grain deficit [WARDA, 1977]. In 1974 as the drought was ending, the government's import of rice reached their maximum ever (71,000 mt of milled rice). But the main thrust of the government cereals policy is the maintenance of self-sufficiency, the increase in rural incomes and the improvement of the general level of nutrition of the population. This policy is mainly built on the incorrect assumption that rice is more nutritive than coarse cereals[6] and the argument that rice production in irrigated and and flooded zones is more reliable and secure against both subnormal rainfall and drought than is rainfed cultivation of coarse cereals.

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[6]This assumption is maintained in the "Bilan Ceralier", a June 1972 publication of the Ministry of Rural Development (Institut d'Economie Rurale). It is known objectively, however, that rice is not more nutritious than millet, at least in terms of grams of protein and fats per kilogram of grain. See FAO Food Comsumption Table for use in Africa, 1969, pp. 16-22. However consumer prices for rice are higher per thousand calories than consumer prices for sorghum and millet [Humphreys and Pearson, 1979]. This is consistent with rice's position as a preferred prestige cereal.

In fact in accordance with its second Five Year Plan (1974-78) the government of Mali has emphasized public investments and interventions to take advantage of the possibility of large scale, low-cost rice land development in the flood plains of the Niger and Bani rivers. This has been the orientation of the government in the last 5 to 6 years with increased investment in the Office du Niger's irrigated system and the empoldered Rice Operations at Segou and Mopti. Growth in global terms has been achieved more at the Office than in the other Rice projects, particularly because output from the latter depend to some degree upon the patterns of rainfall.

The Office du Niger has kept a leading role in Mali's rice production and marketing for more than 30 years. Table 1-5 compares relative performances and clearly demonstrates the contribution of the Office du Niger among major rice projects in Mali over the past decade.

Paddy production from the Office is shown to range from an average of 40 percent of the total Malian production during normal rainfall years to as high as 90 percent in drought years, when output from other major rice projects has failed. Official marketing of paddy appears to be drawn most entirely from the O.N. during bad years but it averages 65 percent in normal rainfall years. By the 1977-78 crop year, production targets set forth by the government for the O.N. in the framework of the Five Year Plan (1974-78) were already fully surpassed without much of the planned investments for infrastructure development being realized [O.N., 1980]. This is illustrated in Table 1-6. Thus yield

TABLE 1-5. Production, Yields and Marketing of Paddy at Major Rice Projects in Mali (1979-1980)

Year	Office du Niger			Operation Riz Segou			Operation Riz Mopti			Total Mali's Rice Subsector		
	Production (000 mt)	Yields (mt/ha)	Marketing (000 mt)	Production (000 mt)	Yields (mt/ha)	Marketing (000 mt)	Production (000 mt)	Yields (mt/ha)	Marketing (000 mt)	Production (000 mt)	Yields (mt/ha)	Marketing (000 mt)
1969-70	54.2	1.6	36.1	9.8	1.2	--	--	--	--	162	1.2	49.0
1970-71	69.7	1.7	38.1	n.a.	--	--	--	--	--	163	0.9	42.0
1971-72	69.6	1.8	46.3	18.6	--	--	7.8	--	--	195	1.2	51.0
1972-73	74.4	1.9	46.8	4.2	1.3	0.8	1.5	0.8	--	100	0.6	50.0
1973-74	83.1	2.1	54.8	8.1	1.5	3.1	3.7	0.9	--	90	0.5	57.0
1974-75	86.0	2.1	65.0	45.0	1.7	14.4	19.4	1.6	4.6	215	1.1	83.0
1975-76	90.0	2.2	63.8	55.7	1.7	20.9	18.4	1.4	8.0	260	1.2	93.0
1976-77	94.4	2.4	65.5	43.5	1.4	15.2	25.4	1.7	8.9	350	n.a.	93.0
1977-78	101.0	2.6	58.0	12.1	n.a.	4.5	n.a.	n.a.	n.a.	220	n.a.	66.4
1978-79	95.0	2.5	52.3	38.5	n.a.	8.1	n.a.	n.a.	n.a.	270	n.a.	62.7
1979-80	61.5	1.7	51.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: Office du Niger, Bureau of Economic Affairs; J. McIntire in WARDA/SD/79/3 1979, p. 18a; Marchés Tropicaux et Mediterranéens, December 1979; Operation Riz Segou, Annual Reports, various years.

TABLE 1-6. The Five Year Plan's Objectives and Actual Production of Paddy at the Office du Niger

	Plan's Targets		O.N. Achievements	
	Area (000 ha)	Production (000 mt)	Area (000 ha)	Production (000 mt)
1974-75	38.5	62.0	40.5	86.0
1975-76	38.5	66.0	39.9	90.0
1976-77	38.5	70.0	39.5	94.4
1977-78	43.0	85.0	37.9	101.0
1978-79	50.0	98.7	36.6	95.0

Source: Mimeo, O.N. Direction Générale, presented at the "Conférence Spéciale Consacrée aux Problèmes de l'Office du Niger," November 1979.

increases in the second half of the 70's allowed the O.N. to reach the Plan's targets with a smaller area under rice cultivation than planned.

The Office du Niger was instituted in 1932 as a French public enterprise with a mandate to carry out development work and a socio-economic organization centered around the settling of independent farmers for the production of irrigated rice and cotton on a large-scale. It is the only agricultural undertaking in Mali that has not been affected by the drought of the early 70's, thus passing a crucial test of its importance to the Malian economy. When compared to other major rice projects in Mali the Office also has the advantage that its main capital costs are sunk, which places it in a relatively better position in terms of net social profitability from the nation standpoint.[7] It is partly for this reason that aid donors are now willing to invest in the rehabilitation program now underway at the Office.

Having proved its mettle the Office current policy is to consolidate the existing infrastructure before embarking on any expansion of the cultivated area. This is the phase of intensification which is evolving in four main directions: (1) redesigning the irrigation system to conform it with an adequate levelling of fields; (2) rehabilitating the drainage network badly affected by lack of maintenance; (3) the eradication of

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[7]A number of WARDA recent studies have shown the current technique at the O.N. to have the highest net social profitability of the rice production techniques considered for Mali. When costs are adjusted for expected adoption of improved practices, the Office system still ranks second after the expected intensified technique for Operation Riz Segou. For more details on net private and social profitability among different techniques in Mali, see WARDA/FRI, Stanford, September 1977 and more recently, S. R. Pearson, J. D. Stryker, C. P. Humphreys and others in Rice in West Africa: Policy and Economics, Stanford University Press, 1981.

weed infestation; and (4) reducing the size of holdings from the 1976 average of 10 hectares per settler to about 6.5 hectares [WARDA, 1977]. Yield improvement being the ultimate goal of the program, the Office will have to make maximum use of the knowledge gained in all domains in order to avoid the mistakes and hitches of the past. This study was to provide for the first time a detailed account of the economics of farm production at the Office du Niger.

1.3 Problem Setting and Need for the Study

Everyone familiar with the checkered history of the Office du Niger would agree that the output it achieves today is disproportionately low given the capital investments and the amount of experience accumulated over nearly 50 years of trial and error. The irrigation/drainage infrastructure which had been designed with a view to the development of 960,000 hectares today irrigates less than 50,000 hectares [O.N., 1963].[8] The administration, which includes currently some 3,800 employees is also disproportionate to the output generated and the active agricultural population which it is responsible for serving. As de Wilde [1967] comments:

> "It is perhaps this disproportion between the original goal and the actual accomplishment that provides the fundamental explanation of the great instability in the policy of the Office and its unsatisfied search for a technical, economic and human equilibrium" (pp. 246-7).

Attempts have been made in the past to alleviate technical deficiencies. For instance the construction of the Markala dam terminated in

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[8] The source of the information is "Historique de l'Office du Niger," mimeo prepared by Mr. Djibril Aw for a training course for the benefit of the extension personnel of the O.N., 1963.

1947, provided the scheme with full water control to all the rice fields, some as far as 200 km from Markala. Intensification of some agricultural practices was introduced in the late 50's. For rice this meant switching from direct sowing to transplanting of seedlings grown in nurseries [de Wilde, 1967]. For cotton, then a major cash crop, intensified practices included the use of improved varieties, fertilizer and pesticides, improvement of drainage and irrigation etc.

In general past intensification campaigns enjoyed only a modest measure of success mostly because farmers in attempting to intensify both rice and cotton cultivations encountered serious labor bottlenecks [de Wilde, op. cit]. It is believed that the shortage of labor prevented the scheme from reaching its historic target of several hundred thousands of hectares of developed land. It was the shortage of labor that also motivated the Office management to embark on mechanization of some agricultural operations and particularly the preparation and levelling of land, and the use of subsoiling techniques. Above all, however, it is the lack of primary data on the socio-economics of farming practices of the settlers that has constrained the O.N. in its search for an economic equilibrium. Since labor remains the basic limitation to increased production, it is the output in terms of returns to labor which must be maximized. Any choice of techniques therefore must be determined in the light of this goal.

In January 1978 the West Africa Rice Development Association (WARDA) honored a long standing request by the Office to examine the collection and analysis of agricultural statistics by its Bureau of Economic Affairs [WARDA, 1978]. The mission also came about as the Office began the preparatory phase of the intensification program which is to involve land levelling and drainage works, rehabilitation of the irrigation works as well as adoption of improved crop husbandry practices. WARDA then proposed that socio-economic studies be conducted to fill in some important gaps in the present knowledge base in the Office. The agro-economic survey conducted by this author from November 1978 until April 80 at the Office du Niger was the first of such studies[9] and constituted an integral part of the preliminary phase of the intensification program.[10] Specifically the study was to provide information and supplement the data necessary for the analysis of three main problem areas identified by the WARDA mission: (1) the problem of undercapitalization of some settlers and the steps needed to improve their plight; (2) the problem of determination of the quantity and the distribution of labor use by current settlers; and (3) the problem of field and storage losses [WARDA, 1978].

1. Under-capitalization of Settlers

Although the problem refers to underequipment[11] of some settlers, it also touches the whole issue of farmers' capital asset structure, for instance its acquisition and replenishment. It was felt that a proper

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[9] A second study by the Institut d'Economie Rurale of the Ministry of Agriculture and Rural Development began in June 1980; it was to be mainly qualitative and to address the socio-economic and motivational aspects of farming in the O.N. settlement.

[10] The intensification program itself was the result of a WARDA identification Mission requested by the Malian Ministry of Agriculture and Rural Development in 1974.

[11] The term describes any state of equipment endowment below what is considered at the Office as a minimum requirement i.e. a pair of oxen, a plow and a harrow.

assessment of the current situation would help in proposing ways of improvement to the benefit of both the Office and its settlers. The 1975-76 records of the O.N. showed that 18 percent of the farmers had one or no oxen. By 1978-79 prior to the beginning of this study, this ratio had reached 21 percent according to the Office annual report.

2. Determination of Labor Use and its Seasonality

As no accurate estimates of labor use and its seasonal distribution has ever been made, it was essential that this study lay stress on that important aspect, particularly in view of the fact that the Office is embarking on an intensification program aimed at consolidating its present infrastructure and raising yields to about 4 mt per hectare with a reduced average holding per settler. An early study by WARDA in 1977 had shown that for such levels of yield to be achieved, labor demand per hectare would have to increase by approximately 70 percent.[12] Will households be able to supply the additional labor at the time needed i.e. is there any utilized pool of labor that households could draw on or will they have to reduce output of other crops[13] and squeeze out their involvement in off-farm occupations? If so at what costs? Specific answers to such questions require first, an assessment of the existing use of family and hired labor and second, an attempt to portray future likely changes.

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[12]The WARDA report however does not show explicitly the underlying assumptions.

[13]For instance cultivation of dryland crops such as millet, sorghum and maize on small plots or vegetable growing.

The problem of field and storage losses was recognized as one that also should be looked into given that losses have been reported substantia at some time. The results of the post harvest survey have already been made available under a separate publication.[14]

Answering the first two problem areas discussed above was to be part of a much broader set of objectives proposed for this study as spelled out in the next section.

1.4 Objectives of the Study

The specific objectives of this study are to:

1) describe the socio-economic conditions of rice production at the Office du Niger.
2) estimate the income and expenditures of the settlers over the course of a year and compute the real cost of producing paddy in the Office du Niger on the basis of the current level of resource utilization in the settlement.
3) estimate the total quantity of labor used on farms, its seasonal distribution and allocation of labor to farm and non-farm activities.
4) develop models of rice farming that could increase farm income using improved technologies.
5) study the economics of undercapitilization of Office settlers and the issues of risk.

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[14]See WARDA Occasional Paper No. 5, by Kamuanga and Spencer (January 1981).

6) discuss policy implications for the Office du Niger and the government of Mali.

A description of the Office du Niger both as an enterprise and a settlement of rice contract-farmers is given in Chapter 2. The research approach and data collection procedures used to fulfill the above objectives are presented in Chapter 3. Analysis of the survey data is carried out in Chapter 4 through 8 and policy implications are discussed in Chapter 9.

CHAPTER 2

THE OFFICE DU NIGER: ORGANIZATION AND SITUATIONAL ANALYSIS

2.1 Introduction: A Historical Perspective

The intriguing history of the Office du Niger goes back to 1918 when a French Mission noted the failure of dryland cotton cultivation in northern Mali and concluded that flood waters from the Middle Niger Basin were remarkably suited for the irrigation of cotton [de Wilde, 1967]. The success of pilot projects in the 1920's on the basis of experiences with family and wage labor led the French government to approve a program for the general development of the Middle Niger Basin (Figure 2.1). On January 5, 1932 the Office du Niger was created as a public enterprise with the mandate to carry out development work and settle villagers in order to undertake irrigated agriculture. Rice was to be their subsistence crop and cotton their cash crop. The latter was mostly needed to supply France's own embattled cotton industry after World War I.

There is no need to repeat here much of the narrative found in various publications concerning the history of the Office until 1960.[1] We shall only highlight certain aspects of the failure to achieve the development that was originally expected and summarize where the Office found itself in the sixties and in the seventies.

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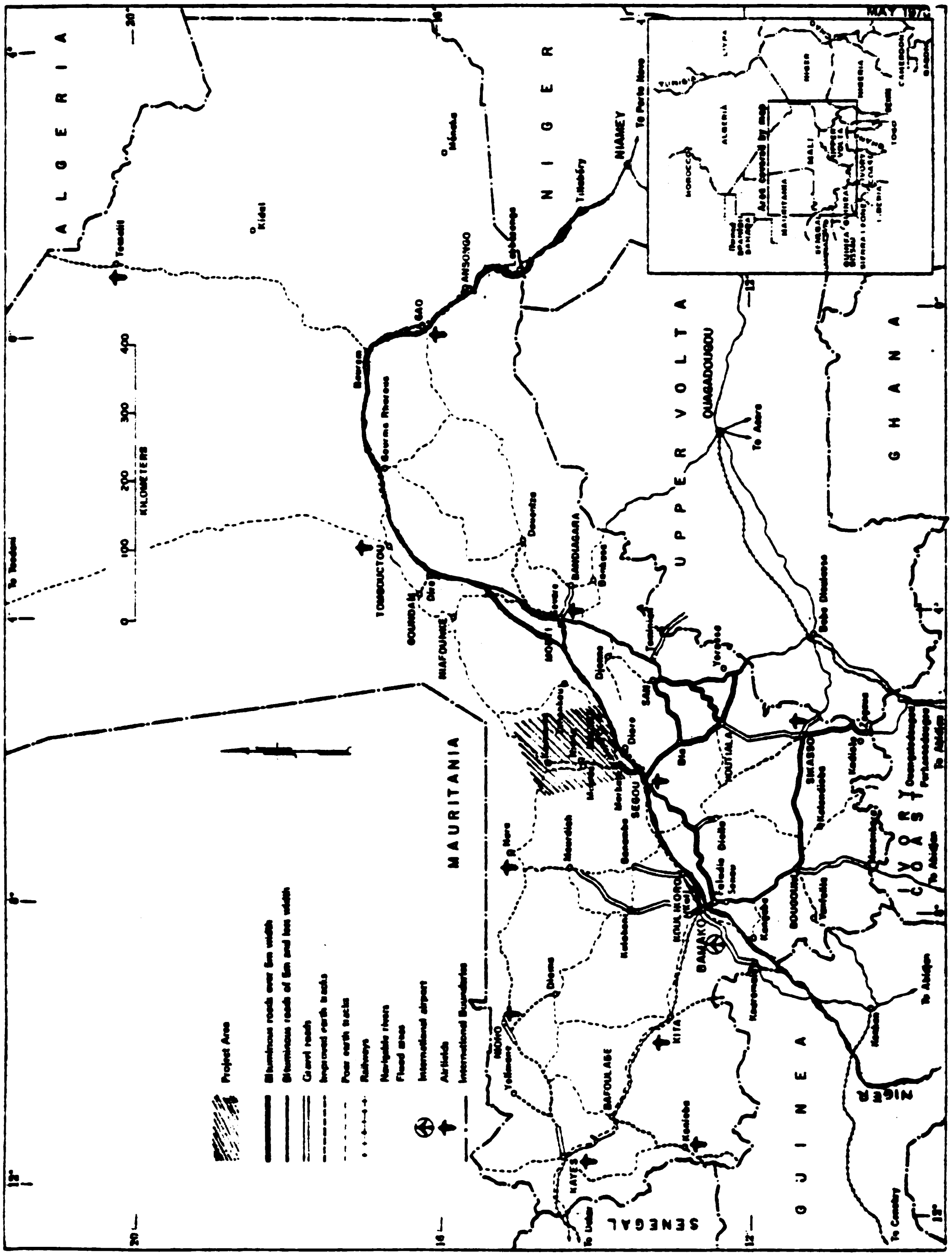
[1]For further information see Guillaume [1960], de Wilde [1967], Jones [1967] and a series of <u>Notice Historique</u> documents available from the O.N.



Office du Niger: Project Area Location

FIGURE 2-1

The Office du Niger in the 1960's

From the beginning the Office has been concerned with both the development of land for irrigation and the settlement of the population that could undertake the necessary farm work. By 1961 the O.N. comprised more than 45,000 hectares of irrigated land on which a population of 37,000 persons produced 41,000 tons of paddy and 7,000 tons of seedcotton. That year the administration until then in the hands of the French, was turned over to the government of Mali.

Until the end of the 60's the Office as an enterprise, however, has never been capable of amortizing or earning a return on the public capital invested in it, which in terms of CFA francs of constant value amounted in 1960 to about 44 billion (or $175 million) [de Wilde, op. cit.]. When Malians took over the administration of the scheme in 1961 the operating deficit amounted to 276,383,000 CFA francs.[2] Still the government embarked the Office on an ambitious expansion program within the framework of the first Five Year Plan (1961-66) targeted at 87,000 tons of paddy and 30,000 tons of seedcotton [O.N., 1979]. However, the difficulty in recruiting new settlers in the early sixties restricted the labor supply at a time when a massive exodus (the second) of settlers of Voltaic origin was

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[2] The source of information is a mimeo by the Direction Génerale presented at the "Conférence Spéciale Consacreé aud Problèmes de l'Office du Niger" November 1979. The deficit was broken down as follows: 142,381,000 CFA francs in the Agricultural sector (rice and cotton), 127,487,000 CFA francs from marketing activities and 6,515,000 CFA francs from the industrial and associated activities.

underway, particularly in the Kolongo sector. This prompted the O.N. management to proceed with direct farming using wage labor on large scale in order to attain the plan production objectives.[3] As shown in Table 2.1 and 2.2 however, the decline in production of both rice and cotton went hand in hand with the decline of the population, but was also precipitated by a substantial reduction of the number of agricultural equipment owned by farmers.[4] By 1969 there were 26 percent fewer work oxen, 18 percent fewer plows and 20 percent fewer harrows in the settlement. Only the number of carts seemed to have increased slightly.

The Seventies

The new decade practically began in 1969 and saw drastic changes in the orientation and objectives of the O.N. As a result of drainage problems cotton cultivation was suspended and its land converted to rice. The move also prompted the Office management to reduce the size of its administration to some 1,700 employees.[5]

Direct farming using wage labor was still practiced on 42 percent of the rice land and contributed 48 percent to the Office rice output. Although this type of farming had shown in the past relatively better

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[3]The approach even received more impetus because it was in accordance with the desire of the socialist government then in power to demonstrate the efficiency and superiority of collective farming as an instrument of both modernity and progress [Jones, 1967, p. 306].

[4]Much of the drop in the density of farm equipment was due to smuggling consequent to the departure of Voltaic nationals and desertion of some Malian farmers.

[5]The number of employees increased again with expansion of rice and sugar production, over much of the 1970's.

TABLE 2-1. Population and Production Trends at the O.N. 1961-1980

Year[a]	Developed Land (ha)	Settled Population: Total	Settled Population: Number of Households	Rice Cultivation: Area (ha)	Rice Cultivation: Production (000 mt)	Cotton Cultivation: Area (ha)	Cotton Cultivation: Production (000 mt)	Sugar Cane: Area[d] (ha)	Sugar Cane: Cane Production (000 mt)	Sugar Cane: Sugar (000 mt)
1961	44,500	38,321	n.a.	29,437	36.5	5,679	5.1			
1962		37,210	--	27,423	23.5	6,817	6.9			
1963		37,348	--	22,900	23.0	7,377	7.7			
1964	53,260	35,022	--	29,306	26.8	7,381	9.4			
1965		33,467	--	28,271	22.4	5,481	6.4			
1966		33,370	--	27,713	24.2	5,404	2.3			
1967[b]		31,210	--	28,636	25.8	4,191	6.2	42	1.3	0.08
1968		30,873	--	29,369	30.9	4,015	2.7	495	24.8	2.6
1969		29,802	3,235	29,898	46.0	3,218	4.0	768	49.7	4.6
1970[c]		30,356	3,209	32,826	54.2	--	--	943	55.2	n.a.
1971		33,302	3,357	39,839	69.7			1,117	60.5	n.a.
1972		34,435	3,381	38,533	69.6			902	52.3	n.a.
1973		35,092	3,392	37,626	74.4			1,026	47.2	n.a.
1974		38,970	3,672	40,139	83.1			939	61.5	n.a.
1975		44,363	4,153	40,774	86.0			1,151	52.7	n.a.
1976		47,460	4,367	39,916	90.0			933	50.5	n.a.
1977	53,260	49,624	4,542	39,567	94.4			1,066	46.7	n.a.
1978		51,052	4,751	37,746	101.0			2,759	207.7	n.a.
1979		52,529	4,863	36,557	95.0			2,735	214.9	18.9
1980		54,110	4,985	36,485	61.5			2,975	228.3	18.1

Source: O.N. Bureau of Economic Affairs.

[a] Ending year of the crop season.

[b] Sugar cane enters into production.

[c] Cotton production is suspended in that year.

[d] Harvested area only.

n.a.: non available.

TABLE 2-2. Agricultural Equipment of the Settlers (in units)
Situation in 1961, 1969 and 1979

Year	Work Oxen	Plows	Harrows	Carts	Population of Settlers
1960-61	10,144	4,453	1,475	1,126	38,321
1968-69	7,501	3,655	1,185	1,136	29,802
1978-79	15,680	6,790	4,538	2,761	52,529

Source: O.N. Bureau of Economic Affairs.

results for rice than for cotton, inadequate supply of labor kept increasing recurrent costs of production, already high given the degree of mechanization required. As years of "good money after bad money" failed to improve the overall performance of direct farming, the area planted to rice under this system was gradually brought down.[6] In 1978-79 only 2 percent of the rice land (600 hectares) were directly farmed this time for seeds development and multiplication purposes.

Although raising yields was the driving motivation in the 1970's, the Office was still facing three fundamental problems. First, the irrigation system was designed on the basis of inadequate data which has made it difficult to level fields and irrigate properly. Second, drainage problems exist because of the lack of maintenance of secondary and tertiary level drainage canals. In fact, as stipulated in the contract, farmers are required to maintain terminal supply channels and drains, or, alternatively, to pay for having this work done by the Office. Often they do neither. In the sector of Kolongo for instance many canals are sanded up and embankments have caved in, a situation which led to the abandonment of some 5,000 hectares. Third, weed infestation is another big problem, particularly in the case of Kolongo where the growth of rhizomatous wild rice (Oryza longistaminata) seriously affects yield.

In light of these continuing problems the Office management has been adhering to a policy of consolidating the existing network before embarking in new expansions.

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[6]But this also came as a result of the decision by the new government in power since 1968 to abrogate any form of collective farming.

2.2 The Physical Environment

1. Climate, Soils and Topography

The climate in the Office du Niger zone is typical of the Sudano-Sahelian savannah with rainfall averaging 600 mm per year, 95 percent of it concentrated within the three months of July through September. Monthly average temperatures range from 26 to 35°c, but a maximum as high as 45°c has been recorded in the past. Evaporation measured in a Colorado Tank is estimated at 3,000 mm a year, higher than rainfall each month, thus making irrigation a necessity, [WARDA, 1977].

Soils in the O.N. area are alluvial and very deep. Their morphology varies from very sandy to nearly pure clay deposits. But sandy and hydromorphic soils have always been excluded from land development in the area. With very low levels of organic matter (0.4 to 2 percent), nirtogen content is the most important factor limiting yield across all type of soils. The Office soils are also characterized by a low level of phosphorus content (0.01 to 0.05 percent) [WARDA, op. cit.].

Irrigation by gravity in the O.N. area has been possible because of a slope gradient of 5 to 10 centimeters per kilometer in the whole Central Niger Delta. However, the micro relief is very uneven in many places and on swelling clay soils, recurrent shrinkage cracks due to overdrying can cause landslips, thus necessitating continual maintenance works if the quality of the installations is to be preserved.

2. The Irrigation Infrastructure

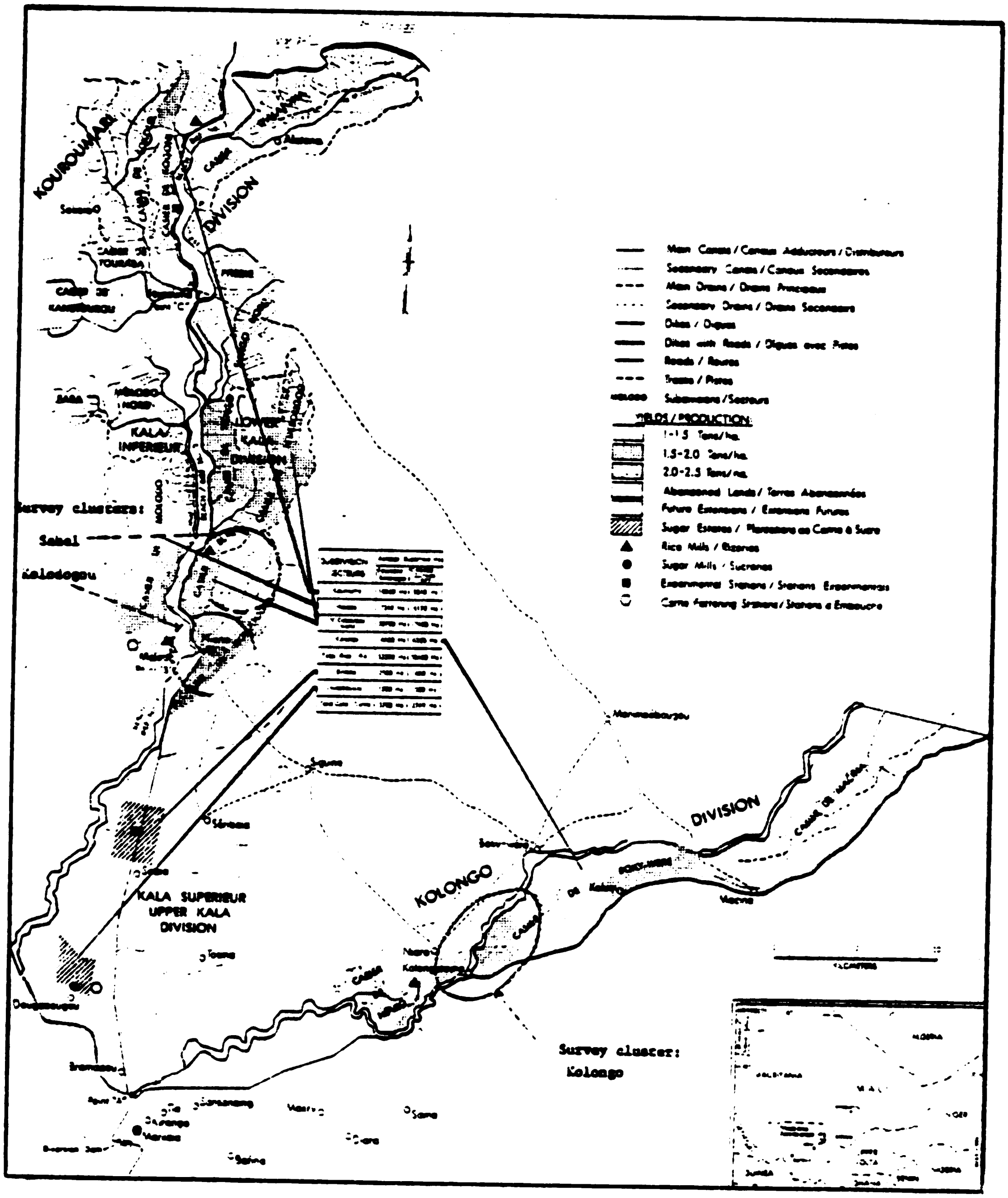
The infrastructure now in palce at the Office is more than 40 years old. Some hydraulic works are still in good shape, others however need major repairs or even new designs to carry out production at acceptable level. The main infrastructure comprises: (1) a dam at Markala on the Niger River, about 250 kilometers downstream from Bamako; (2) an 8 kilometer addictor canal that pours into two feeder canals (Macina and Sahel) totaling 235 kilometers. The feeders are extended through the bed of an ancient floor drain of the Niger (Fala de Boky-Weré) to the south and a natural depression of the Lower Kala near Niono center Fala de Molodo) to the north (Figure 2-2). In addition the Office had a network of dirt roads totaling 350 km, some are national roads.

The basic irrigation infrastructure described above is the property of the government of Mali. The Office as an enterprise owns only the network of secondary and third level canals and drains. As of 1979 the total irrigation/drainage network was 5972 kilometer long, distributed as shown in Table 2-3 below.

TABLE 2-3. Size Distribution of Water Canals at the O.N. (in kilometers)

Type	Supply channel	Drainage
primary	246	329
secondary	483	551
tertiary	2190	2173
Total	2919	3053

Source: Office du Niger, Bureau des Etudes Générales.



Office du Niger Irrigation Scheme

FIGURE 2-2

Water supply depends in the first place on the output of the Niger River at Markala estimated at 4,000 to 5,000 cubic meters in September and only 70 to 130 cubic meters in May. The actual output at the entrance of the feeder canals, however, is conditioned by the state of maintenance of the dam. Silting at the entrance (Point A) of the main canals is known to limit supply particularly in period of low tide. The supply at the fields' level is also known to be below the maximum achievable as many laterals are overgrown with weeds and some have silted in considerably. There is a substantial difference between developed lands along the two main canals. Initial land development was done along the Macina Canal which now irrigates rice fields for the two sectors of Kolongo and Kokry. Hydraulic works were superficially installed and the zone is invaded by rhizomatous rice. The yield potential is much lower than that of the other sectors (average 1 to 1.2 mt). Along the Sahel Canal which was prolonged beyond Niono for the creation of the Kourouma sector in 1952, land is more fertile, the irrigation structures and weed infestation cause relatively less problems. Yields of up to 3 mt per hectare have been reported in some years.

2.3 Organization of the Office Du Niger

Figure 2-3 depicts the administrative organization of the Office du Niger. The chart shows that the Office is not simply a service responsible for public works and settlement, rather it is an enterprise with a comprehensive jurisdiction extending to commercial as well as administrative and agricultural questions. Seven departments (or Services) and 3 special Bureaus coordinate the organization of

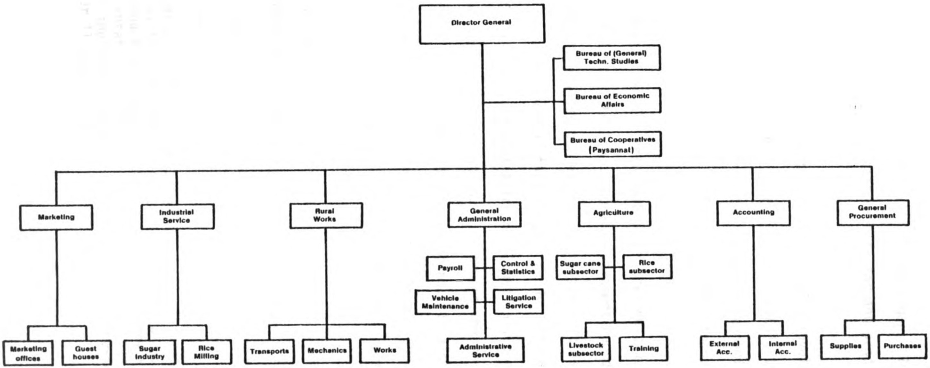


Figure 2.3 Office du Niger Administrative Organization

production, milling and marketing of rice and sugar. The Office also runs a 2,000 head feedlot for cattle fattening and produce citrus for local markets.

However, only three departments are actually involved with production matters: the <u>Bureau des Etudes Générales</u> (BEG), the agricultural department (<u>Service Agricole</u>) and the Bureau of Economic Affairs (BAE). The BEG conceives and executes engineering works (topographic, hydraulic and cartographic) needed for the construction of production infrastructures. The Bureau is also responsible for the construction of houses for Office settlers. The Agricultural department coordinates production activities and supervises the extension service. It is also in control of harvesting and mechanical threshing of paddy. The Bureau of Economic Affairs collects statistics on industrial, commercial and agricultural production activities. It remains the only place where any statistical data on the O.N. can be found. It also estimates costs of works undertaken by the department of works and supplements the work of the Accounting department. The organizational chart of the BAE is shown in Figure 2-4.

The current statutes of the O.N. particularly its obligations to the government were still being discussed in 1980.[7] Historically the Office has been more or less sovereign within its territorial limits.

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[7]A special Conference on the problems of the Office du Niger, sponsored by the President of Mail was held in November 1979 at Segou headquarters. Among other issues debated were the question of future orientation of the O.N. and the adoption of its new statutes, in view of the fact that Mali was returning to a "normal constitutional life" after 11 years of military rule.

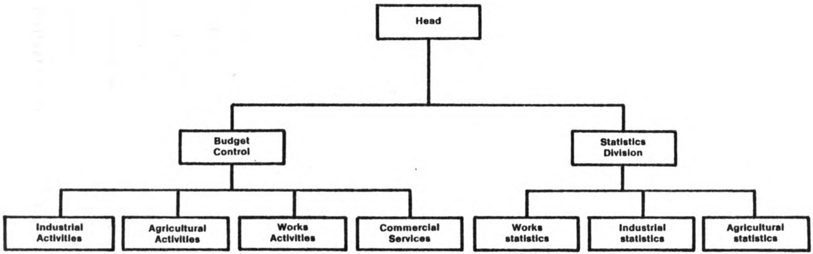

Figure 2.4 Organizational Chart of the O.N. Bureau of Economic Affairs.

It has integrated economic and social activities and performed as a public autonomous enterprise with the responsibility to achieve profitable operations and, at the same time, satisfy the social needs of a large farming population entrusted to its administration.

2.4 The Settlement Policy and the Structure of Farm Production of Rice

1. The Settlement Contract

The idea of settling independent farmers has been an important part of the French colonial doctrine for rural development before the O.N. was established [Jones, 1976]. In the 1920's experiences with both family and wage labor had shown the advantages of having the developed land assigned to tenant farmers who would face the risks and reap the benefits of their work after payment of a fee for services rendered to them. However with forced labor laws then a part of the colonial institution over much of Africa, the decision to settle on the Office land has not always been that of the colonists themselves [Magasa, 1978; Zahan, 1963]. Forced recruitment practices were abolished and a liberal policy was introduced since 1952.

At present the Office processes applications from prospective settlers at a rate of about 3,000 a year during the last 5 years or so.[8] Of the more than 3,000 admission requests processed in 1978-79 only 350 were retained. In fact an admission rate of 15 percent seems to have been maintained in recent years.

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[8]Personal communication from the Bureau de Paysannat, 1979.

As delay in the delivery of farm equipment is common, the Office usually proceeds with land plowing and sowing for the farmer during his first year on the settlement. The head of the household (usually referred to as the colonist) is also entitled to foodstuffs for the nourishment of his family before the first harvest. Although the norm used in allocating land to incoming settlers has changed over time, it has been maintained at 2 to 3 ha per working man in recent years. The first statutes of the O.N. provided that the colonists should become the owners of their land after ten years' cultivation. This clause was never applied and indeed was later repealed [WARDA, 1977]. At present, the settler has a cultivation right that is transferable by inheritance. Still this right can be withdrawn if he makes bad use of the land or if he does not abide by the obligations imposed by the Office administration. Major contract obligations between the Office and its settlers are spelled out below.

Office du Niger	Colonist
1. To supply irrigation water	1. To cultivate the land allocated to him
2. To repair and maintain primary and secondary level canals for irrigation and drainage	2. To abide by the O.N. recommended agricultural practices
3. To supply fertilizer and improved seeds	3. To maintain field level supply and drainage canals
4. To provide mechanical threshing of the rice harvest	4. To deliver the harvest entirely to the Office management after allowances for home consumption and seeds
5. To provide extension services	5. To pay in kind a fee of 400 kg of paddy per hectare as participation in amortization, upkeep of the infrastructure and supervision

Source: O.N. Bureau de Paysannat.

2. The Settlement Population

Table 2-4 depicts the number of farm families by sector in 1979. The 1979-80 O.N. records indicate a population of 54,110 people in 4,985 farm families. This is an all time peak which supports an ever increasing trend since the early 40's despite two successive waves of departures in the late 40's and early 60's. For the last 20 years however, the attractiveness of the Office settlement has suffered from an emergence of opportunities elsewhere in Mali. The most conspicuous of these has been the rapid development of profitable cotton growing in the dryland farming area now sponsored by the Companie Malienne de Developpement de Textiles (CMDT) [de Wilde, 1967]. In the late 60's and early 70's the development of empoldered rice cultivation on the Niger Valley at comparatively modest cost constituted another setback.

TABLE 2-4. Number of Farm Families by Sector at the O.N.

Sectors	Number of Families
Niono	611
Sahel	305
Molodo	718
N'Debougou	1,032
N-Dogofry	590
Kourouma	589
Kolongo	479
Kokry	390
Total 1978-79	4,714
1979-80	4,985

Source: O.N. Annual report 1978-79; O.N. Service Agricole, Annual Report 1979-80.

An overall average rate of growth of about 2 percent per year since 1961 is implied in the trend depicted early in Table 2-1. The highest rate of growth in the 70's (nearly 8 percent) is attributed to two main reasons: first, the discontinuance of cotton cultivation and suppression of direct farming turned many full-time wage laborers into rice farmers as colonists. Second, the Sahelian drought demonstrated the vulnerability of empoldered rice cultivation and the impredictable nature of harvest in dryland farming. These factors increased the number of applications for settling in the Office du Niger.

As to the origin of settlers, recent statistics at the Office show that 62 percent of the colonists come from the 4th Region (Segou) and 18 percent originate from the Sikasso Region. Voltaic nationals currently make up only 16 percent of the Kolongo sector population. Major ethnic groups are Bambara (42 percent), Minianka (21 percent), Mossi and Samogo (12 percent) and 24 percent originate from different minor ethnic groups. About 60 percent of the colonists have between 10 and 40 years of settlement. This seems to indicate that many farmers have a long lived tradition of cultivating rice and have accumulated a considerable amount of experience.

3. Characteristics of the Farming Unit

Family and Rice Farm Size

The average family has 9 people although the range is known to extend from 1 to 30 people or more.[9] The actual mode of the distribu-

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[9]For instance, one of our selected households had 48 members. The family was made up of 5 distinct heads of household living within the same compound. Only the oldest member was registered as the colonist.

tion is 7 members per household. Recent O.N. statistics show that the average size of the active population (age 8 to 55) is 7.3 per household with a spread of 0 to 20 and a mode of 4. The Office uses the number of working men (W.M.) as an indication of the potential labor force available in the family. In 1979 there were 2.5 W.M. per family on the average, with a spread of 0 to 5 and a modal value of 2.

The average farm size at the O.N. has been steadily moved down from 10.5 hectares in 1975-76 to nearly 7.0 hectares in 1979-80. The reduction is due to a 7 percent drop in total area planted to rice in conformity with the current policy of consolidating the existing infrastructure. However, abandonment of some 5,000 ha of improved land in Kolongo for defective drainage and weed infestation also contributed to lowering the Office average holding size. The size distribution of rice farms during the 1979-80 season is given in Table 2-5.

TABLE 2-5. Size Distribution of Rice Farms at the O.N. (1979-80)

Size of farms (ha)	Number of farms	Percentage of total
less than 5	1246	25
5 - 10	2542	51
10 - 15	748	15
over 15	449	9
Total	4985	100

Source: O.N. Bureau of Economic Affairs.

Thus 76 percent of farmers have holdings of less than 10 hectares. However this overall distribution of frequencies conceals a wide disproportion in the total amount of land by stratum. For instance, the group with holdings above 15 hectares occupy 25 percent of total cultivated land. This is in part attributable to the O.N. land allocation policy whereby large families obtain holdings of size proportionate to the number of working men available. In recent years, however, the Office managemnt has agreed to allocate land to a limited number of its employees, private traders and agencies. All of them are absentee settlers and some have holdings as large as 80 ha where the work is performed by wage laborers.

Farm Equipment

All incoming settlers are provided a pair of oxen, a plow and a harrow for a three year repayment schedule.[10] In general the loan is interest free. This initial endowment of farm equipment remains the same for all settlers regardless of the number of hectares of rice land they are allocated. Many settlers increase the size of their equipment lot on their own, either by directly purchasing additional equipment in local markets or as is sometimes the case for oxen, by raising and training young steers. The Office may provide additional farm equipment or even re-equip some settlers on credit; the conditions under which such allotments are made are not specified.

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[10] In recent years the Office management seems to require that new settlers be equipped on their own before joining the scheme. However, no written rules exist on the matter and its enforcement has been difficult.

As of 1979-80 the density of equipment in the settlement was evaluated as follows: one pair of oxen per 4.5 hectares, one plow per 5.2 hectares, one harrow per 7.0 hectares and one donkey-trailed cart per 14 hectares [O.N., BAE, 1979]. The positive correlation known to exist between the density of equipment[11] and average rice yields has been empirically established at the O.N. both in cross section and time series data. This point will be emphasized later in Chapter 8. In 1978, 21 percent of the settlers had one or no oxen at all.

4. Organization of Production at the Farm Level

Cultivation Practices

With direct farming reduced to 600 hectares for seeds development and multiplication, more than 95 percent of the rice output is produced on settlers' fields. A typical crop calendar for rice is shown in Table 2-6.

Many activities are staggered over time and across the entire physical area of the Office. Field work begins in April with a shallow pre-irrigation to permit plowing before the first usable rains arrive in late May. Plowing, broadcast seeding and harrowing are done throughout May and June, and sometimes as late as the first week of August. Hand and hoe weeding are done in July and August. Fertilizer is used on roughly 50 percent of the rice land and recommended rates per hectare are respectively 50 kg of urea, 50 kg of ammonium phosphate

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[11] The density is sometimes expressed in terms of number of pair of oxen, number of plows and number of harrows per farm unit. In 1979, the average farm owned 1.6 pair of oxen, 1.40 plow and 1.6 harrow.

TABLE 2-6. O.N. Crop Calendar for Rice

Field Activities	Date	
	Earliest	Latest
First shallow pre-irrigation	April 1	May 15
First plowing	April 30	June 5
Second pre-irrigation	May 1	June 15
Second plowing	May 15	June 30
First harrowing, sowing and second harrowing[a]	May 20	June 30
Shallow field inundation[b]	May 21	June 30
Second inundation[c]	May 31	July 15
Hoe weeding	June 15	July 31
Hand weeding	June 15	October 31
Fertilizer application (mineral)	June 20	October 31
Deep and final inundation	July 10-15	August 31
Draining of fields	October 25	December 15
Harvesting (cutting and binding)	November 5	January 5
Stacking	December 10	March 10
Mechanical threshing	December 20	March 31
Paddy collection and transport	December 20	June 30

Source: O.N. Service Agricole.

[a]For effective seeds burial.

[b]To allow for initial plant sprouting.

[c]To provide maintenance water.

and 200 kg of Tilemsi phosphate.[12] One application of 25 kg of urea and 50 kg of phosphate is required at the time of tillering, a second application of urea has to be made after plant heading. Fields are inundated in mid-August and drained after the first of November. Harvesting is manual and done with sickles; it begins in late November but may continue as late as the end of January. The Office threshes more than 80 percent of the paddy mechanically with stationary threshers, using its own machine and crews of hired labor. The farmer is charged 120 kg of paddy per metric ton threshed. About one fifth of the harvest is manually threshed by settlers and household members.

Rice Fields in "hors casier" (H.C.)

A number of settlers privately cultivate some additional plots of paddy outside the legal holdings conceded to them by the Office. These illegal fields known as "hors casiers"[13] are irrigated by deviating the water stream from drainage canals, or through leaks from earth dikes that are part of the supply channel structures. In any case the colonist uses the enterprise's means of production for a clandestine activity to evade payment of land fees.[14]

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[12]This is a rock phosphate domestically produced and used as build up fertilizer. It is not always required, but is considered as part of the recommended package given the sandy nature of some soils.

[13]By contrast, with fields in "casier" or legally cultivated. Casier is the French word commonly used to describe a unit of crop land delimited by a network of main irrigation/drainage canals in a specified area.

[14]However when discovered the Office management charges an amount of 240 kg of paddy per hectare. Many H.C. fields are in fact hidden and some are inaccessible to extension agents.

The total area planted in H.C. has never been estimated with accuracy, partly for reason of survey costs involved. The O.N. own estimates in 1979-80 for the area under H.C. were 2,958 hectares.[15] It is believed that twice as much land may be devoted to that activity. Much of the Office concern for farmers' involvement in H.C. springs from the foreseeable competition in the utilization of family labor between the two types of holdings. This issue will be treated at some length in Chapter 5.

Stock Raising on Farms

The majority of settlers keep a number of productive animals on farms for production of meat, dairy and poultry products, for speculative reproduction and sale, and quite commonly also for tradition. Stock raising is also viewed by farmers as a means of capital accumulation and an insurance against crop failure. The relative importance of productive versus draft animals present in the settlement is depicted in Table 2-7. Calculation of density reveals that there were 3.2 draft animals and 3.5 productive animals per farm in 1977 compared to 3.9 and 3.6 respectively in 1980. For draft animals, this increase reflects a sustained demand for farm equipment which has characterized much of the post drought period. For productive animals, stock densities have increased partly in response to the development of market opportunities in neighboring countries.

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[15]The source is O.N., annual report 1979-80.

[16]Office du Niger: Feasibility study (non-dated) p. 34.

TABLE 2-7. Productive and Draft Animals Kept on Farms at the O.N. in 1977 and 1980

	1977	1980
Draft animals		
Oxen	11,071	16,013
Donkeys	2,810	3,159
Horses	82	78
Total	13,963	19,250
Productive animals[a]		
Cattle: cows	6,381	7,832
heifers and bulls	4,611	5,093
Sheep and goats	4,421	5,148
Total	15,413	18,073

Source: O.N. Bureau of Economic Affairs.

[a]Excluding poultry.

Other Agri -Activities, Off-farm Occupations and Incomes

In addition to rice and livestock, farmers in the Office derive extra income from the cultivation of garden plots for vegetable and the planting of millet/sorghum in small plots, in this case often outside the O.N. zone. In a 1974-75 survey made by the Office[16] it was found that settlers' revenues from non rice and livestock activities amounted to 22 percent of the revenue from rice production. Nothing is still known on revenues they derive from non-agricultural activities.

The Structure of the Household Decision Making

Rice production takes place under the sole authority and responsibility of the senior head of household known as the colonist. He is generally the father, the uncle or the eldest brother of all members of the extended family. The decision making process in the Office settlement follows the traditional pattern of family interrelationships known to exist elsewhere in rural Mali.[17] In a typical traditional farming system production choices as a result of the extended family concept are determined by status within the family. For instance young bachelors may be involved in cash crop production such as peanuts and dependent heads of households may combine food and cash crop production on plots allocated to them by the head of the family. Women will usually grow vegetables.

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[16] Office du Niger: Feasibility study (non-dated) p. 34.

[17] Across ethnic groups in Mali family relationships with regard to the authority of the head of household are much the same. For more information see N'Diaye [1970] in "Groupes Ethniques du Mali."

Except for garden plots production and because rice is the only crop grown, the O.N. settler family has no production choice and fragmentation of technical decisions is thus absent. Decisions concerning food production and major financial matters are made by one single individual. This situation simplifies the analysis of the decision making process to be discussed in Chapter 8.

CHAPTER 3

RESEARCH METHODOLOGY

It was pointed out in Chapter 1 that the agro-economic survey was proposed by WARDA in order to fill in some important gaps in the present knowledge base in the O.N. While the study fitted in the preliminary phase of the intensification program now being implemented with assistance of the World Bank,[1] it was also from WARDA's standpoint, a part of its on-going socio-economic analysis of rice development strategies in West Africa.[2]

3.1 Organization and Sampling Procedures

The author arrived in Monrovia (Liberia) in mid October 1978 to gain familiarization with the headquarters of WARDA and to plan the implementation of the research project at the O.N. in Mali. In late October a WARDA mission accompanied the author to Segou, headquarters of the O.N. to introduce him to officials of the Office and make

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[1]The Bank is assisting the O.N. in engineering studies and designs for field testing and selection of the most economic procedures and equipment for land levelling, and in the upgrading of the Office's blurred accounting system.

[2]Similar studies have been or are underway on floating rice in Mali, Upland and Mangrove rice in Sierra Leone, the Gambia, Ivory Coast and Liberia. WARDA's approach is broader in perspectives and addresses the whole range of issues from analysis of costs and returns to the use of international trade policies, prices and investment policies and household consumption studies.

necessary arrangements for launching the survey. In the original research proposal presented by WARDA [August, 1978], the survey was also to cover the zone of the Operation Riz Segou. However practical difficulties in making administrative arrangements at the time the study began prevented the team from extending the study beyond the O.N. area.

Sampling

The survey was limited to Niono and Kolongo sectors which represent conditions along the Sahel and Macina Canals. This was purposively done to account for the difference in the potential of the irrigation works between the two main zones of the Office.

As settlement villages in the O.N. are virtually similar, they became less relevant as sampling units. Thus in delineating the three clusters from which the sample of farmers was drawn, other considerations had to be accounted for. The most important criterion was the difference in expected yields as depicted in Figure 2-2 (Chapter 2). Other considerations included (1) the state of the irrigation/drainage network and the degree of weed infestation (to allow for variation within clusters, (2) the distances from villages to the administrative centers in order to limit enumerators' travel time and (3) the ethnic composition. Two clusters--Kolodogou and Sahel--were delineated in Niono along the Sahel canal, with expected yields of 1.5 and 2.0 mt per hectare, respectively. A total of 56 farmers were selected from the two clusters. An additional 25 farmers were purposively selected in Niono to represent the special case of Foabougou village whose fields were set aside for the pilot intensification program. In Kolongo, along the Macina canal, a sample of 40 settlers was retained from the unique cluster delineated there, and where the expected yield was around 1.0 mt per hectare. In each cluster stratification by size group preceded a proportionate random sampling of farmers. The composition of the sample is depicted in Table 3-1.

In summary 96 farmers in three clusters were randomly selected to represent existing conditions while 25 farmers were purposively chosen to provide information on the expected new conditions after intensification. With a delineation by ecological zone and stratification by size groups, each cluster[3] had the opportunity to be a miniature representation of the universe as discussed by Raj [1972]. In addition to the farm management survey sample, the survey on farmer's risk attitudes and undercapitalization prompted the selection of a separate sample of 31 settlers in the Kolongo sector. The sampling procedures used for that study are discussed in Chapter 8.

Selection of Enumerators

The original questionnaires for the farm management study were prepared in January and February 1979. In March enumerators were selected and trained. The training emphasized the knowledge of agricultural practices, the terminology in use at the Office and more importantly a detailed understanding of the questionnaire schedules.

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[3]Each cluster also represented a particular casier from which it was delineated.

TABLE 3-1. Structure of the Sample of Selected Farmers

Size Group (ha)	Cluster A (Niono-Kolodogou) Number of farmers	Cluster A (Niono-Kolodogou) Area planted % of total	Cluster B (Niono-Sahel) Number of farmers	Cluster B (Niono-Sahel) Area planted % of total	Cluster C Kolongo Number of farmers	Cluster C Kolongo Area planted % of total	Pilate Project (Foabougou) Number of farmers
less than 5	16	46	5	24	18	45	10
5 - 10	12	34	10	48	14	35	15
10 - 15	5	14	4	19	6	15	
over 15	2	6	2	9	2	5	
Total	35	100	21	100	40	100	25

Source: Survey data.

An initial and intensive 8 day training was later supplemented with field practices after a final team of 9 enumerators[4] was selected. Field practices dealt with interviewing methods and the establishment of rapport between enumerators and farmers. Two supervisors were selected among the enumerators. In addition to their normal work as enumerators (with a lesser load relative to others), the supervisors dealt with administrative tasks, supervised and coordinated the work of other enumerators and also served as contact men with the Office administration in their respective zones.

Conduct of the Survey

Actual data collection began in April 1979 with the collection of resource stock data, which was repeated two more times to update the information and account for variations in the stocks. Resource utilization was obtained in twice weekly interviews. This cost-route method was justified by the need to collect the labor and income-expenditures data in as much detail as possible.

Our approach to data collection followed that of Norman [1973], Spencer [1972], Tollens [1975] and others who used multiple visits to generate input-output coefficients and investigate the efficiency of farm operations. This approach contrasts with the farm business survey technique in which a large number of statistically selected farmers are visited only once or twice to complete a questionnaire [Spencer, 1972].

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[4]One more enumerator was added to the team in August 1979.

The fundamental difference in the two approaches lies not so much in the degree of representativeness that is achieved, but rather in the types and the cost of the trade-offs involved, as well as the objectives of the study. A farm business survey (often conducted on a large sample, for instance 300 or more farms) has the advantage of being more representative of the wide differences existing within the population. It can be used when contemplating the introduction of new technology. There is however a great deal of observational errors stemming from the very limited number of visits made and the reliability on secondary data. A cost-route survey deals with relatively small samples but help reduce measurement errors at the farm level by increasing the frequency of visits paid to respondents. This improves the quality of input-output coefficients derived in farm operation. Sampling errors, however, can be quite large particularly if the population is heterogenous. In both approaches the size of the budget available may be the most constraining factor in attempting to reduce the two types of errors.

3.2 Data Preparation

The Farm Management Data Collection and Analysis System (FMDCAS) developed by the Food and Agriculture Organization (FAO) was used in coding and in the preliminary analysis of the survey data. FMDCAS was conceived as a tool for researchers in collecting and analyzing farm level data. It was also expected to promote a systematic approach to concepts and procedures which would facilitate interregional comparison of results [Friedrich, 1977]. FMDCAS also includes a group of integrated computer programs in Fortran IV that accept farm management data at varying levels of aggregation and produce a variety of fixed format printouts of farms, crop and livestock tables.[5]

The package presents a number of advantages including (1) rapid checking and validation of the survey data, (2) the possibility of storing the original data in an easily retrievable standard format, thus facilitating its use in benchmark surveys prior to project development and implementation, (3) quick primary analysis that would make results available to policy makers at an early time and (4) in depth analysis of the data for a variety of uses. FMDCAS, however, lacks the flexibility to handle qualitative data and is cumbersome and inefficient. This led to the development of a second version of the package, FARMAP[6] which has also been conceived with the advantage of running on microcomputers.

The output of FMDCAS (farm, crop and livestock tables) was used to prepare farm budgets and analyze rice and livestock enterprises with emphasis on performance magnitudes in various groups of rice holdings and by ecological zones. For rice this was possible because FMDCAS delivers the situation on a per farm and per field basis, thus facilitating selective aggregation and improving the degree of representiveness of farm situations. Additional results of the study were generated through statistical analysis and linear programming.

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[5]Examples of farm and crop tables are shown in Appendix A and B.

[6]FARMAP stands for Farm Management Analysis Package. It was developed after widespread experience with FMDCAS. It incorporates a wide range of codes and has a modular design that introduces some flexibility in the printouts and allows also for additional programs to be incorporated.

CHAPTER 4

ECONOMIC ANALYSIS OF FARM PRODUCTION AND LABOR UTILIZATION AT THE O.N.

4.1 Introduction

An overview of the economics of production in the O.N. is presented here to set the stage for a detailed analysis of each of the two main enterprises i.e. rice and livestock. The farm is viewed as a whole and the relationships between various activities are stressed. Emphasis is put on the allocation of resources among rice, livestock, other farm and nonfarm activities. The contribution of off-farm revenues in the making of total family earnings is also examined. Analysis of labor utilization on farm is carried out in some detail. Seasonality and percentage distribution of family labor by sex and age group in the performance of agricultural activities are examined with the view to derive some implications for the intensification of production in the Office.

The analyses carried out in Chapter 4 and 5 have used to some extent the terminology and the concepts derived from the FAO package. Some concepts however, were more elaborated and others restricted in their meaning in order to justify their applicability to the Office du Niger farming environment.

4.2 Farm Income Analysis

4.2.1 Defining the Farm

We have defined <u>farm activities</u> in the context of the Office du Niger to include two main enterprises, <u>rice</u> and <u>livestock</u>, plus a group of general activities undertaken by household members. Although the Office management reconizes the importance of livestock activities as a source of additional incomes to settlers, no data has ever been collected to estimate its contribution to the total farm income. Livestock activities compete with rice in the use of farm labor and farmers' financial resources. But the interaction between the two enterprises is also mutually beneficial because animal traction is linked to animal husbandry and cattle manure can be used as fertilizer on rice fields with the latter providing straw and rice by-products to be used as feeds for livestock. For the sake of simplicity, resource utilization was analyzed for the livestock enterprise as a whole with no distinction as to different species of productive animals kept on farms.

General farm activities are somewhat an ambiguous category to define.[1] Clearly it comprises all farm activities not directly attributable to rice or livestock, as yet not outside the farm. Examples of such activities are transportation of rice by-products for feeding animals, repairs and general maintenance of farm buildings, marketing of farm products, construction, etc.

Off-farm activities are defined broadly to include productive and nonproductive occupations (e.g. social activities, small scale industries). In general reference is made to activities other than rice and/or livestock that use household resources to produce marketable or nonmarketable output. Vegetable production in garden plots and dryland

[1]Certain categories of household activities were counted as general farm activities. Fishing was considered an off-farm activity but transportation of wood fell in the category of general farm activities.

cultivation of maize and sorghum/millet on small plots have also been included as part of off-farm activities.[2] This is because these activities are neither official or widespread and generate incomes that settlers consider as a supplement to their farm incomes. Therefore off-farm revenue here is not necessarily nonagricultural, but rather any revenue generated outside the farm as defined above, including renumeration of services performed for others.

4.2.2 Budget Concepts and Derivation of Input Costs

Farm income analysis looks at the structure of costs and returns associated with all farm operations to allow the researcher to determine whether or not in a specific production system farmers are recovering their costs and earning a return out of their capital investment [Brown, 1979]. The objective in this subsection is twofold: (1) to study the efficiency of farms in different ecological zones at the Office du Niger; and (2) to gain awareness of the current distribution of farm incomes across the settlement and analyze its causes.

The comparative analysis for the global farm situation has been restricted to the two sectors of Niono and Kolongo which represent two different ecological settings along the Sahel and Macina canals. Niono is made up of two rice casiers, namely Kolodogou and Sahel,[3] where two

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[2]The distinction between farm and off-farm activities is somewhat arbitrary here, but it is meant to focus on what the Office management considers as official versus unofficial activities. For instance some settlers cultivate dryland crops in small plots outside the O.N. area.

[3]Also referred to as Casier Blanc.

separate subsamples were investigated, but the data were lumped together for the farm analysis in order to provide a meaningful representation of the area along the Sahel canal in the vicinity of the Niono center. First, budget concepts are presented and the way in which the magnitudes of certain farm variables were calculated is shown.

a. Value of Production

The value of production (also referred to as gross return or value of gross output) represents the sum of values of rough rice or paddy, milled rice, by-products and livestock products produced on the farm during the 1979-80 season. For budget calculations, however, only the total disposable output of paddy was used to account for field losses.[4] Inventory changes for paddy production were taken into account only for those farms (mostly large farms) with some amount of grain left over from the previous harvest. In general the majority of settlers in the

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[4]Disposable (or net) output of paddy is defined as the difference between the total achievable output (that we estimated for each farm using the yield plot method) and the total field losses plus adjustments (upward) that accounted for the quantities family members gleaned on fields after harvest and the average amount they recovered from the standing stacks after machine threshing. For practical reasons the disposable output was easily obtained by adding 8 percent of achievable output to the total amount farmers market through the O.N. channel, as this amount was known with certainty. This adjustment was decomposed as follows: total family gleanage of 3 percent [Kamuanga and Spencer, 1981] and a 5 percent recovery from standing stacks known as "fond de gerbier." The latter figure was calculated on the basis of the O.N. estimate and the author's field experience. A second alterntive in the presentation of budgets would have been to value the total achievable output of paddy at the official price and enter field losses as a production cost. This however would have put undue emphasis on operating costs and was so avoided.

sample had their granaries depleted long before the beginning of the new season.[5] The output of paddy was valued at the official farmgate price of 60 MF per kilo. But additional sales of paddy or milled rice from the farmers' stores were valued at the retail sale price, usually higher than the official producer price.[6]

Livestock products were also valued at their market prices often reflecting seasonal variations.[7] Inventory changes were ignored because the magnitudes involved were negligible or difficult to measure. Table 4-1 provides the price range for major livestock products sold in the O.N. area.

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[5] Source is [Kamuanga and Spencer, 1981].

[6] Stored rice was sold later on during the year either in the form of paddy or milled rice, in which case the per kilo price would go as high as 200 MF, depending on the period of the year. Although quantities involved were small relative to the output sold as harvest, double counting was avoided. The average price of output per kilo in the budget is higher than 60 MF per kilo in some cases for the above reasons.

[7] In particular, goat and sheep prices were twice as high during the Muslim season of Tabaski in October-November as compared to other periods of the year.

TABLE 4-1. Market Price Range for Major Livestock Products In the O.N. Area in the 1979-80 Season

Item	Unit	Price MF[a]
Live animals (adults)		
cattle	-	50,000-100,000
goat/sheep	-	20,000-50,000
poultry	-	500-1,000
Livestock products		
cow milk	liter	50-100
goat/sheep meat	kg	800-1,500
eggs		50-80
butter		variable

Source: Survey by the author.

[a]The exchange rate in 1979-80 season was $1/420-440 MF.

b. Variable Costs and the Gross Margin

The farm gross margin is derived by deducting all variable costs from the composite total value of rice and livestock productions. The details on the type of variable costs in rice and livestock production are given in Chapter 5 and 6 where each enterprise is separately tackled. Briefly, major variable cost components for rice include seeds and fertilizer, a paddy threshing charge of 120 kg per metric ton and paid seasonal labor. Feeds, veterinary care and animal replacement were the most common variable expenses found for livestock production in the area. Wage rates for hired labor varied from 500 to 1,000 MF per day or more depending on the task, the period of the year and the location.

c. Overhead Costs and Net Farm Earnings

The most important fixed charge of rice production is the O.N. land and water utilization fee of 400 kg of paddy per hectare levied at harvest time. This fee theoretically represents farmers' participation in amortization and upkeep of the installations, as well as in the cost of organization and supervision.

Linear depreciation was estimated for only three of the pieces of equipment (plows, harrows and carts), including all draft animals. The total amount of money tied up in this investment is about 350,000 MF per average farm at current purchase prices. Other fixed charges include the salaries to permanent laborers on farms where they were found and miscellaneous expenditures of a fixed nature such as rents and harnessing charges for draft animals.

A measure of the year after year profitability of the farm is given by the <u>net farm earnings</u>, a term interchangeably used with <u>net farm income</u> in this study because no interest was charged on borrowed capital by farmers [Dillon and Hardaker, 1980]. Net farm income stands as a reward to the farmer's labor, his unpaid family labor, operating capital and management contributed by the farm family during the year [Brown, 1979].

d. Family Earnings

Settlers at the O.N. show various degrees of involvement in off-farm activities (as defined in Section 4.1), some with opportunities for substantial income generation. Family earnings are calculated by adding off-farm incomes to the net farm earnings, hence they represent the source of funds that cover all household expenditures and the value of home consumed products.

e. Cash Flow Statement

Family cash earnings are derived from family earnings by adding to the latter the values of depreciation and sales of farm equipment, and then subtracting the value of livestock appreciation. The magnitude left after deducting the value of equipment purchases and household expenditures (including the value of home consumption) from family cash earnings represent the amount of cash income including "cashable" products,[8] which the family has the option to use for either replacement of capital goods, for investments, for savings and/or increased consumption. This magnitude (referred to in the FMDCAS printout as "balance") is very important in the case of the O.N. farm families because it indicates whether or not their sources of cash are adequate to cover cash expenses.[9] It is a useful indicator throwing light on the general living conditions of the settlers and the viability of their farm business [Friedrich, 1977]. The cash flow statement is a less useful efficiency criterion compared to gross margin and farm earnings.

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[8]Assuming that any stored amount of paddy and livestock products such as meat and milk can be sold for cash at any time.

[9]Such expenditures as fertilizer and the land fee which are paid in-kind are considered as cash to the extent that they are directly deducted from the harvest.

4.2.3 Farm Budgets for Niono and Kolongo

1. Presentation

The budgets reported here have been rearranged from the initial farm tables derived by the FMDCAS program as shown by the example of computer printout in Appendix A. As said earlier, Kolongo and Niono sectors represent two different ecological and infrastructural settings well known to the Office management. Aggregation by size groups of holdings was introduced as a proxy for differences in resource endowments among farmers. The group size stratification is also in accordance with the practice in use in the O.N. reports. This, however, does not take into account the relative "size" of the livestock enterprise which varies across the strata. However it will be shown later that large herds are associated with large farms.

Financial budgets representing mean physical resource utilization are shown in Tables 4-2 through 4-7. Total labor use per unit of enterprise income and expenditures is examined. Labor inputs are calculated in man-days whereby a man-day relates to a person working 8 hours. The stock of labor is expressed in man-equivalents (ME) following FMDCAS conversion scale. Only one such budget for an average farm in Niono in the group of 5 to 10 ha is briefly discussed below. All farms of size 15 ha and above in Niono and Kolongo have been excluded from the comparative analysis because of the small number of observations available. Two such "oversized" farms (one in each sector) are treated only as case studies to shed light on the order of the financial magnitudes involved, and also as a reference for any future comparative evaluation.

TABLE 4-2. Average Budget for 19 Farms of Zero to 5 Hectares[a]
Sector of Niono (Kolodogou and Sahel)

1. LABOR USE	Manpower available: 4.6 man-eq.		
1.1 Farm activities	Amount (man-days)	1.2 Source	Amount (man-days)
rice	579	farmer	235
livestock	24	family	681
general farm activities	348	seasonal	32
		community	3
Total farm	951		951

2. INCOME AND EXPENDITURES		
2.1 Production	Amount	Value (MF)
rice	5670 kg	357,236 (128,506)[b]
livestock		21,538 (47,051)[b]
Total		378,774
2.2 Operating expenses		
hired labor	32 man-days	21,920
non-labor expenses		162,123
Total		184,043
2.3 Gross margin		194,731
2.4 Overhead costs		
land fee	1600 kg	96,000
depreciation		22,600
repairs and maintenance		1,958
others		4,826
Total		125,384
2.5 Net farm earnings		69,347

[a]The average farm size for this group was 4.0 ha (SD=0.87).

[b]Standard deviation in brackets.

TABLE 4-3. Average Budget for 21 Farms of 5 to 10 Hectares[a]
Sector of Niono (Kolodogou and Sahel)

1. LABOR USE	Manpower available: 6.7 man-eq.		
1.1 Farm activities	Amount (man-days)	1.2 Source	Amount (man-days)
rice	892	farmer	271
livestock	36	family	1,054
general farm activities	513	seasonal	106
		community	10
Total farm	1,441		1,441

2. INCOME AND EXPENDITURES		
2.1 Production	Amount	Value (MF)
rice	12,630 kg	833,571 (340,573)[b]
livestock		51,021 (122,773)[b]
Total		884,592
2.2 Operating expenses		
hired labor	106 man-days	72,610
non-labor expenses		331,988
Total		404,598
2.3 Gross margin		479,993
2.4 Overhead costs		
land fee	3,080 kg	184,800
depreciation		39,300
repairs and maintenance		4,663
others		6,203
Total		234,966
2.5 Net farm earnings		245,027

[a]The average farm size for this group was 7.7 ha (SD=1.44).

[b]Standard deviation in brackets.

TABLE 4-4. Average Budget for 12 Farms of 10 to 15 Hectares[a]
Sector of Niono (Kolodogou and Sahel)

1. LABOR USE	Manpower available: 13.4 man eq.			
1.1 Farm activities	Amount (man days)		1.2 Source	Amount (man-days)
rice	1,454		farmer	266
livestock	78		family	1,832
general farm activities	749		seasonal	164
			community	19
Total farm	2,281			2,281

2. INCOME AND EXPENDITURES		
2.1 Production	Amount	Value (MF)
rice	17,206 kg	1,187,201 (373,900)[b]
livestock		72,241 (85,720)[b]
Total		1,256,442
2.2 Operating expenses		
hired labor	164 man-days	112,340
non-labor expenses		564,061
Total		676,401
2.3 Gross margin		583,041
2.4 Overhead costs		
land fee	5,040 kg	303,120
depreciation		82,200
repairs and maintenance		13,441
others		56,893
Total		455,653
2.5 Net farm earnings		127,388

[a]The average farm size for this group was 12.6 ha (SD=1.95).

[b]Standard deviation in bracket.

TABLE 4-5. Average Budget for 18 Farms of Zero to 5 Hectares[a]
Sector of Kolongo

1. LABOR USE — Manpower available: 4.7 man-eq.

1.1 Farm activities	Amount (man-days)
rice	374
livestock	15
general farm activities	55
Total farm	445

1.2 Source	Amount (man-days)
farmer	125
family	317
seasonal	3
community	0
	445

2. INCOME AND EXPENDITURES

	Amount	Value (MF)
2.1 Production		
rice	2,532 kg	151,896 (12,442) [b]
livestock		18,778 (50,894) [b]
Total		170,675
2.2 Operating expenses		
hired labor	3 man-days	1,740
non-labor expenses		85,456
Total		87,196
2.3 Gross margin		83,240
2.4 Overhead costs		
land fee	1,400 kg	84,240
depreciation		17,200
repairs and maintenance		3,279
others		1,867
Total		106,585
2.5 Net farm earnings		-23,107

[a]The average farm size for this group was 3.5 ha (SD=0.8)

[b]Standard deviation in brackets.

TABLE 4-6. Average Budget for 14 Farms of 5 to 10 Hectares[a]
Sector of Kolongo

1. LABOR USE — Manpower available: 6.1 man-eq.

1.1 Farm activities	Amount (man-days)	1.2 Source	Amount (man-days)
rice	461	farmer	91
livestock	5	family	429
general farm activities	55	seasonal	2
		community	0
Total farm	522		522

2. INCOME AND EXPENDITURES

	Amount	Value (MF)
2.1 Production		
rice	5,014 kg	300,844 (50,470)[b]
livestock		11,535 (44,822)[b]
Total		312,378
2.2 Operating expenses		
hired labor	2 man-days	1,400
non-labor expenses		171,902
Total		173,302
2.3 Gross margin		139,076
2.4 Overhead costs		
land fee	2,820 kg	169,200
depreciation		34,200
repairs and maintenance		6,330
others		3,902
Total		212,922
2.5 Net farm earnings		-73,846

[a]The average farm size for this group was 7.05 ha (SD=1.2).

[b]Standard deviation in brackets.

TABLE 4-7. Average Budget for 6 Farms of 10 to 15 Hectares[a]
Sector of Kolongo

1. LABOR USE — Manpower available: 10.0 man-eq.

1.1 Farm activities	Amount (man-days)	1.2 Source	Amount (man-days)
rice	821	farmer	120
livestock	4	family	792
general farm activities	90	seasonal	2
		community	1
Total farm	915		915

2. INCOME AND EXPENDITURES

	Amount	Value (MF)
2.1 Production		
rice	5,975 kg	358,500 (15,557)[b]
livestock		37,547 (88,473)[b]
Total		396,047
2.2 Operating expenses		
hired labor	2 man-days	1,400
non-labor expenses		330,228
Total		331,628
2.3 Gross margin		64,419
2.4 Overhead costs		
land fee	4,720 kg	283,920
depreciation		82,000
repairs and maintenance		9,538
others		5,339
Total		380,797
2.5 Net farm earnings		-316,378

[a]The average farm size for this group was 11.8 (SD=4.4).

[b]Standard deviation in brackets.

Budget for a Medium Sized Farm in Niono

Table 4-2 displays the budget for an average farm of 7.7 ha assumed to represent conditions which prevail for settlers with holdings between 5 and 10 ha. The mean age of settlers in this group was found to be 49.7 years, and there were 6.7 man-equivalents of available manpower. Of the 1,441 man-days of total on-farm labor use 892 man-days were devoted to the cultivation of rice, 36 man-days in livestock, and 513 man-days in general farm activities. The mean percentage contribution of farm labor was allocated as follows: 19 percent from the colonist settler, 73 percent from the rest of the family, 7 percent from hired seasonal workers and 1 percent from nonpaid community labor.

The gross value of rice output per farm was estimated at 108,256 MF per hectare. The standard deviation reflects the variation in holding size within the group. The value of livestock production amounted to 6,626 MF per hectare with a wide standard deviation caused by larger differences in both the size of the stock and the value of sales of livestock products per farm. With per hectare mean operating expenditures of 52,545 MF and a mean overhead cost of 30,515 MF, the net farm earnings per hectare were evaluated at 31,822 MF. Details on the cashflow statement are discussed later in this subsection.

2. Comparative Analysis and Overview of Costs and Returns

As a research technique, comparative analysis of current or past results is used to facilitate the comparison between different groups of farms in the sample in order to be able to generalize the results to the

the larger population they represent and in the process provide a feedback for reorientation of research.[10]

Comparison of farm efficiency criteria for the O.N. settlers is particularly valid for the following reasons: (1) they all face the same kind of institutional constraints and respond to the same set of factor and product prices; and (2) they have access to similar services. Thus differences in farm productivity are very likely to reflect the difference in the potential of local hydraulic structures as well as farmers' own varying levels and quality of management. The main economic characteristics of farms and their distribution across holdings of different sizes are compiled in Tables 4-8 through 4-12.

a. Rice and Livestock Shares of the Gross Return

Despite the wide variation in gross returns from livestock in each size group as indicated by the ratio of the mean value to its standard deviation in the budget tables, the livestock share of the total value of production is relatively constant at 6 percent in Niono in all size groups (Table 4-8). It is higher on small sized farms in Kolongo but but lower among farms with holdings between 5 to 10 ha. For the

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[10]As Dillon and Hardaker [1980] point out, this use of comparative analysis should be distinguished from its use as an extension technique. In the latter case it describes the process of comparing the performance of an individual farm with some standard which may be any of the following: (a) previous performance for the same farm; (b) average performance for the group of broadly similar farms; (c) some synthetic or benchmark farm based on experimental and other data; or (d) budgeted performance for the farm in question.

TABLE 4-8. Relative Share of Rice and Livestock in the Total Value of Production for Niono and Kolongo

Sector / Farm size group	Niono		Kolongo		Average for Survey area[a]	
	MF	%	MF	%	MF	%
I 0-5 ha						
Rice output	357,236	94	151,896	89	254,566	93
Livestock	21,538	6	18,778	11	20,158	7
Total	378,774	100	170,675	100	274,725	100
II 5-10 ha						
Rice output	833,571	94	300,844	96	567,208	92
Livestock	51,021	6	11,535	4	31,278	8
Total	884,591	100	312,378	100	598,486	100
III 10-15 ha						
Rice output	1,187,201	94	358,500	91	791,624	94
Livestock	72,241	6	37,547	9	54,894	6
Total	1,259,442	100	396,047	100	846,518	100

Source: Calculated from Tables 4-2 to 4-7.

[a]Averages are weighted by the number of farms in each size group.

settlement as a whole, the gross return from rice production was found to be about 93 percent of the total value of farm production.

b. Value of Output per Man-Equivalent

The amount of manpower available on farms for agricultural production is expressed in man-equivalents calculated using the FAO scaling conversion.[11] One measure of both technical and economic efficiency in farm operation is given by the ratio of total value of production to the number of man-equivalents available for farming. These ratios are shown in Table 4-9 for Niono and Kolongo by size groups, referred to as I (below 5 ha), II (5-10 ha) and III (10-15 ha).

The data show that the average number of man-equivalents is roughly the same within each size group for both Niono and Kolongo but farmers achieve more than twice as much output per man-equivalent in the former than the latter sector. Output per man-equivalent is higher in the medium size group of 5 to 10 ha in both sectors. These results point out the substantial difference between Niono and Kolongo with respect to

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[11]The FAO Agriculture Service Bulletin No. 34 gives the following weights for the family labor force available for farming: (a) for farmer and adults (males and females 15 to 60 years): 1 minus time in off-farm occupation; (b) for permanent laborers: 1; (c) for youth and old (males and females 10 to 15 years and over 60 years): 0.5; (d) children under 10 years are not counted. The O.N. management restricts the amount of labor force available to the total number of adult males between 15 and 55 years. This practice systematically understates the potential labor force available within families where female and youth labor contribution is substantial, as will be shown later in Section 4.3.

TABLE 4-9. Output Per Man-Equivalent in Niono and Kolongo

Item	Niono Size Groups			Kolongo Size Groups			Survey area[a] Size Groups		
	I	II	III	I	II	III	I	II	III
Mean size (ha)	4.0	7.7	12.6	3.5	7.0	11.8	3.8	7.4	12.2
Average number ME/family	4.6	6.7	13.4	4.7	6.1	10.0	4.7	6.4	11.7
Output per ME (MF)	82,342	132,029	93,988	36,314	51,210	39,605	62,036	97,080	80,392

Source: Calculated from Tables 4-2 to 4-7.

[a]Weighted by the number of farms in each size group.

achieved physical output and also provide an indication of the relative efficiency of medium sized farms in the O.N. settlement.

c. Gross Margins

Since variable costs are deducted from the total value of farm production in estimating the gross margin, the latter stands as a better measure of relative profitability of different farms than gross returns. The gross margin represents what is left to the farmer to pay for his fixed costs. Table 4-10 depicts the total gross margins per hectare and the average number of livestock units (LSU)[12] per farm by size group.

Gross margins are higher in Niono than Kolongo due to substantially higher yields of rice. Although the number of LSU does not vary directly with the farm size, the relation seems to hold more firmly in Niono than Kolongo. In both sectors however, gross margins per hectare and the average number of LSU do not move in the same direction. The lack of a clear pattern of association between the two variables is also an indication of the variation in herd sizes and farmers' involvement in livestock as an income generating activity. This point will be expanded further in Chapter 6.

d. Financial Test Ratios

To provide additional support for results obtained through comparitive analysis, and gain a broader insight into the general structure of costs across the survey area, a series of income statement ratios was

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[12]A definition of the livestock unit is provided later in Chapter 6.

TABLE 4-10. Comparison of Gross Margins for Rice and Livestock Activities in Kolongo and Niono

Item	Niono Size Groups			Kolongo Size Groups			Survey area[a] Size Groups		
	I	II	III	I	II	III	I	II	III
Average no. of LSU	1.1	3.4	14.6	1.7	2.5	1.5	1.4	2.9	8.1
Mean farm size (ha)	4	7.7	12.6	3.5	7.0	11.8	3.8	7.4	12.2
Gross margin/ha (MF)	48,683	62,337	46,273	23,783	19,727	5,459[b]	37,698	43,911	36,069

Source: Calculated from Tables 4-2 to 4-7.

[a]Average gross margins for the survey area were weighted by the number of farms in each size group.

[b]The gross margin is lower for this group due to higher variable costs incurred in livestock production.

calculated as shown in Table 4-11. Both operating and fixed ratios are expenses-to-income ratios indicating the degree to which the value of total production exceeds production costs in percentage terms [Murray, et. al., 1980].

The results strongly indicate that variable costs as a share of total output increase as one moves from small to large farms, and are much higher in Kolongo than Niono area. When the mean size of farms in each stratum is used as weight, operating expenses amount to 51 MF and 70 MF per 100 MF of gross income in Niono and Kolongo areas, respectively. By analogy 33 MF and 82 MF fixed expenses are incurred to generate 100 MF worth of gross return. The sum of operating and fixed ratios is called the gross ratio and stands for the proportion of total costs to the total gross income. Weighted values of the gross ratio were respectively 0.84 and 1.55 for Niono and Kolongo. These figures should be interpreted as follows: Niono settlers make 16 MF of profit for each 100 MF of gross income, while those in Kolongo spend on average 155 MF to generate a gross income worth only 100 MF. Farmers in Kolongo therefore operate at substantial loss attributable to the higher proportion of fixed costs relative to variable costs. The most important fixed cost as shown earlier is the land fee.[13]

A quick appraisal of efficiency in the utilization of farm capital (here restricted to farm equipment) is made by comparing capital

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[13]This is recognized by the O.N. management. The land fee of 400 kg of paddy per hectare is disproportionate to the average net yield realized in Kolongo and estimated at 1,100 kg. The issue of a fixed land fee per unit of area and its effect on the level of farmers' indebtedness is discussed later in Chapter 8.

TABLE 4-11. Financial Test Ratios for Sample Farms in the O.N. Survey Area

Item	Niono			Kolongo			Survey area		
	I	II	III	I	II	III	I	II	III
Mean farm size (ha)	4.0	7.7	12.6	3.5	7.0	11.8	3.8	7.4	12.2
Operating ratio[1]	0.49	0.46	0.54	0.51	0.55	0.84	0.50	0.51	0.69
sector average		(0.51)			(0.70)				
Fixed ratio[2]	0.33	0.27	0.36	0.62	0.68	0.96	0.48	0.48	0.51
sector average		(0.33)			(0.82)				
Gross ratio[3]	0.82	0.73	0.90	1.13	1.23	1.80	0.98	0.98	1.35
sector average		(0.84)			(1.52)				
Capital turn over ratio[4]	2.02	2.96	2.54	1.19	1.68	1.29	1.61	2.32	1.92
sector average		(2.59)			(1.40)				

Source: Derived from Tables 4.2-4.7 and individual printout tables.

[1]Operating ratio = $\frac{\text{total operating costs}}{\text{gross income}}$

[2]Fixed ratio = $\frac{\text{total fixed costs}}{\text{gross income}}$

[3]Gross ratio = $\frac{\text{total expenses}}{\text{gross income}}$

[4]Capital turnover ratio = $\frac{\text{total income}}{\text{average capital investment}^{a}}$

[a]Average capital investment is the average of opening and ending balances on the values of farm equipment (draft animal plus durables) as generated in computer printout tables. See Appendix A.

turnover ratios among farmers. Table 4-12 indicates an overall value for Niono of 2.59 compared to 1.40 for Kolongo. These figures should be expected because gross revenues were shown to be substantially lower in Kolongo in relation to average values of farm capital. In both sectors however, capital turnover ratios are higher for the group of medium sized farms (5 to 10 ha) indicating that farm capital is more efficiently used in this group than in the others.

In summary, the analyses of the structure of costs and returns in the O.N. settlement show that: (1) the ability of farmers to recover their total costs of production and earn a profit from their involvement in rice and livestock activities is limited on large farms as indicated by the gross ratios; (2) farmers in Kolongo operate at loss because the gross return per hectare is very low (particularly on large farms) compared to Niono. This is attributed to a higher land fee in relation to the total output they are able to produce, which can be itself linked to the lower yield potential known as a characteristic of the sector; and (3) farm capital, in its restricted sense of the value of draft animals and associated equipment, is relatively more efficiently used by settlers with holdings between 5 and 10 ha.

e. Distribution of Family Earnings and Net Farm Cash Flows

By deducting the value of livestock appreciation[14] and adjusting for depreciation of farm capital, the net farm earnings are turned into net farm cash incomes[15] (or net cash profits). Total family earnings are

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[14] Including births which occurred during the season.

[15] Assuming that stored produce is a cashable item.

TABLE 4-12. Cash Flow Statement and the Distribution of Family Earnings in the Survey Area (in Malian Francs)

Item	Niono			Kolongo		
	I	II	III	I	II	III
Net farm earnings	69,347	245,027	127,388	-23,107	-73,846	-316,378
plus value of equipment sales[a]		15,600		18,314	12,900	
plus depreciation	22,600	39,300	82,200	17,200	34,200	82,000
less value of livestock appreciation[a]	13,399	25,100	27,300	15,414	10,200	4,401
Net farm cash income	78,548	274,827	182,288	-3,007	-36,946	-238,799
Off-farm earnings	118,438	116,081	252,521	61,263	45,000	49,538
Family cash earnings	196,986	390,908	434,809	58,256	8,054	-189,241
less value of home consumption	16,421	32,626	62,797	5,067	11,811	5,905
less household expenditures	236,198	343,944	449,016	66,994	102,865	155,842
less value of equipment purchases[a]	4,400				8,000	
Net cash flow	-60,033	14,338	-77,004	-13,805	-114,622	-350,988

Source: Survey data and calculations from Table 4.2-4.7.

[a]Values separately derived from farm tables.

obtained by adding the amount of off-farm incomes to net farm cash incomes for the accounting period in consideration. Off-farm earnings consist of wage incomes from employment, remunerations from diverse nonagricultural activities, and revenues from sales of farm produced goods (including the produce from garden plots). Thus family earnings represent the amount of income available to the farm family for all purposes.

Examination of Table 4-12 reveals that off-farm earnings were a major source of family income for the majority of selected farmers in Kolongo during the 1979-80 season. Among the farms surveyed however, off-farm incomes were not high enough to pay for the level of household expenditures incurred during the season. Off-farm incomes are much higher in Niono area particularly because the town is a large commercial center with a sizeable nonagricultural population. There are more opportunities to engage in profitable off-farm activities there than in Kolongo. Off-farm incomes in Niono contributed from 30 to 60 percent in the making of family earnings.

By subtracting total household expenditures on consumption goods including the value of home-consumption, the magnitude left represents the net cash flow available to the farm family during that year.[16] Net cash flow reflects the family's ability to meet cash payments of loans falling due during the period under consideration.

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[16]A complete cash flow statement would have taken account of debt transactions [Murray, et. al., 1980] during the same period. However, payment of principal on debts contracted in previous years was not entered. Therefore current year level of household expenditures should be considered as understated.

According to Table 4-12, positive cash flows in 1979-80 season were generated only in Niono among the group of medium sized farms. For the majority of settlers in the sample, the current level of household expenditures could not be met out of total family cash earnings during the year. This observation does not support the view commonly held about the attractiveness of living conditions in the O.N. settlement.

4.2.4 Case Studies of Farms Larger than 15 ha

It was indicated in Chapter 2 that only 9 percent of the settlers have holdings above 15 ha, nonetheless they cultivate 25 percent of the total developed land. The number of such farms that can be included in any sample of acceptable size therefore becomes restricted, thus limiting the scope for statistical comparison with the majority of farms of less than 15 ha. There were 6 farms in that category out of 96 who were randomly selected to represent existing conditions in the settlement. Average performances for 4 of those farms in Niono and 2 in Kolongo are shown in Tables 4-13a and 4-13b.

The average farm size in this group is 20.5 ha in Niono and 23.5 ha in Kolongo. Total value of production amounts to 2,477,528 MF in Niono, 4 percent of which was contributed by the value of livestock products. In Kolongo such an "oversized" farm was found to generate only 809,779 MF, 9 percent of which was from livestock activities. Twice as much on-farm labor was used in Niono compared to Kolongo (3,160 and 1,506 man-days respectively), a difference attributable in part to a 2 to 1 proportion of man-power available for farming (21.8 and 10.9 man-equivalents in Niono and Kolongo respectively). The mean farm cash income was estimated at 1,011,286 MF in Niono compared to a substantially negative value of

TABLE 4-13a. Average Budget for 4 Farms of Size Above 15 Hectares
Case Study for Sector of Niono

1. LABOR USE — Manpower available: 21.8 man-eq.

1.1 Farm activities	Amount (man-days)	1.2 Source	Amount (man-days)
rice	2,035	farmer	249
livestock	152	family	2,744
general farm activities	971	seasonal labor	168
		community labor	1
Total farm	3,160	Total farm	3,160

2. INCOME AND EXPENDITURES

	Amount	Value (MF)
2.1 Production		
rice	35,578 kg	2,383,691
livestock		93,838
Total		2,477,528
2.2 Operating expenditure		
hired labor	166 man-days	113,710
non-labor expenses		833,281
Total		946,991
2.3 Gross margin		1,530,537
2.4 Overhead costs		
land fee	8,200 kg	492,000
depreciation		165,100
repairs and maintenance		13,394
others		13,857
Total		684,351
2.5 Net farm earnings		846,186

3. CASH FLOW STATEMENT

equipment sales	
depreciation	165,100
value of livestock appreciation	54,100
3.1 Net farm cash income	1,011,286
3.2 Off-farm earnings	12,183
3.3 Family cash earnings	1,023,469
value of home consumption	24,915
household expenditures	353,518
equipment purchases	60,010
3.4 Net cash flow	579,026

Source: Survey data.

TABLE 4-13b. Average Budget for 2 Farms of Size Above 15 Hectares
Case Study for Sector of Kolongo

1. LABOR USE — Manpower available: 10.9 man-eq.

1.1 Farm activities	Amount (man-days)	1.2 Source	Amount (man-days)
rice	1,433	farmer	61
livestock	7	family	1,276
general farm activities	66	seasonal	168
		community	-
Total farm	1,506	Total farm	1,506

2. INCOME AND EXPENDITURES

	Amount	Value (MF)
2.1 Production		
rice	12,298 kg	737,879
livestock		71,900
Total		809,779
2.2 Operating expenditures		
hired labor	168 man-days	117,600
non-labor expenses		805,308
Total		923,408
2.3 Gross margin		-113,629
2.4 Overhead costs		
land fee	9,400 kg	564,000
depreciation		91,500
repairs and maintenance		10,476
others		3,000
2.5 Net farm earnings		-782,605

3. CASH FLOW STATEMENT

equipment sales	
depreciation	91,500
value of livestock appreciation	22,500
3.1 Net farm cash income	-713,605
3.2 Off-farm earnings	200,100
3.3 Family cash earnings	-513,505
value of home consumption	34,925
household expenditures	319,235
equipment purchases	
3.4 Net cash flow	-867,665

Source: Survey data.

-713,605 MF in Kolongo. Only one percent of family cash earnings on large farms in Niono was contributed by off-farm incomes (12,813 MF with a low standard deviation of 3,488). This seems to indicate that the need to supplement family income is reduced because of a better financial performance on rice farms. This assumption is also supported by an estimated gross ratio of 0.66 and a higher capital turnover ratio of 6.5. Also the net cash flow was positive at 579,026 MF during the survey year.

In sum the difference in efficiency measures between Niono and Kolongo that was found to exist for farms below 15 ha also prevails for farms above 15 ha, though the limited number of observations prevents from drawing strong conclusions. There is a significant difference between Niono and Kolongo on "oversized" farms in the proportion of incomes generated in off-farm activities: settlers in Kolongo earn 16 times as much off-farm revenues than their counterpart in Niono. One probable explanation is that the lower agricultural potential in Kolongo may have forced settlers with large holdings to rely more upon their traditional off-farm occupations as a source of family income.

4.3 The Pattern of On-Farm Labor Use at the Office du Niger

1. Introduction

This section describes the pattern of labor use and assesses its implications for the adoption of improved technologies now being contemplated. A major weakness of the available statistics on the O.N. is in fact the quality of the household labor input data, which is in direct contrast to rather detailed and accurate records on nearly every other aspect of the farming system in the settlement [WARDA, 1978]. Since labor has been and remains the basic limitation on production it is essential to know much more about its availability throughout the cropping season, and the division by sex and age group in the performance of major agricultural tasks.

Labor utilization is to be discussed also in terms of its allocation to rice, livestock and general farm activities. Total labor requirement by task in the production of rice is presented in Chapter 5. It is necessary at the onset to provide some precision on how both the labor stock and labor flow were defined and measured in this study. Because the study used the FMDCAS format developed for inputing and analyzing farm data, concepts of labor stock and flow were restricted to that initial convention. Hence with regard to the farm family 4 groups of people were distinghished in the evaluation of manpower (expressed in man-equivalents) available for farming: (1) adults, males and females of age 15 to 60 years were weighted by 1.0 minus time in off-farm occupation; (2) permanent laborers (where applicable) were weighted by 1.0; (3) youth of both sex between 10 and 15 years of age, and old people over 60 years were weighted by 0.5; and (4) children below 10 years were not included (weight = 0).

The flow of labor is the actual productive effort that comes from the labor force. FMDCAS calculates labor flow in man-days whereby a man-day relates to a person working 8 hours, this being simply a convenient magnitude for comparing labor inputs which were originally entered in hours. The program however does not differentiate labor input (as a flow measure) by sex or age category. This convention was introduced on the assumption that any person doing a certain operation performs it in an efficient manner, that no substitute would do it better and that a natural labor division exists whereby everyone is concentrating on the jobs which he can best perform [Friedrich, 1977].[17]

There is no need to review the literature on this particular matter but it is necessary to point out that there is no standard way of aggregating the stock and the flow of labor. Moreover the problem may be further complicated as relative work productivities vary depending on the type of task being performed. For instance Norman [1973] used the following weights: adult males: 1.0, adult females: 0.75, the elderly and the children, 7 to 14 years: 0.5 and children under 7 had a zero weight. Haswell [1953] used weights in proportion to average calorie consumption for different categories. Spencer [1972] referred to age categories "Very Old," "Old," "Young" and "Child" but employed different weights by task as well. His work was indeed expressed in days not in hours. He also suggested that in weeding, bird-scaring and harvesting, children and women are just as efficient as men and so should have the same weight. Tollens [1975] used Spencer's conversion scale but gave a 1.0 weight to women for agricultural works in the forest zones of Zaire, because they were judged as efficient as men in the type of tasks they usually perform.

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[17]Although the author agrees with this way of aggregating the flow of labor, it does not seem to fall in line with the previous recognition of the differences in the potential labor as shown in the weighting scale used to aggregate the stock of labor. Just as an aggregate stock of labor is obtained in terms of man-equivalents, one would expect man-equivalent hours or days to be generated as a flow measure. FMDCAS fails to do so. However the contribution of children and the elderly in major agricultural activities will be shown to be minimal, so that the measure of the flow of labor is not affected substantially.

In the final analysis any conversion scale of female, elderly and child labor to man labor units is open to bias.

The pattern of labor use and availability in agriculture is determined by a number of factors. These include: (1) the composition of the total labor supply available; (2) the availability of labor originating from outside the family farm; (3) the seasonal nature of the demand for labor with respect to the types of cropping systems used by farmers; (4) technological innovation; and (5) the importance of nonagricultural activities and the opportunities for off-farm employment [Cohen, 1980]. The present section examines the effect of the seasonality of the demand for labor in all household activities on the availability of labor for intensive cultivation of rice at the Office. First, a profile of the sample population is given to throw light on farm families' characteristics proper to the Office settlement. Second, the profile of labor use in rice, livestock, general farm activities and off-farm occupations is discussed before considering the implication for intensification of rice cultivation at the Office.

2. Profile of the Sample Population

a. Family Size Composition and Farm Sizes

The total population in the sample amounted to 1,023 individuals leading to an average family size of 10.6 persons (standard deviation 8.6).[18] An attempt was made to correlate the farm size with different

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[18]O.N. records for 1979-80 show a total population of 54,110 people present in the settlement, composed of an active population (15 to 50 years) of 36,006, with a total of 12,595 working men in 4,985 families scattered in 138 villages [Service Agricole, O.N. 1980]. For this analysis all selected families (including those with holdings above 15 ha) were studies.

expressions of the family size. These were respectively the total family population, the number of working men[19] and man-equivalents available in the family. The results are shown in Table 4-14.

TABLE 4-14. Correlation of Family Size Variables With Farm Sizes for the Sample Population

Family Size Variables	Total	Average per Household	Correlation with Farm Size
Family population	1023	10.6 (8.6)[a]	0.39
Number of working men	270	3.03 (2.5)[a]	0.64
Number of man-equivalents	650.4	7.3 (5.5)[a]	0.67

[a]Standard deviation.

Family population is the least correlated to the size of holding because its composition in terms of number of males of working age is variable.[20] The average number of working men in the sample is 3.03 per family; its correlation to the farm size is slightly less than that between farm size and the number of man-equivalents. The latter is shown to be 7.3 per family. Although the allocation of land is based on the number of working men per family when settlers are installed,

[19]The O.N. management uses a "working-man" as the unit for measuring the stock labor available within settlers' households. Working men, however, refer only to the number of adult males between 15 and 55 years.

[20]The allocation of land is based on the number of adult males present in the family.

readjustment of holding sizes to changes in family size and composition are not always implemented. Therefore as family sizes increase both in terms of total population and the size of labor force available, a cross section examination of the sample at a particular point in time is likely to indicate a relatively lower correlation between holding sizes and the number of working men.

b. Labor Force Ratio in the Sample Population

The labor force ratio is a measure of the proportion of economically active members in the family. Because the Office only refers to the number of working men in sizing up the stock of manpower, it is necessary to contrast this measure with one based on the number of man-equivalents. This is done with the view to assess the degree of understatement of the size importance of the labor stock in O.N. reporting. The results are shown in Table 4.15 which depicts the distribution of the sample population by sex and age group along with the two measures of the labor force ratio. Families' sizes were stratified in three groups of less than 7, 8 to 15 and over 15 people in order to assess the possible differences between small and large families[21] in the amount and the use of labor.

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[21]A small household in the O.N. settlement consists of a male head, his wife or wives, and children. The average number of people in this group was around 7. Medium and large households generally consist of a male head (the colonist), his wife or wives, their children, brothers of the colonist and their wives. In some cases the colonist has one or more old sons with their wives living in the same compound. The demarcation between medium and large households was obvious but arbitrarily set at 8 to 15, and above 15 persons. There were 15 households (out of 96) of large size ranging from 16 to 48 members, with an average of 28 members.

TABLE 4-15. Sample Population: Distribution by Age and Sex and Labor Force Ratio

	(10) Under 10	(2) 10-15	(3) 16-60	(4) Over 60	(5) All age	Labor force ratio[a] % A	B
Small households							
(a) males	9	9	54	2	74		
(b) females	11	8	50	3	72	37	79
(c) total	20	17	104	5	146		
Medium households							
(a) males	66	37	118	8	229		
(b) females	56	32	130	12	230	26	64
(c) total	122	69	248	20	459		
Large households							
(a) males	76	30	98	2	206		
(b) females	65	34	108	5	212	23	58
(c) total	141	64	206	7	418		
Total sample population							
(a) males	151	76	270	12	509		
(b) females	132	74	288	20	514	26	63
(c) total	283	150	558	32	1023		

[a]Ratio A is 3(a)/5(c). Ratio B is 3(c) plus half the values in 2(c) and 4(c) divided by 5(c). For instance ratio A for small households is 54/146 = 0.37 and ratio B is (104 + 8.5 + 2.5)/146 = 0.79. The number of man-equivalents is not adjusted here for time involvement in off-farm activities.

Although the age bracket (16-60) used to classify adult males in Table 4-15 is 5 years above the Office's definition,[22] the results are self-explanatory. Restricting the measure of the labor force to the number of working men as it is currently done at the Office, results in a substantial understatement of its size. The data indicate a ratio of 1 to nearly 2.5 when the labor stock is measured in terms of man-equivalents. Stratification by family sizes also reveals a particular feature: there is more manpower (in percentage terms) available for farming in small households than in large ones. This is true for both measures of the labor force size (ratio A and B). Thus if households are viewed in terms of the number of consumption versus work units, the results of Table 4-15 indicate that medium and large families are also associated with a relatively larger number of consumption units. These results are important for the determination of upper limits of labor available by size group and its implication as one examine the introduction of more labor intensive production techniques.

3. Percentage Distribution by Type of Labor in Rice and Nonrice Activities

a. Labor in Rice and Nonrice Activities

The total labor contributed by males, females, youth and children (both family and hired labor) in rice production, livestock activities, general farm and off-farm activities was calculated in percentage terms

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[22]In which case the labor force ratio A is a little overstated.

to assess the degree of specialization (if any) in the utilization of labor at the Office du Niger. The results are shown in Table 4-16.

Although specialization of adult male and female's labor according to task does not appear pronounced, certain differences can be observed. Adult males contribute nearly 55 percent to the total labor in rice production, while 27.4 percent is brought in by adult females. If youth males are included, total male labor increases to 62.2 percent.

Eighty-four percent of livestock activities are performed by men. The contribution of women's labor in both general farm and off-farm activities is also substantial and higher than their inputs of labor in rice activities. Their mean contribution in these two types of activities was estimated at approximately 40 percent.

Table 4-16 also illustrates the relationship between household size and labor allocation by type. There seems to be a slight downward trend in the percentage contribution of adult males and females in rice and livestock activities as the household size increases. This appears to indicate the increasing role of youth and children's labor in large households, although the trend fails to be firm. The contribution of children is the highest in livestock activities (9.2 percent) because they play an important role in guarding and herding of livestock.

b. Division of Labor by Task in Rice Production Activities

Rice activities were grouped in five broad categories as shown in the farm tables (see Appendix A). These were respectively land

TABLE 4-16. Percentage Distribution in Rice, Livestock, General and Off-Farm Activities by Types of Labor[a]

	Rice				Livestock				General farm activities				Total farm activities				Off-farm activities			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Adult males 16 to 60	56.3	56	53	55.5	81.2	71.1	65.0	73.3	49.6	49.9	50.3	49.8	51.8	50.8	52.2	51.4	58.5	49.7	52	53.0
Adult females 15 to 60	29.1	26.9	25.4	27.4	6.7	5.7	6.0	6.1	37.8	39.2	37.2	38.4	35.7	32.3	30.7	33.1	35.3	40.7	38.4	38.5
Youth Males 10 to 15	6.0	5.1	12.0	6.7	8.6	8.4	20.4	10.7	2.1	1.7	4.8	2.4	4.2	4.7	10.0	5.5	3.0	2.1	5.4	3.0
Youth females 10 to 15	4.4	6.0	4.1	5.1	0	0.7	1.6	0.6	3.2	5.3	5.9	4.7	4.6	6.6	4.7	5.6	2.2	3.2	3.2	2.8
Children under 10	3.2	6.0	2.7	4.7	3.5	14.1	7.0	9.2	7.3	3.9	1.8	4.7	3.7	5.6	2.4	4.4	1.0	4.3	1.0	2.6
Elderly[b] over 60	1.0		2.8																	
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

[a]Headings (1), (2) and (3) refer to small, medium and large households; (4) is the overall weighted average.

[b]Calculated as a residual.

preparation, sowing, cultivation including weeding and thinning, harvesting and stacking.[23] All remaining tasks were grouped as miscellaneous activities.

As illustrated in Table 4-17 some degree of specialization in rice activities can be inferred. For instance, land preparation, sowing and cultivation appear to be typical males' activities. This is substantiated by a high proportion of labor they contribute to these activities and the low degree of variation implied in the ratio of means to their standard deviations. Adult women contribute the most in harvesting and related activities with nearly 50 percent of the total labor required. When labor inputs from youth females is accounted for, the overall female involvement in harvesting raises to 56 percent.

Low percentage values and high standard deviations in all pre-harvest activities strongly indicate that adult females' participation in these activities is casual. For instance their involvement in cultivation/weeding is only 4 percent. This is contrary to what has been recently reported for southern Mali where women's labor in weeding is 19 percent higher than of males [Cohen, 1980]. Whether this is linked to a particular tradition in the O.N. cannot be substantiated here.

Table 4-17 also singles out the individual contribution of the head of household (colonist) in rice activities. There is a declining trend in the colonist participation in all field activities as family sizes increase. Thus the importance of the colonist as a contributor to

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[23]Including transportation of the harvest, manual threshing, gleaning of fields and post-harvest treatment.

TABLE 4-17. Percentage Distribution in Rice Activities by Types of Labor

					Sowing				Cultivation-Weeding				Harvesting-Stacking				Miscellaneous			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Adult males 16 to 60	74.8 (32.4)	68.0 (39.2)	68.7 (28.0)	70.4	84.0 (27.5)	84.6 (29.9)	94.7 (39.8)	86.3	86.1 (47.7)	87.8 (40.9)	81.6 (29.8)	85.8	32.2 (16.6)	34.3 (19.8)	42.8 (30.0)	35.1	70.4 (47.0)	61.1 (50.0)	75 (64.4)	66.7
of which the colonist	47	32.6	23.9	35.8	67.3	65.7	31.5	60.2	62.6	48.7	23	48.3	20.3	17.2	13.7	17.5	49.7	28.1	24.4	34.5
Adult females 16 to 60	12.3 (16.6)	5.8 (9.0)	4.5 (6.2)	7.7	6.3 (14.3)	5.1 (17.7)	3.1 (7.0)	4.6	5.8 (15.4)	4.1 (7.8)	1.8 (3.9)	4.2	51.4 (24.4)	50.7 (19.7)	41.0 (19.8)	49.1	10.2 (15.4)	23.8 (46.3)	6.7 (6.7)	16.1
Youth males 10 to 15	7.3 (4.6)	8.2 (7.9)	16.9 (10.1)	9.5	2.7 (3.5)	2.4 (4.2)	1.0 (0.8)	2.2	6.1 (4.4)	4.5 (4.0)	13.3 (6.7)	6.6	4.9 (4.2)	3.5 (1.8)	8.3 (4.7)	4.8	8.6 (10.7)	4.6 (8.2)	14.8 (11.7)	7.8
Youth females 10 to 15	2.5 (4.0)	6.1 (6.0)	6.2 (4.7)	4.9	1.5 (0.4)	3.2 (2.7)	0.2 (0.2)	2.1	0.8 (0.8)	1.9 (1.2)	1.3 (1.1)	1.4	7.1 (6.0)	6.6 (7.8)	5.7 (6.9)	6.6	1.6 (2.5)	4.4 (6.5)	1.2 (1.2)	2.9
Children under 10	8.1 (9.6)	11.3 (10.3)	3.7 (1.2)	8.8	2.5 (1.8)	4.7 (4.6)	0 (-)	3.1	1.2 (1.1)	2.3 (2.6)	2.0 (2.9)	1.9	2.0 (3.8)	4.9 (7.4)	2.2 (5.2)	3.4	5.2 (4.8)	6.1 (7.9)	2.3 (3.8)	5.1
Elderly above 60[b]	---	0.6	---		3.0	---	1.0	1.7	0				2.2	---			4.0	---	---	1.4
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

[a]Numbers (1), (2) and (3) refer to small, medium and large households respectively; (4) = overall average weighted by the number of households in each size group.

[b]Contribution by the elderly was calculated as a residual.

production activities is strongly felt only within small families. Availability of other adult male labor in large families seems to alleviate the colonist role.

Youth males and children contribute their largest share of labor in land preparation tasks. This is due in particular to the requirement of oxen cultivation in which youth and children as well guide the animals and follow them with a whip while one adult male holds the plow handle. Youth females provide their largest contribution (nearly 7.0 percent) in harvesting and related activities.

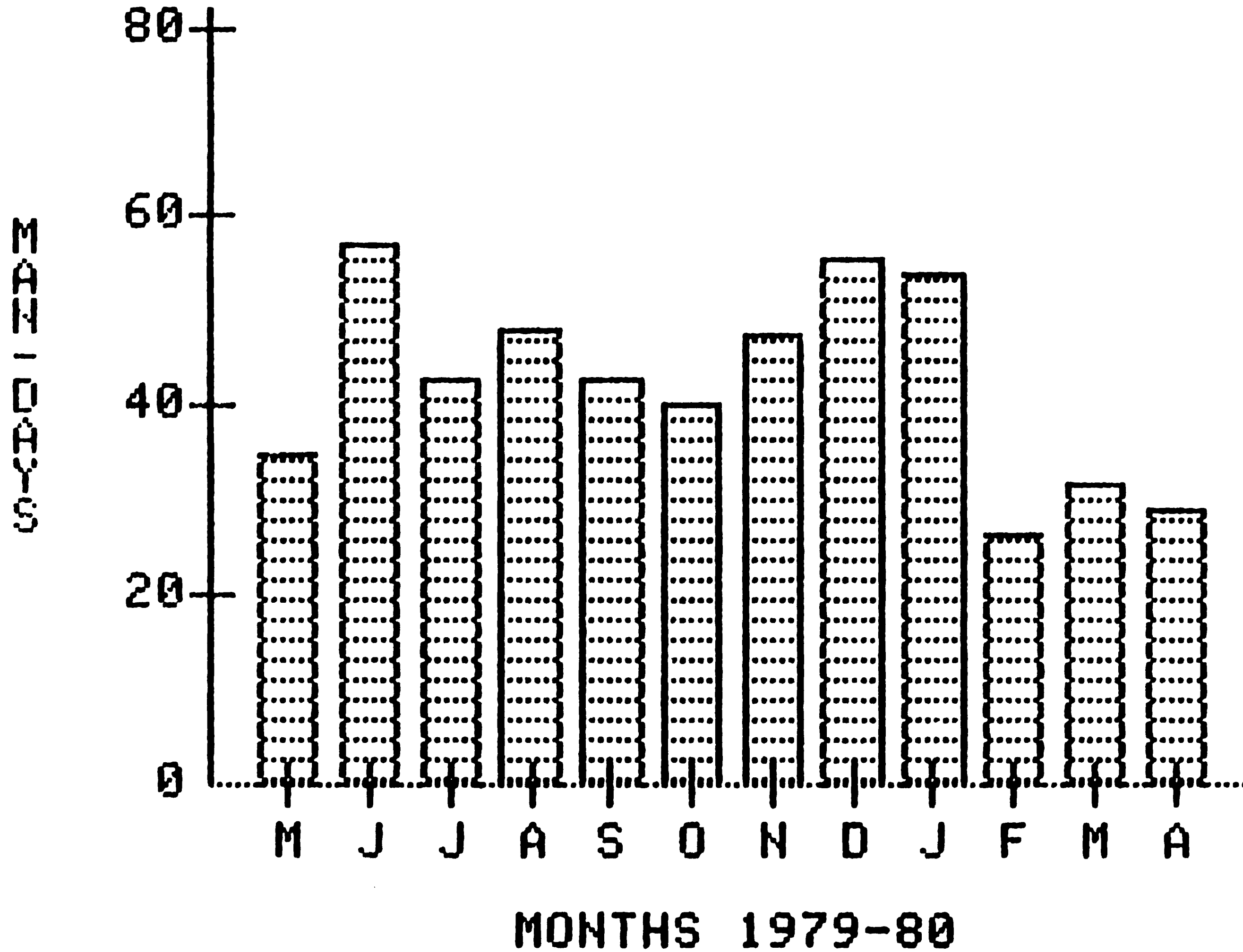
4. Seasonality of Labor Use

a. Monthly Distribution of Labor in Rice Production

Rice being the most important enterprise, the pattern of labor use in other activities is influenced by the demand for labor in rice activities. Farming practices for rice cultivation were described in Chapter 2 and labor requirements by task for the production of one hectare of rice are presented in Chapter 5. In this section, only mean labor inputs per month are shown for the three size groups of households. The monthly distribution of labor used in rice is illustrated in Figures 4-1 (a, b and c).

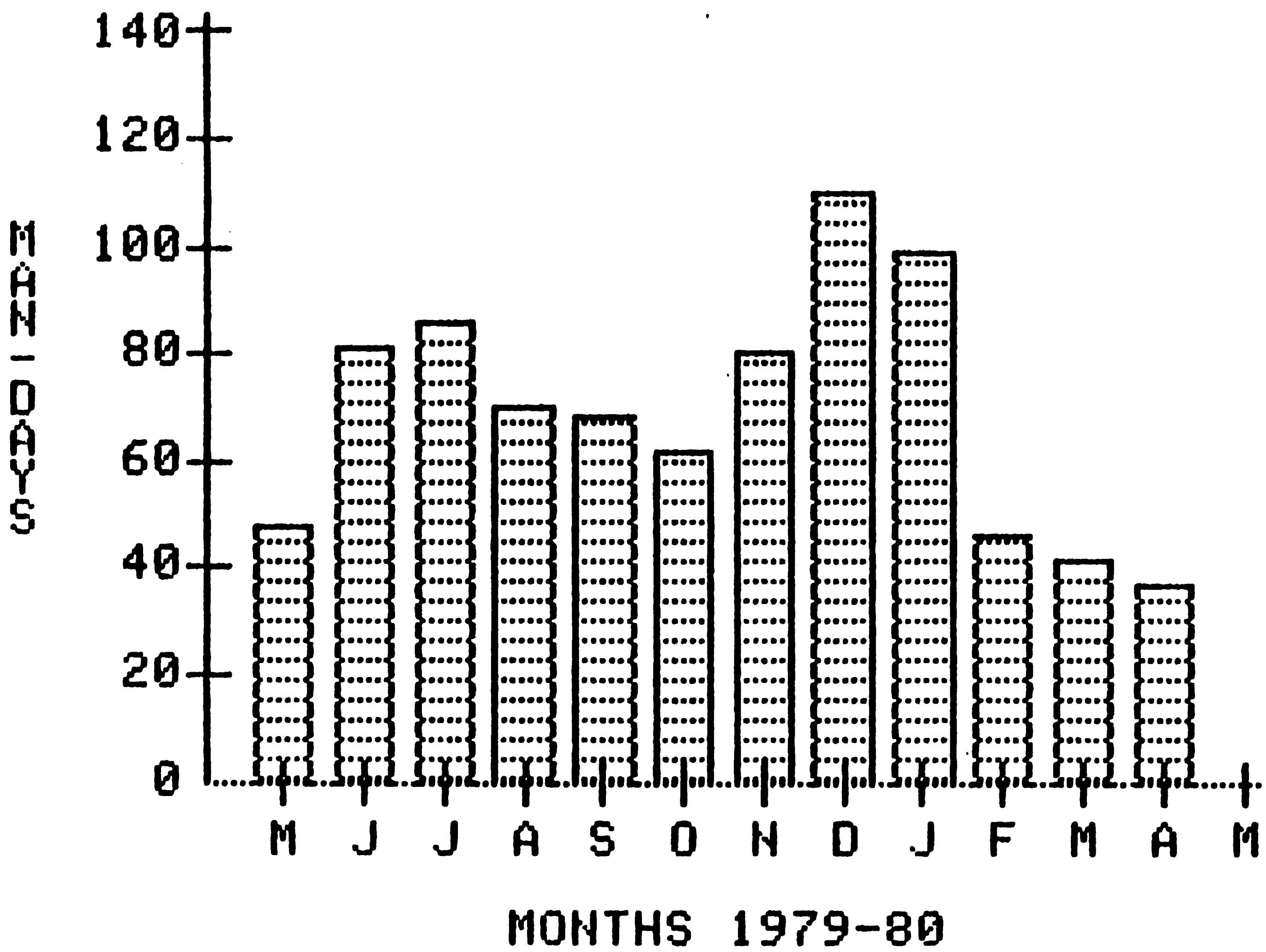
Labor use shows greater seasonality within medium and large families than within small households.[24] In general the use of labor in rice production peaked at two separate periods of the cropping season. First,

[24]A possible explanation could be that there are more consumption units than work units in medium and large families compared to small families as shown by low labor force ratios discussed earlier. This creates a relative scarcity of labor in large households.



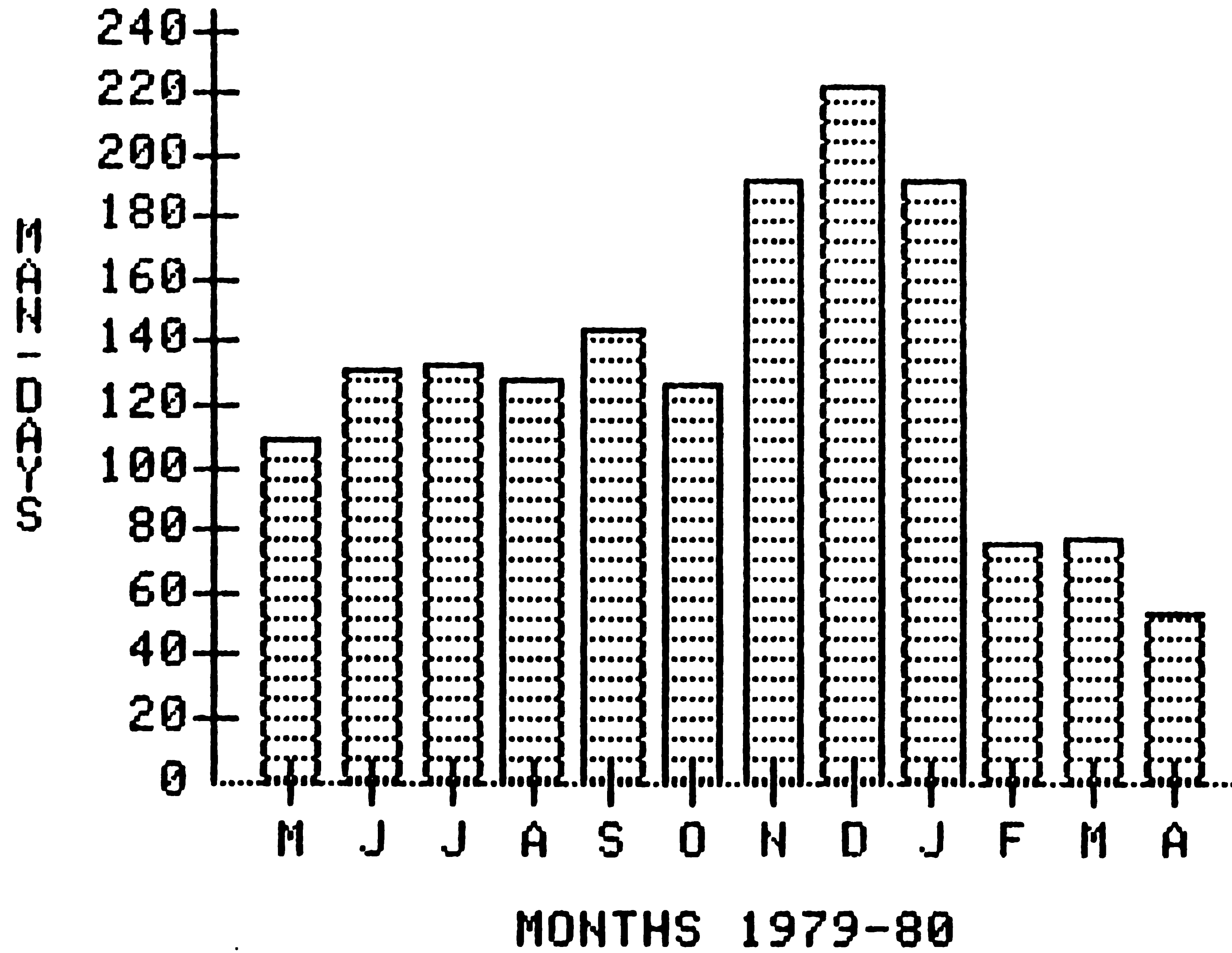
Labor Profile in Rice Production for Small Families

FIGURE 4-1a



Labor Profile in Rice Production for Medium Sized Families

FIGURE 4-1b



Labor Profile in Rice Production for Large Families

FIGURE 4-1c

in June and July which correspond to an increased demand for labor in land preparation and second, during the harvesting months of November through January. Thus harvesting can be considered the most critical of rice activities in terms of both the amount of labor demanded and the duration of the peak period. The highest labor demand occurs in December.[25] The mean labor requirements for this month were estimated at 55.6, 109.8 and 221.5 man-days respectively for small, medium and large families. This translates into an average of 5 hours daily per adult in small families, 6 and 5.5 hours in medium and large families, respectively.

As to the duration of the harvesting period, guidance and recommendation from the Office extension service call for harvesting to be started at three-quarters maturity of the paddy which occurs usually in mid-November. However with the work carried out manually and because holdings are large compared to those of farm families outside the Office, a good part of the crop ends up being harvested after December, at a time when much of the hired labor also becomes available.

A third peak period may occur in August, September or October depending on the frequency of weeding, thinning and other care cultivation practices by family members. This appears to be the case for large households as shown in Figure 4-1c.

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[25]Except for small sized families where the highest demand occurs in June (57.2 man-days), which is slightly above the December peak of 55.6 man-days.

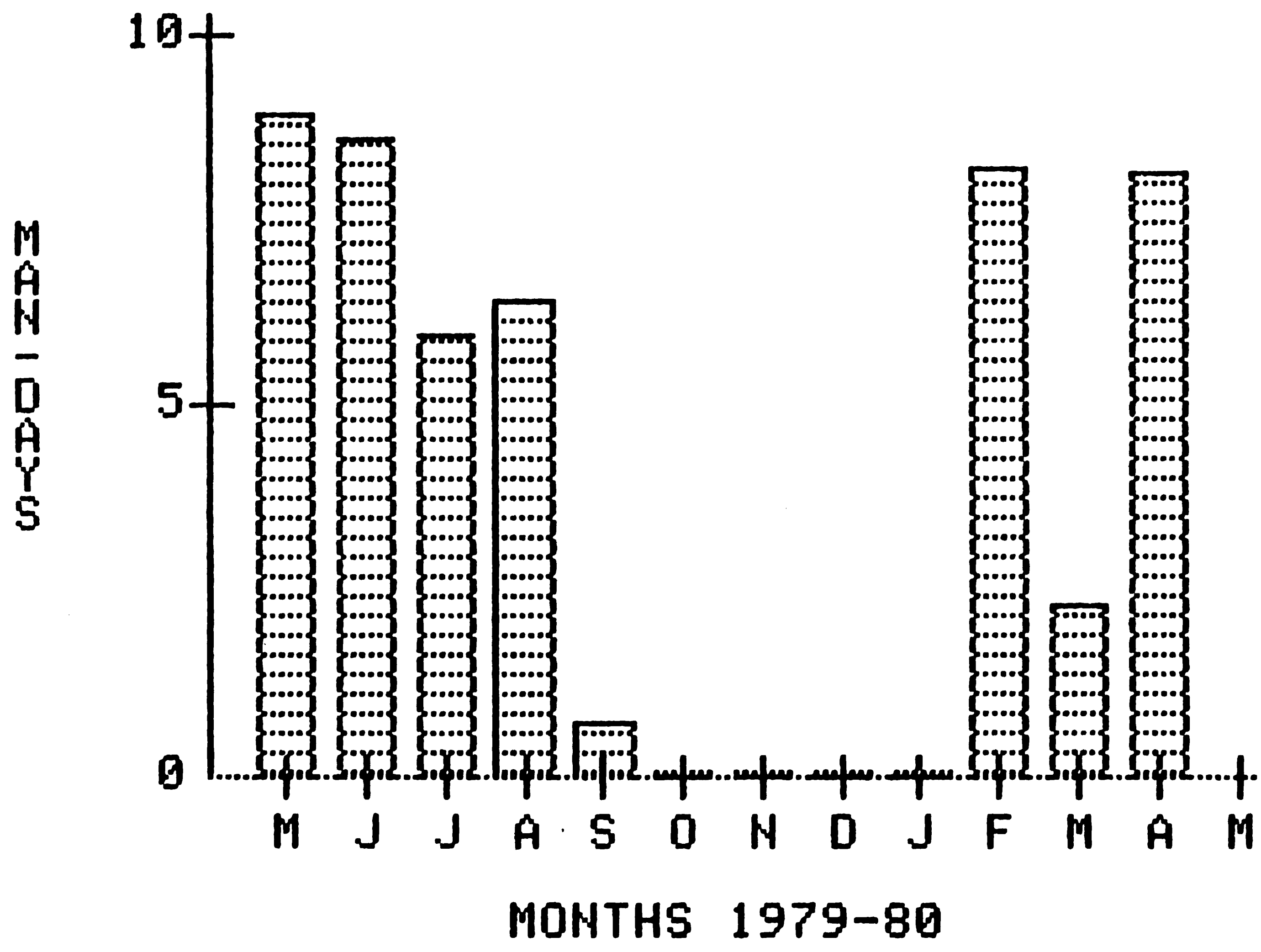
[26]Most laborers are coming from millet-growing areas and migrate to the Segou rice zones after they finish harvesting their own fields.

The slack period in rice cultivation occurs during the months of February, March and April, as families use much of their labor in general farm activities and/or nonrice activities, some with opportunities for income generation.

b. Monthly Distribution of Labor in Livestock Activities

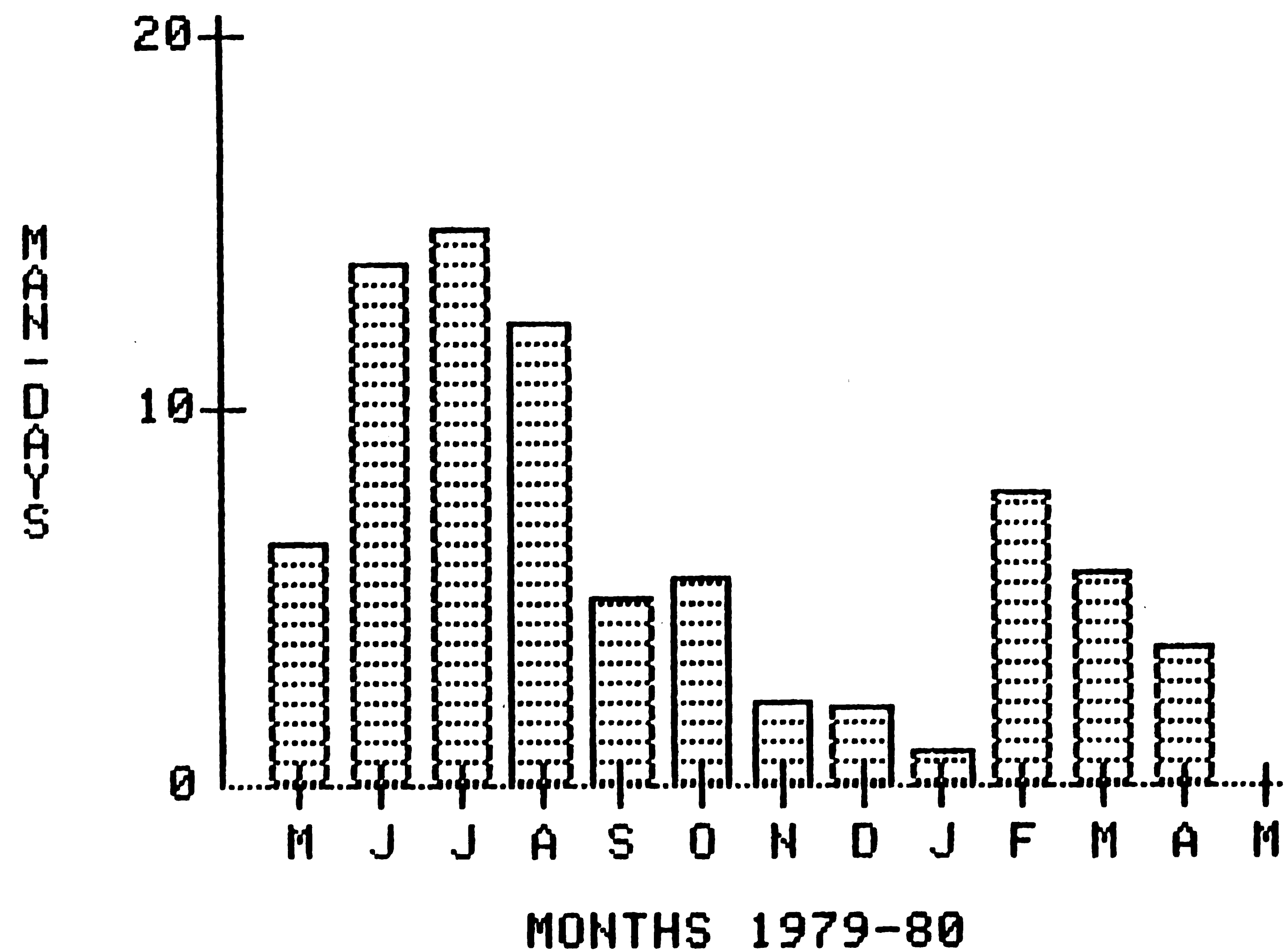
Figure 4-2 (a, b, and c) depicts the seasonality and the mean monthly labor requirements in livestock activities on O.N. farms. Contrary to rice activities, there is a greater seasonality in the use of farm labor for livestock activities, for small and large households alike. Although the single most important factor determining the seasonal nature of demand for labor is rainfall and its distribution, the pattern of labor demand in rice activities also has an influence on the seasonality in livestock labor demand, as explained below.

At the beginning of the rainy season in May through July, longer grazing of the animals is practiced by most households. This period corresponds to the peak labor demand for land preparation, raising opportunity for conflicts in the allocation of labor despite the fact that livestock production takes a secondary role in the Office. It is however the labor demand for rice in weeding, and harvesting from August through January which cause a drastic decline in the amount of time allocated to cattle. A second peak in the demand for labor in livestock activities occurs shortly after January, which corresponds to slack periods in rice cultivation. The extra time worked with the cattle and small ruminants during this dry period usually involves on-farm care of animals (for instance feeding, veterinary care, milking and so on) as grazing becomes limited due to lack of green grass (_gramineas_).



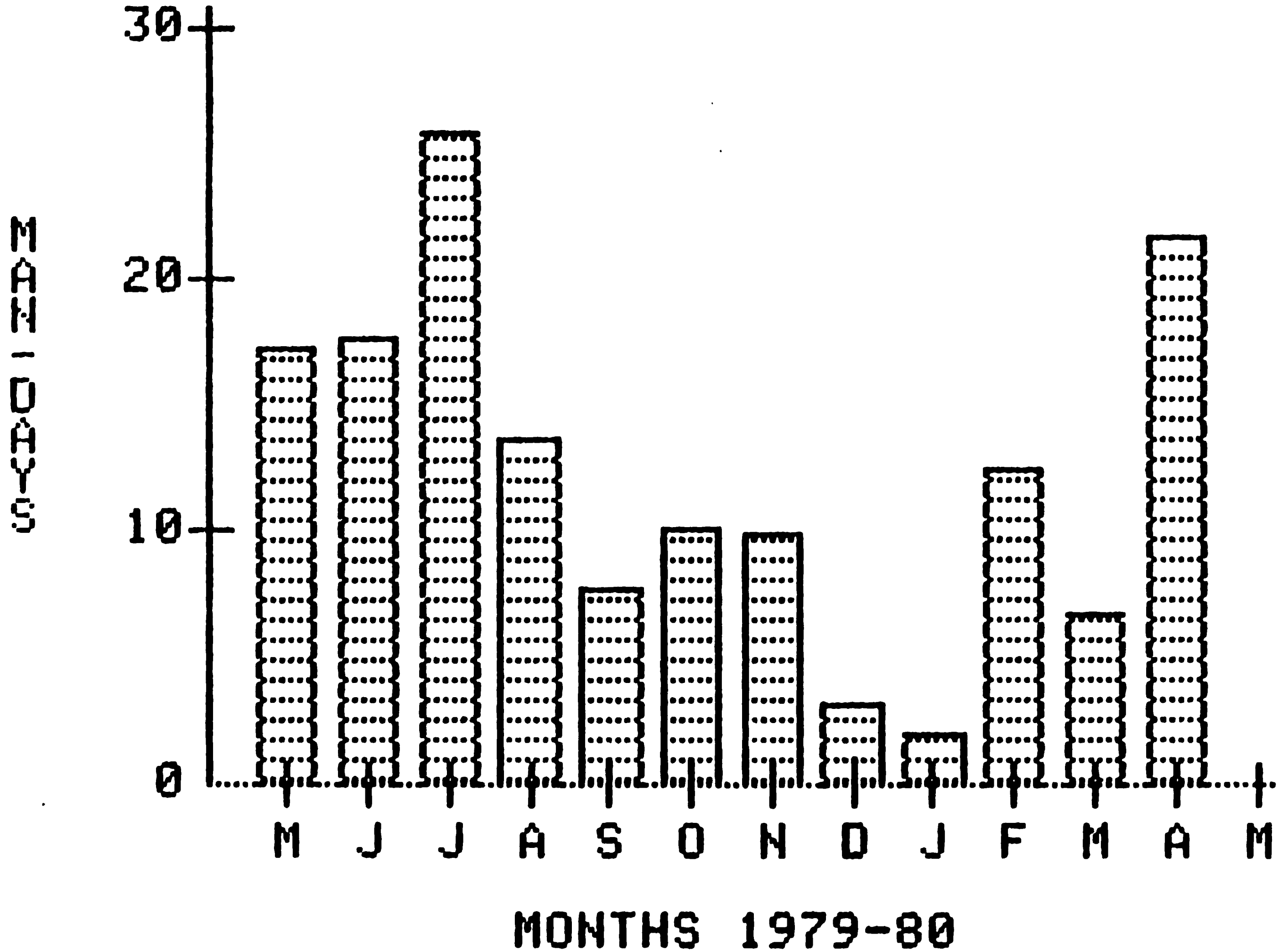
Labor Profile in Livestock Activities for Small Families

FIGURE 4-2a



Labor Profile in Livestock Activities for Medium Sized Families

FIGURE 4-2b



Labor Profile in Livestock Activities for Large Families

FIGURE 4-2c

In any case when compared to mean labor used for rice production, families' involvement in livestock is minimal. For instance for large households, the highest labor demand for livestock in July amounts only to 25.7 man-days, nearly one hour of work, daily and per adult member.

c. Monthly Distribution of Labor in General Farm and Nonrice Activities

General farm activities were defined earlier as those which could not be directly credited to either rice or livestock enterprise, but which contributed to the profitability of the farm business. In the O.N. context, such groups of activities include transportation of farm supplies, building maintenance and repairs, marketing of farm produce, fishing, hunting as well as some typical household activities. As illustrated in Figure 4-3 (a, b, and c), there is a steady increase in general farm activities from the beginning of the season and a unique peak period occurs after January, the slackest period in rice production. In terms of magnitudes of monthly labor demand, general farm activities constitute after rice the second most important group of occupations to which households devote their time.

Off-farm occupations include all nonrice activities and household members' involvement in garden plots and vegetable production. The trend shown in Figure 4-3 illustrates the constancy of the demand for labor in off-farm occupations with no perceptible seasonality. Monthly labor requirements for off-farm activities however are higher than those for livestock activities in all three size groups of households.

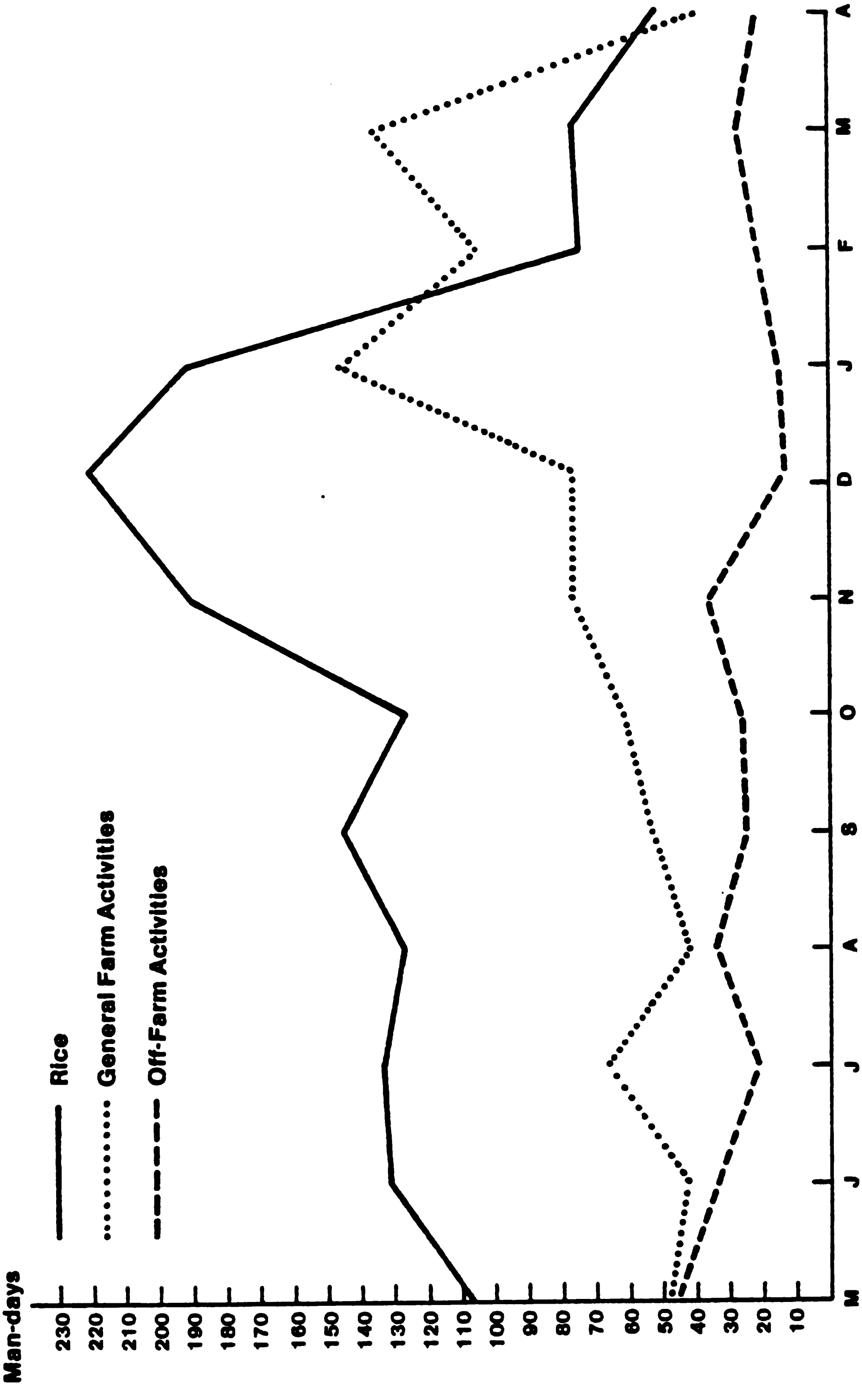


FIGURE 4.3a
Seasonality of Labor In Rice, General Farm and Off-farm activities
for Large Households

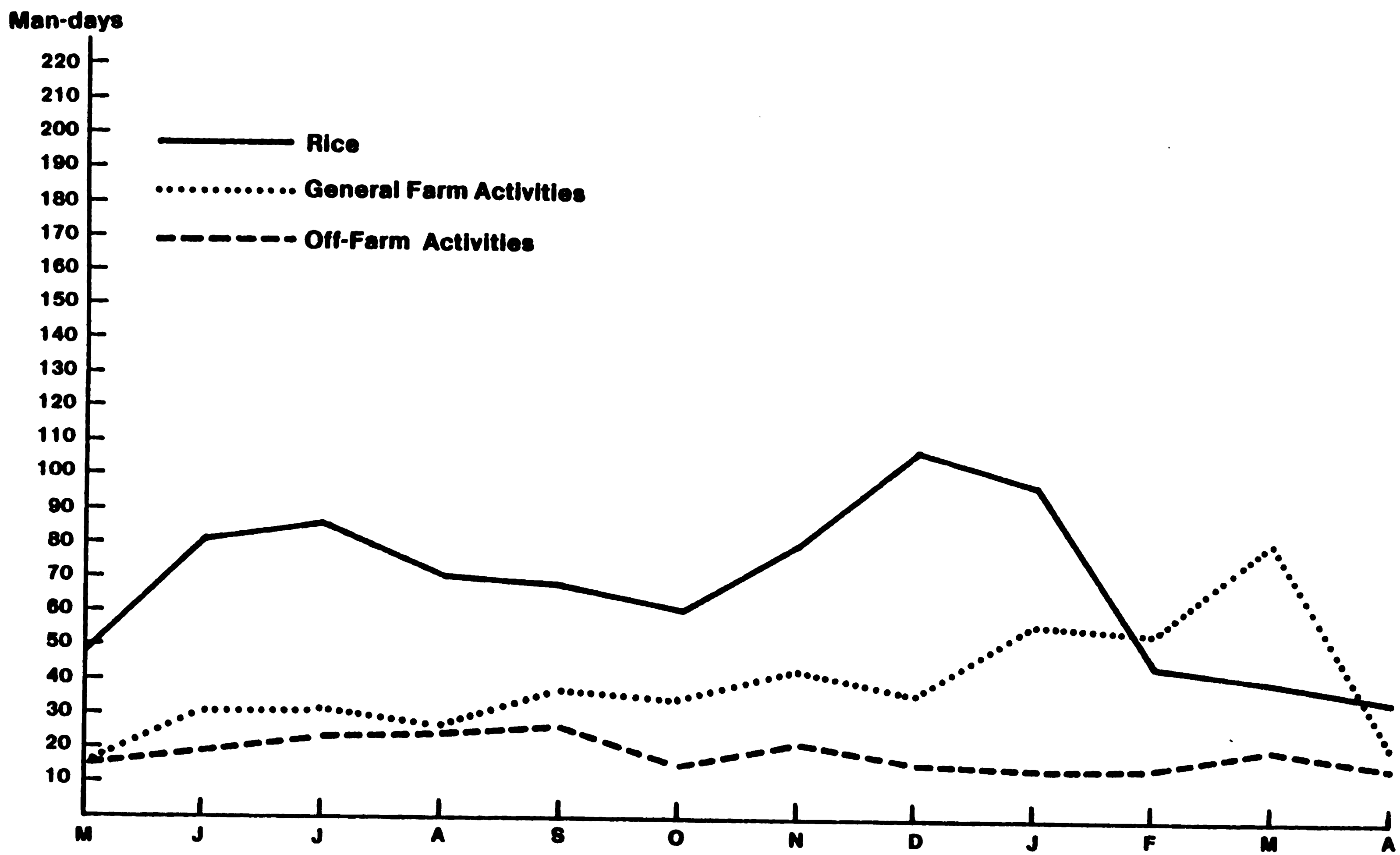


FIGURE 4.3b

Seasonality of Labor in Rice, General Farm and Off-Farm Activities for Medium sized Households

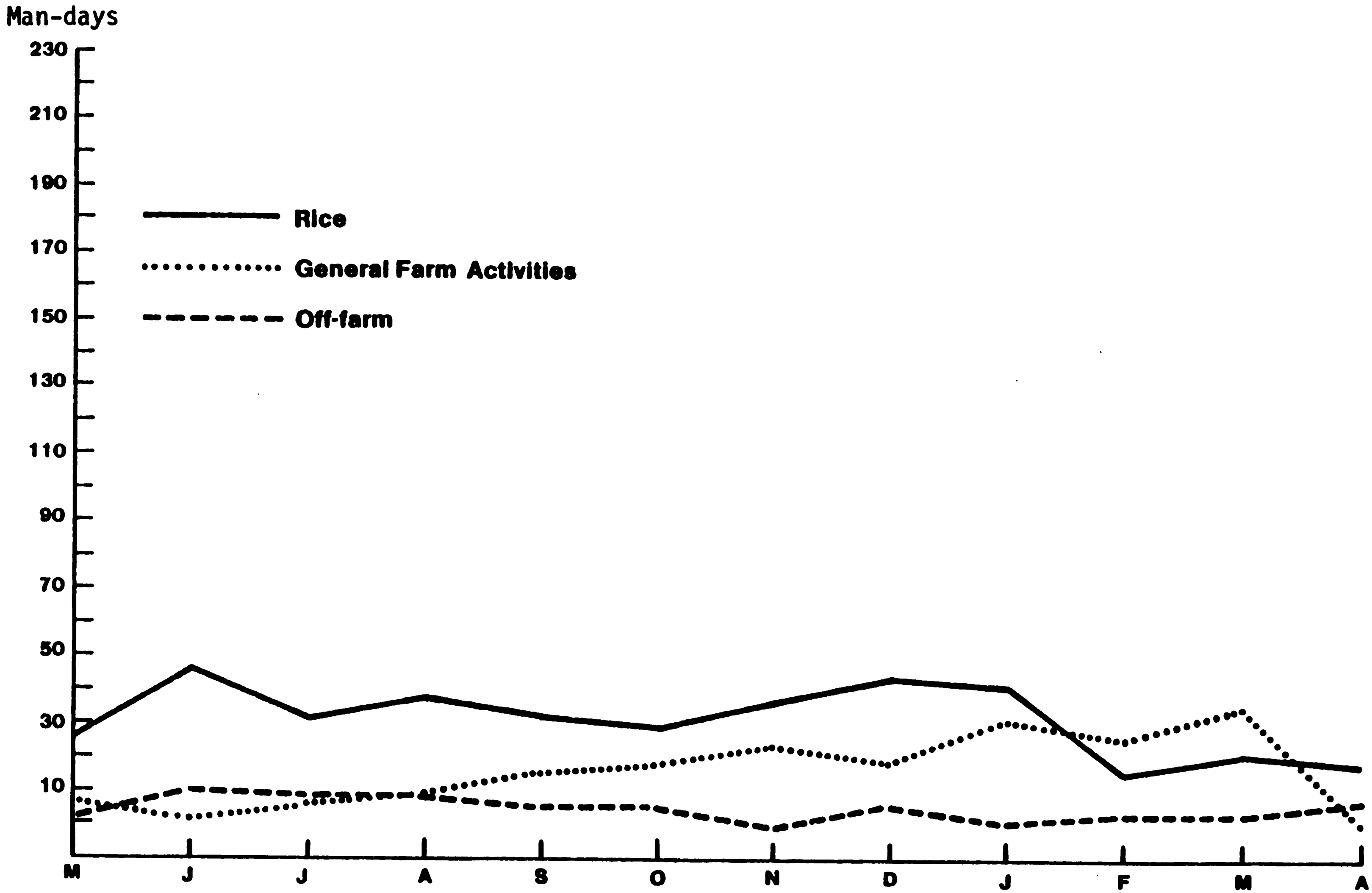


FIGURE 4.3c
Seasonality of Labor in Rice, General Farm and Off-Farm Activities for Small Households

5. Total Household Labor Demand and Intensification of Production

The monthly distribution of total household labor use is depicted in Figure 4-4 (a, b, and c). The three histograms were derived from Table 4-18 to illustrate the current level of labor demand as determined by rainfall and its distribution, the requirements of the present cropping and livestock systems, the prevailing technology and the competing nonfarm claims on family labor.

On the supply side labor availability is determined by the size of the labor force within households and the conventional duration of a normal working day. Issues related to the measurement of the stock and the flow of labor were discussed earlier and need no further elaboration here. Conventionally a working month is set at 25 days to account for weekends and varying lengths of the calendar month [FAO, 1977].[27] Household members are assumed to engage in productive activities for an average of 8 hours a day. This helps retain consistency with the working definition of a man-day used for the estimation of labor demand in this study.[28] The aim of any study of labor allocation and seasonality is to bring the supply and demand for labor into balance [Clayton, 1981].

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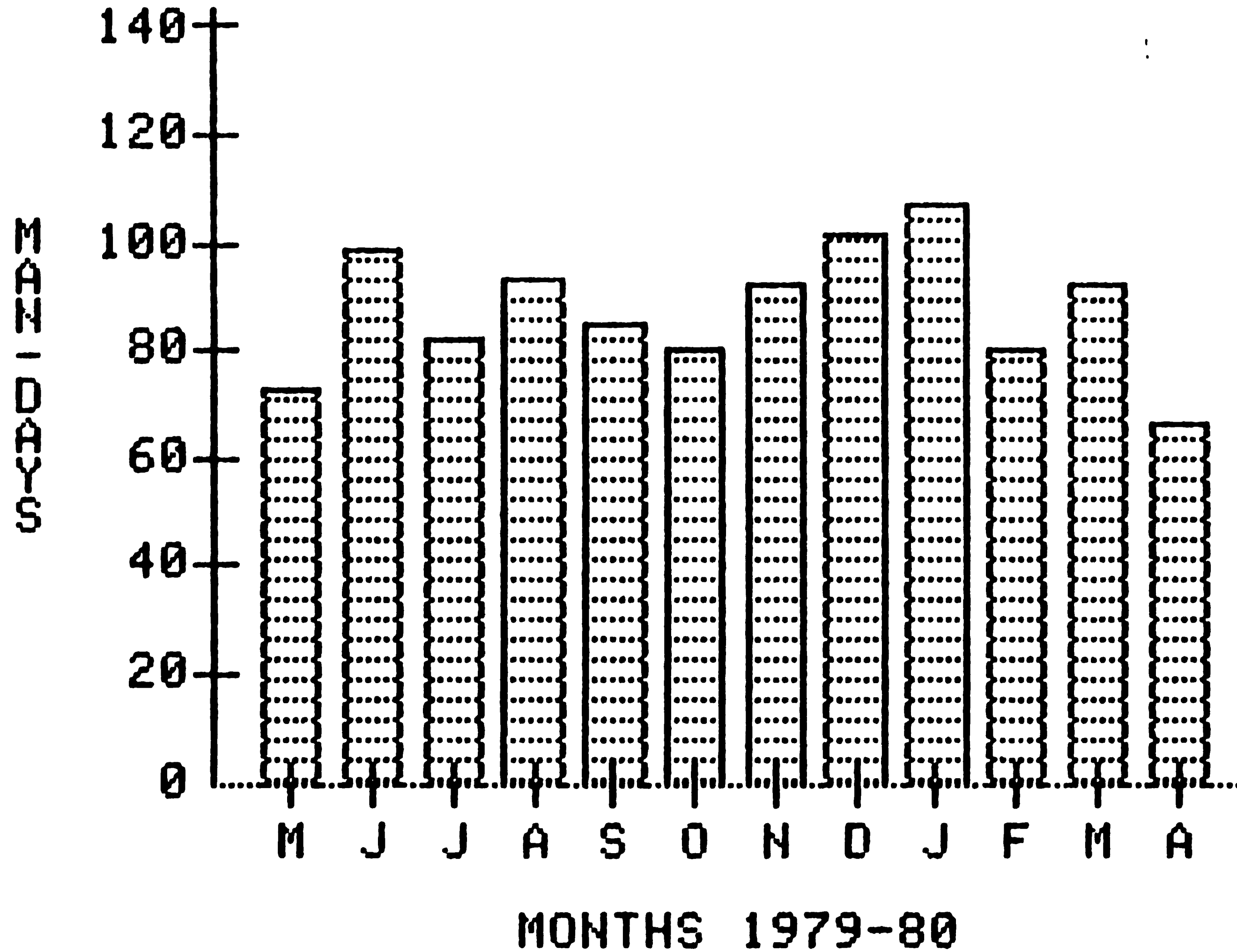
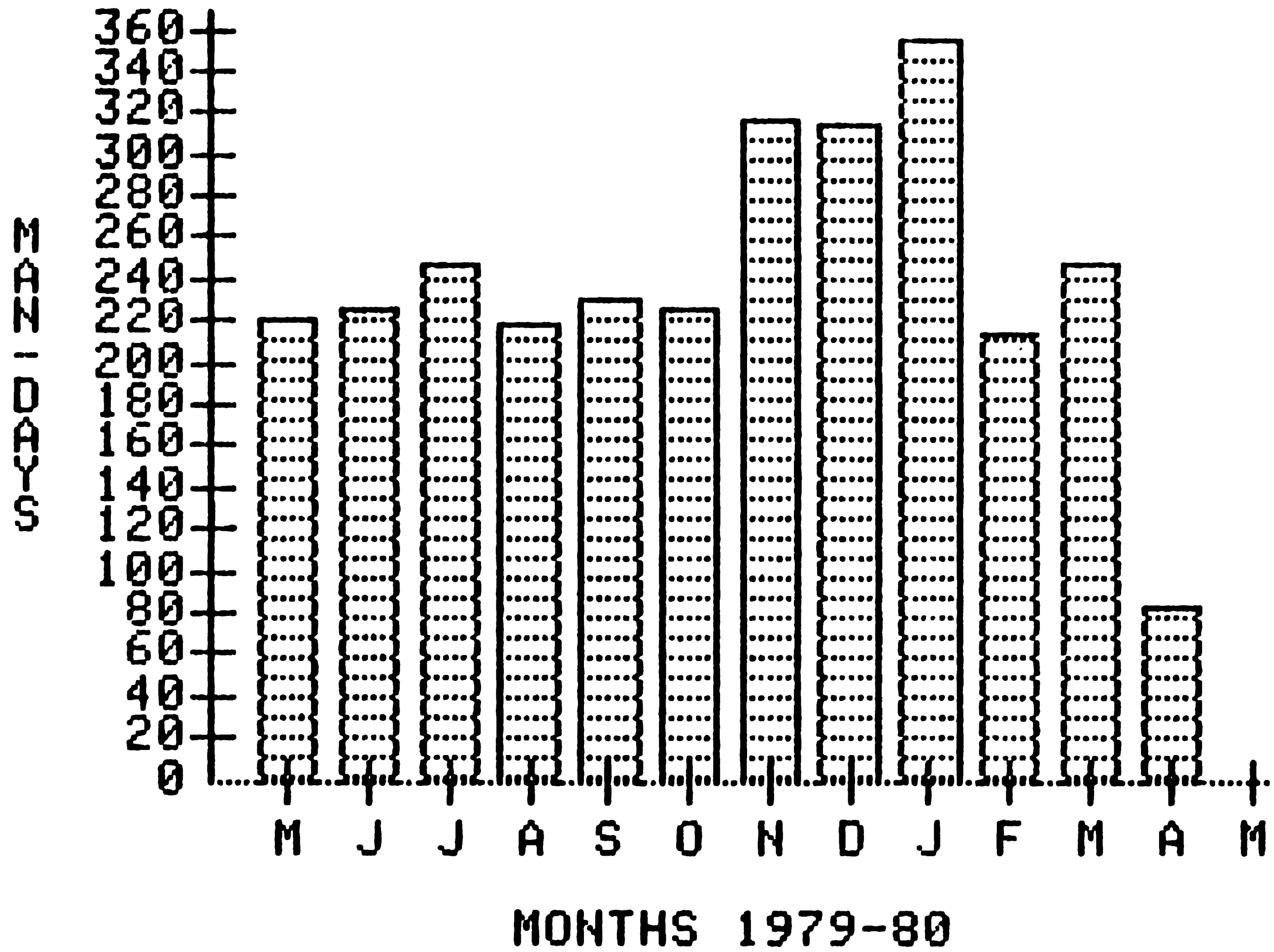
[27] This convention appeared to be relevant for the cultural environment in the Segou zone.

[28] In practice this may lead to an overstatement or understatement of the duration of a day of work. However consistency is maintained by expressing labor in homogenous man-days.



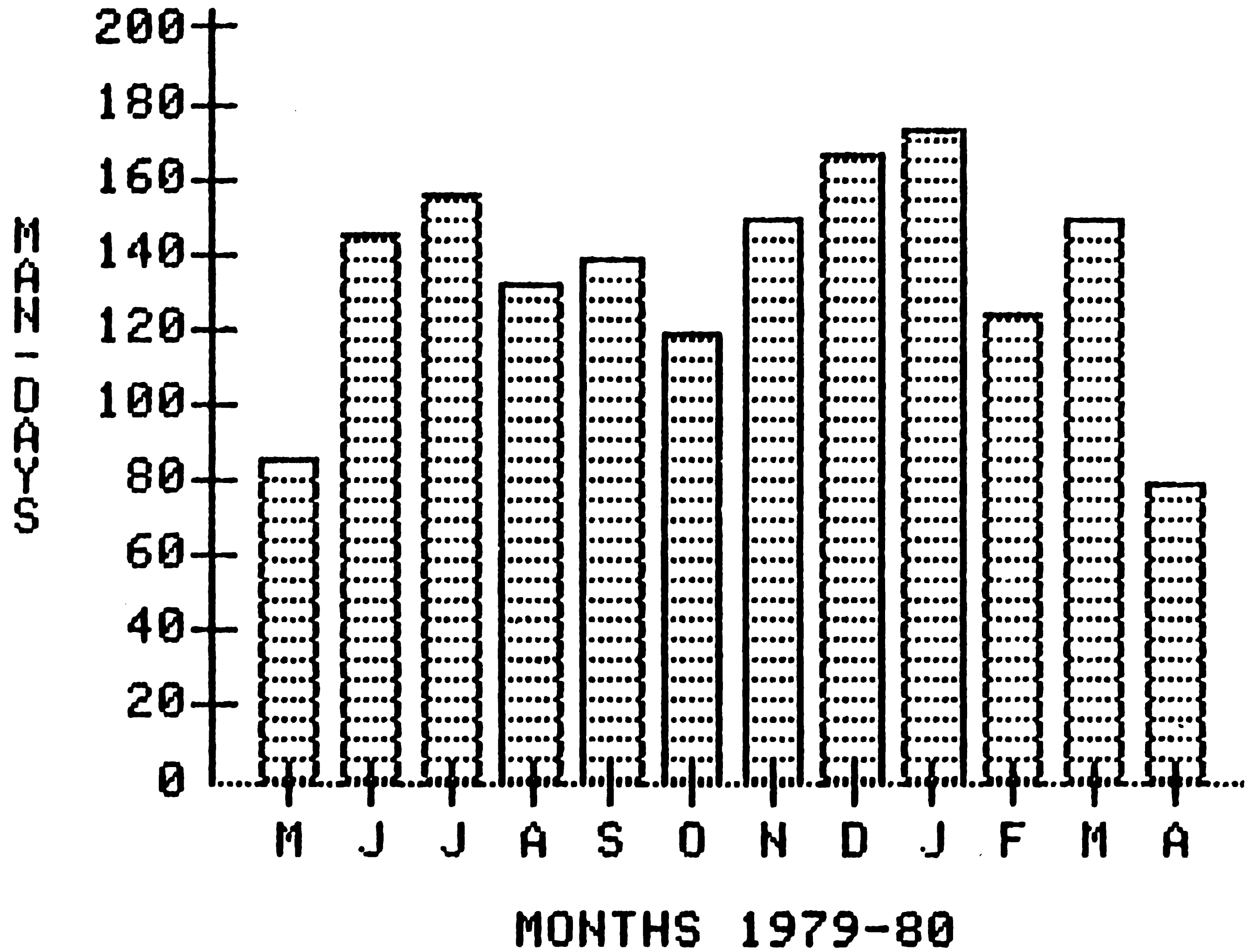
Seasonality and Demand for Total Household Labor in Small Families

FIGURE 4-4a



Seasonality and Demand for Total Household Labor in Medium Sized Families

FIGURE 4-4b



Seasonality and Demand for Total Household Labor in Large Families

FIGURE 4-4c

Almost by definition, improved practices when introduced in a traditional farming system will involve increased labor inputs.[29] The use of fertilizer, disease and pest control measures, the substitution of in-line for broadcast sowing, the adoption of transplanting techniques in rice cultivation, the harvesting of a large crop that improved practices make possible: all of these require more labor. For the Office du Niger the question to be asked is of the following nature: do farm families have the slack to supply the additional labor at the time needed if improved technologies are introduced?

To assess the size of any unutilized pool of labor that households could draw on, the following procedure was adopted. First, mean labor requirements in all activities are added up. This step was performed in the computations which led to the drawing of the histograms in Figure 4-4. Second, total monthly requirements are subtracted from the potentially available pool of labor in each month. The latter was calculated by multiplying the average number of man-equivalents available per household in each size group by 25 work-days per month. The mean number of man-equivalents per selected households was internally calculated

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[29]But some relationships are not always as expected. Clayton [1981] for instance reports that the introduction of rotary weeders into the rice fields of the Phillipines led to increased labor use whereas, on the experimental station, they substantially increased labor efficiency and hence required less labor. Spencer and Byerlee [1976] have shown that in a situation of high land-labor ratio mechanical technology can overcome peak season labor constraints and increase the acreage cultivated, but the increased acreage resulting from mechanization also requires added labor for planting and harvesting.

by the FMDCAS program and amounted to 4, 7 and 15 for small, medium and large households, respectively.[30] When multiplied by 25 work-days per month, this translates into 100, 175 and 375 man-days as upper limits of potential labor available in the three size groups. The results are shown in Table 4-18 (a, b, and c). For small households Table 4.18a illustrates the scarcity of labor available for accomplishing agricultural tasks particularly during the peak season of November through January. With an average of 4 man-equivalents this results into a labor deficit of 1.9 and 7.3 man-days during December and January respectively.[31]

Intensification of rice cultivation in the Office is likely to require a higher labor demand per hectare, and the mix of improved practices now available for adoption may also cause a change in the seasonal distribution of labor demand as well. Therefore any effort toward intensification in the Office must begin with a proper assessment of the expected increase in labor and its implications as to the size of the labor pool in small, medium and large families from which additional man-days of adult labor can be withdrawn.

Summary

The economics of farm production at the O.N. was presented taking the farm as a whole. The results of the farm analysis reveal a striking

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[30]The number of man-equivalents shown in Table 4.9 refers to farm families aggregated by size of holdings and not family sizes.

[31]It is this deficit which makes hiring of outside labor a necessity for removing labor bottlenecks at peak season. This will be demonstrated in Chapter 5 when rice enterprise budgets are calculated.

TABLE 4-18a. Derivation of Monthly Labor Inputs Available for Agricultural Intensification For Small Households in the O.N. Survey Area (Man-days)

Activities	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total year
Rice	34.6	57.2	42.5	47.9	42.7	39.9	47.4	55.6	53.6	26.2	31.5	28.8	507.9
Livestock	8.9	8.6	5.9	6.4	0.7	0	0	0	0	8.2	2.3	8.1	49.1
General farm activities	17.4	12.9	16.0	19.9	26.5	24.5	34.3	29.7	41.9	37.4	45.4	12.2	318.1
Off-farm activities	12.1	20	17.8	18.8	14.8	15.5	10.1	16.6	11.8	16.2	12.9	17.4	184.0
Total household	73.0	98.7	82.2	93.0	84.7	79.9	91.8	101.9	107.3	79.8	92.1	66.5	1,050.9
Total potentially available [a]	100	100	100	100	100	100	100	100	100	100	100	100	1,200.0
Balance [b]	27.0	1.3	17.8	7	15.3	20.1	8.2	-1.9	-7.3	20.2	7.9	33.5	149.1

[a] Derived by multiplying the mean of 4 man-equivalents (for small households) by 25 work-days assumed available per month.

[b] Total potentially available minus total household labor demand.

TABLE 4-18b. Derivation of Monthly Labor Inputs Available for Agricultural Intensification For Medium Families in the O.N. Survey Area (Man-days)

Activities	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total year
Rice	47.5	80.7	85.8	70.3	68.3	61.4	80.4	109.8	98.4	45.5	41.0	36.7	825.8
Livestock	6.4	13.8	14.8	12.2	5.0	5.5	2.2	2.0	0.8	7.8	5.6	3.7	79.8
General farm activities	16.5	30.7	31.6	25.5	38.7	35.2	43.7	37.4	58.6	55.1	81.8	22.4	477.2
Off-farm	15.4	19.7	23	23.8	26.0	16.4	22.1	17.6	15.7	15.3	20.4	16.3	231.7
Total households	85.8	144.9	155.2	131.8	138	118.5	148.4	166.8	173.5	123.7	148.8	79.1	1,614.5
Total potentially available [a]	175	175	175	175	175	175	175	175	175	175	175	175	2,100.0
Balance [b]	89.2	30.1	19.8	43.2	37	56.5	26.6	8.2	1.5	51.3	26.2	95.9	485.5

[a] Derived by multiplying the mean of 7 man-equivalents (for medium families) by 25 work-days assumed available per month.

[b] Total potentially available minus total household labor demand.

TABLE 4-18c. Derivation of Monthly Labor Inputs Available for Agricultural Intensification For Large Households in the O.N. Survey Area

Activities	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total year
Rice	108.1	131.3	132.7	127.5	144.5	126.0	191.1	221.5	191.7	75.1	77.1	52.7	1,579.3
Livestock	17.1	17.6	25.7	13.7	7.6	10.0	9.8	3.0	1.8	12.4	6.6	21.5	146.8
General farm activities	48.8	43.7	67.3	42.4	53.7	61.7	76.3	76.2	144.7	104.6	136.0	40.0	895.4
Off-farm	46.0	32.0	20.2	34.1	24.2	26.9	39.8	13.4	16.7	22.0	27.9	20.6	323.8
Total household	220.0	224.6	245.9	217.7	230	224.6	315	314.1	354.9	214.1	247.6	82.1	2,890.6
Total potentially available	375	375	375	375	375	375	375	375	375	375	375	375	4,500.0
Balance	155	150.4	129.1	157.3	145	150.4	60	60.9	20.1	160.9	127.4	292.9	1,609.4

[a]Derived by multiplying the mean of 15 man-equivalents (for larne families) by 25 work-days assumed available per month.

[b]Total potentially available minus total households' labor demand.

difference in efficiency parameters between the two sectors of Niono and Kolongo. For instance, output per man-equivalent in the latter is less than half that generated in Niono. Financial test ratios calculated across different farm size groups indicated the difficulty facing Kolongo's farmers compared to those in Niono in generating an equal value of gross revenue. Production costs were found to be 52 percent higher than the value of output in Kolongo. When off-farm earnings are added to net farm cash incomes the resulting family earnings for all but the medium sized group of farms in Niono do not cover the use of cash in home consumption, household expenditures and the purchase of farm equipment. Although the results refer only to the 1979-80 crop season, they do shed light on the actual living conditions and cash income problems for the majority of O.N. settlers.

A profile of the sample population at the Office du Niger provided some insights as to the composition of the labor force within small, medium and large families. The data indicate that large households have relatively few workers given the size of their consumption units.

The pattern of labor use and its distribution among various agricultural and nonagricultural activities suggests that adult females have their largest contribution only in nonrice activities, but contribute nearly 30 percent of the labor required for the cultivation of rice. Labor allocation to different rice field tasks indicate that land preparation, sowing and weeding are typical male activities in the Office, but adult females contribute half the required labor in harvesting and related activities.

The analysis of the total household labor inputs and their monthly distribution has demonstrated that peak season labor demand is indeed a constraint to increasing rice production, particularly for farm families of small size who, by the Office standards, count less than 7 people and cultivate less than 5 ha. Moreover there is relatively little underutilized labor among of farmers in the medium and large sized groups during the harvesting period. These results have some implications as to the demand for labor under alternative intensification techniques now being contemplated at the Office du Niger.

CHAPTER 5

ANALYSIS OF THE RICE ENTERPRISE

5.1 Introduction

The survey data were analyzed in the preceding chapter with regard to the farm as a whole in an attempt to gain insights into the relationships between farm production activities and off-farm operations, and the use of labor and nonlabor resources. Comparison of farm budgets among groups of settlers in different strata of holdings helped reveal and quantify the striking difference between two main ecological zones of the O.N. settlement namely Niono and Kolongo.

Above all this difference can be attributed to one single cause: rice yields. The purpose of this chapter is to analyze in greater detail the extent to which resources have been used in rice production, an enterprise which provides 93 percent of the farm incomes in the settlement. Farm performance patterns discussed in Chapter 4 become much clearer by examining the composition and the variation of costs of rice production among different groups of settlers.

The rice enterprise is analyzed in reference to 3 cultivation "casiers," two in Niono (Kolodogou and Sahel) and one in Kolongo.[1] This delineation corresponds to the three clusters selected for sampling and also reflects the differences in the ecological and irrigation network potentials known to the Office administration.

It should be pointed out here that input-output coefficients derived in this chapter reflect the current pattern of use of resources in rice production as revealed during the 1979-80 farm survey. As such they may depart from the norms established by the O.N. management which are often based on recommended levels of resource use. The magnitudes of enterprise variables presented later in the rice budgets are mean values of resource use for the average farm in a particular size group. These values include data obtained on "hors-casier" fields where applicable. The issues associated with farmers' involvement in "hors-casier" activities are discussed later in section 4. Finally, private costs in rice production will be adjusted for transfer payments made to farmers to derive an estimate of the economic cost of production in the O.N. based solely on the current level of resource utilization.

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[1]Prior to 1977, the administrative sector of Niono was made up of three casiers: Kolodogou, Sahel and N'Debougou. Since then the zone delimiting each casier was turned into a sector for efficient administration and better control. Currently, Kolodogou refers to the new sector of Niono, Sahel is an administrative sector of its own and Kolongo has been partitioned into two sectors: Kolongo and Kokry. It was preferable to maintain the delimitation of casiers used prior to 1977 to conform with the three separate ecological zones selected for sampling.

5.2 Resource Utilization on Rice Farms

Rice fields were counted as individual observations and aggregated at two levels: first, at the farm level to generate mean levels of resource use for each settler's rice enterprise in the sample and second, by aggregating individual rice enterprises to arrive at mean levels of resource use by size group in each casier. An example of rice enterprise table as initially generated by the computer program is shown in Appendix B. The previous stratification by size of holding is also maintained as shown in Table 5-1.

1. Labor Use and Average Labor Productivities

Labor utilization was discussed in detail in Chapter 4. Only total labor inputs per hectare and their variation across strata are briefly reported here. The results shown in Table 5-2 are averages of labor per hectare weighted by the size of fields included in the initial aggregations. Pairwise comparison of sample mean labor inputs on legal fields per farm (before aggregation at the casier level) indicated that the differences between the three rice casiers were significant at the 5 percent level.[2]

The results seem to indicate that total inputs of labor (in man-days) decline as the size of holding increases. Averages per casier are 105, 147 and 81.3 man-days for Kolodogou, Sahel and Kolongo, respectively. One probable explanation for the higher per hectare number of man-days in Sahel is the higher proportion of Minianka settlers who are

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[2]Comparisons were made on the assumption that the population variance was the same. Details of calculation are shown in Appendix C.

TABLE 5-1. Stratification of Rice Holdings In the O.N. Survey Area

Holdings	Kolodogou	Sahel	Kolongo
Size group I: 0-5 ha			
mean farm size	3.8	4.2	3.5
standard deviation	(0.79)	(0.81)	(1.15)
number of fields aggregated	19	13	14
Size group II: 5-10 ha			
mean farm size	7.6	7.4	7.1
standard deviation	(1.53)	(1.81)	(1.1)
number of fields aggregated	31	24	21
Size group III: 10-15 ha			
mean farm size	12	12.7	11.8
standard deviation	(1.51)	(2.31)	(1.37)
number of fields aggregated	27	13	9

Source: Survey data.

TABLE 5-2. Labor Input (Man-Days)[a] and Available Man-Power (Man-Equivalents)[b] on Rice Fields

Size Group	Kolodogou		Sahel		Kolongo		Survey area
I							
mean labor input/ha	115		151.5		109		125.2
mean man-equivalent	4.1	(1.8)	5.2	(2.0)	4.7	(2.3)	4.7
per hectare	1.08		1.24		1.34		1.22
II							
mean labor input/ha	97.9		136.5		65.7		100.3
mean man-equivalent	5.3	(1.5)	8.4	(2.1)	6.1	(3.2)	6.6
per hectare	0.7		1.14		0.86		0.90
III							
mean labor input/ha	102		153		69.3		108
mean man-equivalent	13.7	(3.7)	10.1	(2.9)	10.1	(4.0)	11.3
per hectare	1.1		0.80		0.85		0.92
overall mean labor input/ha	105		147		81.3		104[c]

[a]Mean labor inputs were weighted by the size of fields to which they referred.

[b]Standard deviation in brackets to the right of the number to which they refer.

[c]Overall mean weighted by the sample size in each sector.

recognized as a disciplined ethnic group and hard working farmers.[3] Lack of motivation and incentives in a sector with low productivity are also possible reasons for lower inputs per hectare in Kolongo. The average of 105 man-days per hectare in Kolodogou seems to better picture the overall O.N. labor input in rice production. There seems to be a direct relationship between the amount of labor input per hectare in each casier and the density of man-power (man-equivalents per ha) available.

A common pattern of labor use in each casier is revealed by the fact that total labor per hectare is the lowest for the group of medium sized farms all across the settlement. This can be attributed more to the lower density of man-power per hectare than to relative efficiency in the use of labor.[4]

A first glance to the relationship between labor use and total output of rice is provided in Table 5-3 where average products of labor are calculated in terms of total gross yield. Higher inputs of labor

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[3]Personal communication.

[4]This itself may reflect past O.N. land allocation policies by which families acquired land on the basis of 1 ha per working man available. The average farm size in each stratum is respectively 4, 7.5 and 12 ha which implies that 2, 3 to 4 and 6 working-men are available on farms in each size group. This translates into an equal density of 0.5 working-man per hectare in each stratum. Densities of man-power when expressed in terms of man-equivalents per hectare will be higher; but to be relatively lower on medium sized farms one has to accept that family composition in terms of the additional number of youth, adult females and the elderly is relatively lower in this group than the others. The premise for discussion here is that there exists some direct relationship between the number of man-equivalents per hectare and total labor use.

TABLE 5-3. Average Products of Labor on Rice Farms in the Survey Area (kg/man-day)

Size Group	Kolodogou	Sahel	Kolongo	Survey area
I				
gross yield (kg/ha)	2055 (593.3)	1789 (492.0)	1280 (335)	1708
average product of labor	17.9	11.8	11.7	13.8
II				
gross yield (kg/ha)	2144 (508.6)	2013 (696.1)	1320 (482.1)	1826
average products of labor	21.9	14.7	20.1	18.9
III				
gross yield (kg/ha)	1766 (384.6)	2337 (258)	1343 (355)	1815
average products of labor	17.3	15.3	19.4	17.2
Averages (kg/ha)	1988	2046	1314	
kg/man-day	19.0	13.9	17.0	16.6

Note: Standard deviations in brackets below the mean to which they refer.

per hectare in Sahel cause average products of labor to be lower compared to other casiers despite the highest level of gross yield realized there. In a cross-section view of the settlement this could be interpreted as follows: farmers in all three casiers can be considered as producing in stage II of a one variable input (i.e. labor) production function, <u>ceteris paribus</u>. Those in Sahel may already be producing in the neighborhood of the maximum achievable output of rice determined by the high physical potential of that casier. Thus their marginal physical products of labor are lower compared to those in other casiers and this causes their average physical products (APP) of labor to be lower as well. For the Kolongo sector in particular, higher APP relative to Sahel also mean that substantial increases in rice output are possible in view of the fact that weed infestation, poor drainage conditions are known to be more constraining yields than family labor availability and use. For the survey area as a whole, APP of labor are the highest on farms with holding between 5 and 10 ha.

2. Farm Equipment and Animal Power Use

Table 5-4 summarizes the density of farm equipment in different size groups of holding and provides data on average productive life of draft animals and farm implements as reported by farmers. The number of draft animals and pieces of equipment per farm increases in general as one moves toward larger holdings. Animal traction has remained one of the strong points of the Office. In addition to the yield effect, ox cultivation has resulted in increases in production due to expanding of the area under cultivation and has facilitated farmers' adherence to the agricultural calendar.

TABLE 5-4. Density and Average Productive Life of Farm Equipment in the Survey Area

Rice Casier and Farm Size Groups	Oxen		Donkeys		Plows		Harrows		Carts	
	Density Per Farm (Head)	Average[a] Productive Life Per Animal (Years)	Density Per Farm (Head)	Average[a] Productive Life Per Animal (Years)	Density Per Farm (Units)	Average[b] Productive Life Per Unit (Years)	Density Per Farm (Units)	Average[b] Productive Life Per Unit (Years)	Density Per Farm (Units)	Average[b] Productive Life Per Unit (Years)
Kolodogou										
I (0 - 5 ha)	1.4		0.5		1.2		0.9		0.6	
II (5 - 10 ha)	4.9	7.5	1.3	6.7	1.6	8.8	1.3	9.0	0.9	10
III (10 - 15 ha)	7.0		1.6		2.6		1.2		1.4	
Sahel										
I (0 - 5 ha)	0.8		0.8		1.0		0.8		0.6	
II (5 - 10 ha)	2.0	7.0	0.9	7.0	1.4	9.2	0.9	9.5	0.9	10
III (10 - 15 ha)	7.0		0.8		2.0		1.5		1.0	
Kolongo										
I (0 - 5 ha)	1.9		0.2		1.2		0.8		0.2	
II (5 - 10 ha)	1.8	8.1	0.7	6.9	1.3	10	0.8	9.6	0.4	10
III (10 - 15 ha)	4.0		1.3		1.3		1.0		1.0	
Survey Area Average										
I (0 - 5 ha)	1.4		0.5		1.1		0.8		0.5	
II (5 - 10 ha)	2.9	7.5	1.0	6.8	1.4	9.3	1.0	9.4	0.7	10
III (10 - 15 ha)	6.0		1.2		1.9		1.2		1.0	

Source: Survey data.

[a]The average represents farmers' estimate of years of remaining life after the animal begins its career.

[b]The figure represents the average number of years of useful life with appropriate maintenance.

Animal power use shown in Table 5-5 is the total of oxen and donkey hours in rice production. More than 85 percent of the animal power is devoted to land preparation which is done solely with oxen.

The variation in animal-hours per hectare seems to reflect the pattern of variation found in the total labor use per hectare. But lower inputs of animal power in Kolongo must also be attributed to the sector's low density of equipment per farm. Overall weighted means by casier were estimated at 144.0, 206 and 102 hours of animal power for Kolodogou, Sahel and Kolongo, respectively.

The averages for the survey area indicate a general increase in the amount of animal-hours with the size of holdings. From examination of Tables 5-4 and 5-5 this suggests that large farms are associated with both larger stock of farm equipment and a higher rate of service extraction from it. A complementary relationship between animal power and human labor may exist despite the varying proportion in man-power associated with animal use, particularly for oxen.[5]

3. Use of Hired Labor on Rice Farms

Use of hired labor by settlers is also the least documented aspect of farm activities in the O.N. records. However, it is recognized that the majority of farmers resort to the practice most commonly at harvest time. Permanent laborers were employed by only 3 out of 96 families in the farm management sample. Both hired and permanent laborers should be

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[5]In plowing for instance one man holds the plow handle and two children are employed with one guiding the animals and the other following them with a whip. With better trained oxen the third person was not needed.

TABLE 5-5. Hours of Animal Power (oxen and donkey) Use Per Hectare in the O.N. Survey Area

Item	Kolodogou			Sahel			Kolongo			Survey area		
	I	II	III	I	II	III	I	II	III	I	II	III
average per ha	116	156	147	121	184	247	149	107	85	128.7	149	159.7
standard deviation	(83.3)	(106)	(101)	(62.7)	(112)	(110)	(59)	(80.3)	(39)			
average by casier		144.9			206			102			140[a]	

[a]The overall mean was weighted by the sample size in each casier.

distinguished from members of the "floating" population who increase the consumption unit (as contrasted to production unit) of some settlers' families at the start of the off-season.[6]

Hired workers were of two main types: (1) daily wage earners who were paid in cash and/or in kind; and (2) contract laborers who were paid by the task, with the latter case being more frequent during the harvesting season. Between members of settlers' families of long standing acquaintance, payment for various contracted agricultural tasks undertaken during the crop season was only honored after the harvest has been sold.[7]

Table 5-6 depicts the proportion of hired labor and the average wage paid by survey zone. The data reveal that a higher proportion of hired labor was used on rice farms in Kolodogou and represents 10 percent of total labor with an average daily wage of 718 MF per man-day. Further analysis of Kolodogou data indicates that higher wages were paid by settlers with holdings below 5 ha at an average of 1020 MF per man-day. The most probable explanation for this is the proximity of small sized farms to the Niono center, the largest urban agglomeration in the entire O.N. area. Though the supply of unskilled labor is higher in Niono compared to other O.N. centers, the availability of alternative employment

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[6]The floating population is made up of nonsettlers who migrate into the Office area (some accompanied by their families) to look for food in exchange for farm or household works around and after the harvest season, Members of the "floating" population who performed agricultural work and were paid for it were legally treated as hired labor.

[7]In which case total payment was entered along with an estimate of man-days of labor contributed.

TABLE 5-6. Proportion of Hired Labor and Average Wage Paid on Rice Farms by Survey Zone

Item	Kolodogou	Sahel	Kolongo	Survey area
Size group I (0-5 ha)				
1. Hired labor (% of total)	9	1	1	3.7
2. Average wage paid (MF/md)	1,020	615	845	
	(442)	(215)	(706)	
Size group II (5-10 ha)				
1. Hired labor (% of total)	14	1	1.5	5.5
2. Average wage paid (MF/md)	471	818	734	
	(671)	(919)	(408)	
Size group III (10-15 ha)				
1. Hired labor (% of total)	7	6	1	4.7
2. Average wage paid (MF/md)	662	910	215	
	(504)	(904)	(418)	
Averages	10	3	1.5	4.6
	718	781	598	699

Note: Standard deviations are in brackets below the number to which they refer.

opportunities provided by the O.N. industrial and commercial activities, the local administration and private businesses make agricultural wages also more competitive in the area. However, there is a relatively homogenous wage pattern for agricultural work in the O.N. zone ranging from 500 to 1000-1200 MF per day, depending on the season. For instance off-farm labor is scarce in June and July (the plowing season) because hired workers who often come from millet growing regions are planting their own fields then. It is relatively abundant during the harvest period because by that time workers from millet growing areas have finished their harvest in November and migrate to the O.N. area in December. Wage rates are also higher in rice activities because of the competing demand from the O.N. sugar cane industry.

4. Seed and Fertilizer Use

All varieties now recommended for use by farmers in the O.N. area have shown a yield potential of more than 6 metric tons per hectare in research station [WARDA, 1977]. Much of the research work in the Office has in fact been concentrated on varietal improvement. Of the rice varieties now in use, some are imported (Doc Phun Lung, D52-37, Gambiaka, Kokoum, Kading, Thans, etc.) while others were derived by local hybridation (NKG98, DK3, GH2). All, however, are clearly superior to traditional varieties of the Sikasso type. Presently some settlers use seeds from their own harvest with a proportion of red rice (Orizea barthii and glablerrina).[8] Although accurate results have been obtained under

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[8]It has been estimated that two out of every three years many farmers plant their fields with their own seeds (personal communication).

research station conditions, the results of fertilizer use have not yet been fully demonstrated at the farmers' level.[9]

The most important issue is whether farmers use seeds and fertilizer at the recommended rates. These rates are: (1) 120 kg of seeds per hectare in broadcast sowing and 80 kg per hectare in row seeding; and (2) 50 kg of ammonium phosphate and urea (46%) per hectare, each. These rates are recognized to be lower than optimal for irrigated cultivation of rice.[10] The use of domestic Tilemsi phosphate as a build-up fertilizer is also being pushed in the settlement with some success. Prevailing prices in 1979-80 for ammonium phosphate, urea and Tilemsi phosphate were 140 MF, 120 MF and 60 MF per kilo, respectively. Improved (foundation) seeds were sold to farmers at 70 MF per kilo.

Although farmers can obtain fertilizer on credit, the quantity they actually request translates into density of application often lower than the recommended rates. However, as shown in Table 5-7 obtained from O.N. records, data on the rice area under mineral fertilization by sector do not show the actual density of application by the settlers.

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[9] A number of milti-local trials at the farm level are conducted by the Kogoni research station since 1975. For 1979-80 two varietal trials on long stemmed rice, one phosphorus response trial and one chemical weed control trial were undertaken in Niono and Kolongo. The fertilizer trial showed increasing returns to phosphorus for doses up to 30 units of P_2O_5. Yields were respectively 10 and 28 percent higher over two control plots: one with a nonphosphorus fertilizer, and the other without fertilizer. [O.N. 1979-80, annual report].

[10] Doses of 100 to 150 kg/ha for urea and ammonium phosphate are in the optimal range for rice under irrigated conditions [Dobelman, 1976, pp. 102-105].

TABLE 5-7. Area Coverage of Mineral Fertilization in the 1979-80 Season at the O.N.

Sectors \ Area Covered	Urea (ha)	Ammonum Phosphate (ha)	Tilemsi Phosphate (ha)
Kolongo	751	637	32
Kokry	501.25	498	20.40
Niono	3,268	1,102	399
Molodo	2,356	1,428	441
N'Debougou	2,120	5,128	250
Sahel	1,310.50	1,370	248
Kourouma	4,356.10	4,097	120
Dogofry	4,013	3,773	---
Total sectors			
1979-80	18,675.85	18,033	1,510.40
1978-79	22,242	4,013.75	1,319,75

Source: O.N. Service Agricole: Rapport de fin de campagne 1978-80.

In an attempt to assess the actual level of use of fertilizer and seeds among selected farmers, records of the amount they requested from the O.N. were obtained at the end of the 1979-80 season. The data were then checked against farmers' reports from July through September.[11] The results are shown in Table 5-8 in which the total amount of fertilizer (urea and phosphate only) is stratified in groups of less than 50 kg, 50-100 kg, and 100 kg or over. A similar stratification was done for the rate of seeding (less than 80 kg, 80-120, and above 120).

The data show that 72 percent of the farmers in the survey area used less than the recommended level of 100 kg of fertilizer (urea and phosphate), while 18 percent applied it at rates higher than 100 kg per hectare. Ninety percent of the selected farmers used some fertilizer. The mean density of application by type of fertilizer is shown in Table 5-9. Application rates reached the recommended level of 50 kg of urea only in Sahel which also has the highest rate of application for ammonium phosphate.

Nearly 50 percent of the settlers in the sample seeded their fields at the recommended density of 120 kg per hectare or above; 80 percent used seeding rates above 80 kg. The mean density of application was 111.1 kg, 142.7 and 98.5 kg per hectare for Kolodogou, Sahel and Kolongo, respectively. Additional evidence of the difference in agricultural practices among farmers in the selected zones is given by the proportion

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[11] This was done by administering a resource utilization form around the period most farmers in the sample have finished applying fertilizer. The question asked referred to the number of bags of urea and phosphate they actually used on each of their fields. Generally the total of quantities reportedly applied on fields was equal to that reported in official records.

TABLE 5-8. Frequency Count of Rates of Fertilization and Seeding in the Survey Area

Item	Kolodogou	Sahel	Kolongo	Survey area
Fertilizer (kg/ha)				
less than 50	10	3	25	38
50-100	14	6	11	31
100 and over	9	8	0	17
Total (number of farms)	33	17	36	86
Seeds (kg/ha)				
less than 80	5	3	7	15
80-120	12	4	14	30
above 120	15	14	15	44
Total (number of farms)	32	21	36	89[a]

Source: Survey data.

[a]Actual number of farmers with consistent data.

TABLE 5-9. Actual Versus Recommended Level of Fertilizer and Seeds Application in the Survey Area[a]

Item	Urea	Ammonium phosphate	Tilemsi[b] phosphate	Seeds
Recommended level in kg/ha	50	50	200 and over	120
mean level of application (kg/ha)				
Kolodogou	36.5 (12.5)	18.2 (9.4)	10.6 (14.6)	111.1 (28.9)
Sahel	50.1 (18)	20.7 (18.5)	2.6 (3.5)	142.7 (57.6)
Kolongo	24.7 (11.2)	17.9 (7.9)	---	98.5 (34.4)
mean survey area	37.1	18.9	---	117.4

Source: Caculated from survey data.

[a]Standard deviations are in brackets.

[b]Tilemsi phosphate is a build up fertilizer applied to improve the soil texture (usually on sandy soils); its effects are expected to last 3 to 5 years. It is not recommended with the package of urea and ammonium phosphate.

of farmers who used "Foundation" seeds to plant their fields. These ratios were respectively 98, 81 and 40 percent for Sahel, Kolodogou and Kolongo. Further analysis of the Kolongo data indicated that 5 out of 16 settlers who planted their fields with selected seeds also used varying proportions of ordinary seeds. Another point to raise for Kolongo is that 19 out of 40 settlers in the sample were provided ordinary seeds on credit (at 60 MF versus 70 MF per kilo for "Foundation" seeds) by the Office management; this is an indication of the proportion of Kolongo settlers with "empty" granaries at the beginning of the season, unable to supply themselves with seeds taken out of previous harvests.

The correlations between gross yields of rice and varying rates of seeding and fertilization is shown in Table 5-10 using the sample data. This cross-tabulation illustrates the increase in yields among the sample farms who used fertilizer and/or selected seeds at higher rates than others. The maximum cross section increase in gross yields associated with varying seeding rates, even with a level of fertilization below 50 kg per hectare is 22 percent. When the table is read vertically at the 120 kg rate of seeding there is a 52 percent maximum increase in gross yields across the sample at different levels of fertilization. A production function fitted to the survey data would have possibly led to the same conclusions. A cross-tabulation of this sort, however, illustrates the expected results in a clearer way.

5. Other Major Costs of Rice Production in the O.N.

As pointed out earlier, the single most important charge is a land fee of 400 kg of paddy per hectare levied on regular "casier"

TABLE 5-10. Cross-Tabulation of Average Gross Yields by Rates of Seeding and Fertilization in the Survey Area

Fertilization rates[a] (kg/ha) / Seeding rates (kg/ha)	Below 80	80-100	100-120	120 and over
Below 50				
Gross Yield (kg/ha)	1274	1284	1455	1558
Number of farms	(7)	(9)	(7)	(9)
50 to 75				
Gross yield (kg/ha)	----	1415	1653	1600
Number of farms		(4)	(6)	(12)
75 to 100				
Gross yield (kg/ha)	----	----	2335	2231
Number of farms			(2)	(11)
100 and over				
Gross yield (kg/ha)	----	----	1943	2370
Number of farms			(4)	(13)

Source: Calculated from the survey data.

[a]Total quantity of urea and ammonium phosphate per hectare.

Note: Numbers in brackets represent the number of farmers from which average gross yields were computed from individual fields.

fields.[12] Originally the principle of a fixed fee of paddy weight per unit of area was supposed to encourage farmers to achieve high per hectare yields. As developed land varies greatly in its potential however, the land fee has apparently failed to be an incentive. Farmers tend to increase the size of their holdings in order to maximize returns to labor. In so doing they actually use little manpower and fewer inputs per hectare which results in lower yields than expected.

The threshing charge is currently 120 kg of paddy for each metric ton threshed. It has been calculated in such a way as to cover actual cost to the Office du Niger.

The issue of field losses as a direct cost of production needs to be treated at some length. The difference between the total achievable output of rice and the amount farmers actually dispose of can be considered as lost in global terms.[13] However, farmers recover about 8% of the total potential output through family gleanage of fields after harvest, including at the time of mechanical threshing. The disposable output of rice used in this study's budgets is net of field losses and was derived by adding 8 percent of the potential output to the amount settlers market through the O.N. channel.

Other uses of resources for rice production refer to expenditures on repairs and maintenance of farm equipment, harnessing, feeds and

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[12] A tax of 240 kg per hectare is also levied on hors casier field when discovered.

[13] Results from the post-harvest loss study led to an estimate of 21% [Kamuanga and Spencer, 1981].

veterinary care for draft animals. On some farms the cost of Tilemsi phosphate was entered at a third of its purchase price in the amortization charge because it has a multi-year effect on soil texture.

5.3 Rice Enterprise Budgets for Selected Farms in the O.N.

Rice budgets by farm size group in each of the three casiers are presented in Tables 5-11a through 5-11c. The format of budget tables was modified from the original format of crop tables generated by the FMDCAS package in order to sort out particular items in the structure of operating costs which are of relevance to the O.N. farmer. The following is a detailed comparative analysis of costs and returns per hectare among different farm size groups in the survey area.

1. Labor Use by Field Activity

Inputs of labor in man-days by field activity are shown in Table 5-12 derived from the crop tables and aggregated by casier. The proportions of labor allocated to peak season activities are roughly the same for land preparation (20 to 21 percent of total labor), but substantially different for weeding and harvesting. Farmers devoted 12, 15 and 9 percent of total labor to weeding, and 36, 42 and 41 percent for harvesting for Kolodogou, Sahel and Kolongo, respectively. Little weeding is done in Kolongo perhaps because weed invasion there has reached a point where farmers have lost the incentive to weed.

The composition of animal power use on fields is depicted in Table 5-13. Soil preparation absorbs 92 to 96 percent of the total animal power use on fields. The use of animal power in cultivation and at

TABLE 5-11a. Rice Enterprise Budgets per Hectare for Kolodogou Casier (sector of Niono)

A. Enterprise characteristics						
1. Size group	I		II		III	
2. Average holding (ha)	3.8		7.6		12.0	
3. Number of field observations	19		31		27	
B. Income and expenditures	Amount (kg)	Value (MF)	Amount (kg)	Value (MF)	Amount (kg)	Value (MF)
1. Value of production	1,728	103,596	1,774	104,644	1,464	37,322
2. Variable inputs						
seeds	89	5,709	111	7,245	128	3,576
fertilizer[a]						
mineral	47	6,133	71	8,772	51	6,383
organic	0		27	1,430	0	---
threshing charge	207	12,442	209	12,557	176	10,541
animal power (hours)						
own use	114	3,102	132	4,367	147	2,304
hired[b]	2	34	24	695	---	---
hired labor (man-days)	10	10,195	14	6,591	7	4,637
others[c]	---	250	---	344	---	440
Total	---	37,365	---	42,501	---	33,336
3. Gross margin		66,051		62,143		54,486
4. Fixed expenses						
land fee	400	24,000	400	24,000	400	24,000
depreciation	---	1,394	---	1,790	---	4,975
family labor (man-days)	105	---	83.9	---	95	---
others[d]	---	386	---	386	---	386
Total		25,730		26,175		29,362
5. Returns to land, labor, capital and management		40,271		35,967		25,124
less opportunity cost of operating capital @ 15%[e]		5,580		6,376		5,000
6. Net returns to land, family labor and management		34,691		29,591		20,124
7. Returns per man-days[f] of family labor		357		391		238

[a]Total quantity of urea and diammonium phosphate. Organic fertilizer refers to cattle manure.

[b]Hire of equipment includes both farm implements and draft animals.

[c]Miscellaneous expenses on bags and small tools.

[d]Including the cost of Tilemsi phosphate entered at a third of its value.

[e]This is the average cost of capital in the informal rural credit market.

[f]Obtained by dividing item 5 by the total number of man-days of family labor.

TABLE 5-11b. Rice Enterprise Budgets per Hectare for Sahel (sector of Niono)

A. Enterprise characteristics						
1. Size group	I		II		III	
2. Average holding (ha)	4.2		7.4		12.7	
3. Number of field observations	13		24		13	
B. Income and expenditures	Amount (kg)	Value (MF)	Amount (kg)	Value (MF)	Amount (kg)	Value (MF)
1. Value of production	1,558	98,154	1,723	108,549	1,948	122,724
2. Variable inputs						
seeds	146	10,226	127	8,749	186	13,020
fertilizer[a]						
mineral	80	9,709	67	8,366	93	12,090
organic	0	---	0	---	0	---
threshing charge	187	11,218	207	12,405	234	14,026
animal power (hours)						
own use	102	5,157	169	1,197	247	2,360
hired[b]	19	633	15	1,090	---	---
hired labor (man-days)	2	1,230	1.5	818	9	8,186
others[c]	---	33		3,466		171
Total		38,206		36,091		49,853
3. Gross margin		59,948		72,458		72,871
4. Fixed expenses						
land fee	400	24,000	400	24,000	400	24,000
depreciation	---	1,291	---	1,786	---	3,798
family labor (man-days)	1,495	---	135	---	144	---
others[d]	---	120	---	120	---	120
Total		25,411		25,906		27,918
5. Returns to land, labor, capital and management		34,537		46,552		44,353
less opportunity cost operating capital @ 15%[e]		5,732		5,414		7,430
6. Net returns to land, family labor and management		28,805		41,138		37,473
7. Returns per man-day[f] of family labor		231		325		266

Source: Survey data.

[a]Total quantity of urea and diammonium phosphate. Organic fertilizer refers to cattle manure.

[b]Hire of equipment includes both farm implements and draft animals.

[c]Miscellaneous expenses on bags and small tools.

[d]Including the cost of Tilemsi phosphate entered at a third of its value.

[e]This is the average cost of capital in the informal rural credit market.

[f]Obtained by dividing item 5 by the total number of man-days of family labor.

TABLE 5-11c. Rice Enterprise Budgets Per Hectare for Kolongo

A. Enterprise characteristics						
1. Size group	I		II		III	
2. Average holding (ha)	3.5		7.1		11.8	
3. Number of field observations	14		21		9	
B. Income and expenditures	Amount (kg)	Value (MF)	Amount (kg)	Value (MF)	Amount (kg)	Value (MF)
1. Value of production	747	48,555	713	42,780	516	33,540
2. Variable inputs						
seeds	81	5,103	109	7,627	123	7,626
fertilizer[a]						
mineral	40	4,967	42	5,234	30	3,534
organic	0	---	0	---	0	---
threshing charge	90	5,378	86	5,134	62	3,715
animal power (hours)						
own use	146	4,006	96	1,513	84	1,852
hired[b]	3	86	11	212	1	42
hired labor (man-days)	1	761	1	734	1	215
others[c]						
Total	---	21,146	---	21,108	---	17,084
3. Gross margin		27,409		21,672		16,456
4. Fixed expenses						
land fee	400	24,000	400	24,000	400	24,000
depreciation		2,598		1,607		799
family labor (man-days)	108	---	64.7	---	68.3	---
others[d]	---	---	---	---	---	---
Total	---	26,598	---	25,607	---	24,799
5. Returns to land, labor, capital and management		311		-3,935		-8,343
less opportunity cost of operating capital @ 15%[e]		3,172		3,166		2,563
6. Net returns to land, family labor and management		-2,361		-7,101		-10,906
7. Returns per man-day[f] of family labor		7.2		-60.8		-1[illegible].2

[a]Total quantity of urea and diammonium phosphate. Organic fertilizer refers to cattle manure.

[b]Hire of equipment includes both farm implements and draft animals.

[c]Miscellaneous expenses on bags and small tools.

[d]Obtained by dividing item 5 by the total number of man-days of family labor.

[e]This is the average cost of capital in the formal rural credit market.

[f]Obtained by dividing item 5 by the total number of man-days of family labor.

TABLE 5-12. Man-days of Labor Use Per Hectare on Rice Farms by Activity

Activity	Kolodogou	Sahel	Kolongo	Survey area
Land preparation	21.6	28.2	17.2	21.4
plowing	12.6	15.1	12.2	12.9
harrowing	8.1	10.4	4.9	7.3
Sowing	1.0	1.2	1.1	1.1
Fertilizer application	2.3	3.8	2.3	2.6
Irrigating	1.7	3.3	1.2	1.8
Weeding[a]	12.7	22.3	7.1	12.4
Harvesting and stacking	37.6	61.4	33.6	38.8
Manual threshing, bagging, and post-harvest treatment[b]	3.9	7.4	4.7	3.5
Miscellaneous	23.9	19.3	14.0	20.0
Total	105	147	81	104

Source: Derived from crop tables.

[a]Includes thinning as well.

[b]Manual threshing is practiced on a limited scale in the O.N. settlement. Post-harvest treatment refers to hand pounding and winnowing. This figure also includes loading and unloading time.

TABLE 5-13. Hours of Animal Power Per Hectare by Field Activity in the Survey Area

Activity	Kolodogou Size groups			Sahel Size groups			Kolongo Size groups			Survey area Size groups		
	I	II	III	I	II	III	I	II	III	I	II	III
Soil preparation[a]	107.4	147	141.0	115.2	175.7	242.4	137.1	98	81.0	119.9	140.2	154.8
Cultivation	0.5	0.3	1.0	0.6	1.6	---	---	1	0.6	0.5	0.6	0.8
Harvesting[b]	0.1	1.0	1.7	0.9	3.0	4.7	2.9	4.5	---	1.3	2.8	3.2
Others	7.5	7.7	3.3	4.3	3.7	---	9.0	3.5	3.4	6.9	4.9	3.4
Total	116.0	156.0	147.0	121	184	247	149	107	85.0	128.7	149	159.7

Source: Survey data.

[a]Includes plowing and harrowing.

[b]Refers to transport and hauling at harvest-time using donkey-trailed carts.

harvest time (donkey mostly) refers to transportation of seeds, fertilizer, paddy and rice by-products. The intensity of animal power use for the survey area as a whole increases from small to large holdings.

2. Composition of Variable and Fixed Costs in Rice Production

Much of the cost structure was discussed in Chapter 4 as rice constitutes the mainstay of the settlement and farm costs are to a large extent those incurred for the rice enterprise. The total financial and economic cost of producing one metric ton of paddy is discussed in section 5.5. This part deals with the relative proportions of operating and fixed costs and the importance of the expenditure on seeds and fertilizer in the total mix of costs of rice production across the settlement.

The structure of costs per hectare is shown in Table 5-14. No perceptible difference exists in the per hectare value of fixed costs, due essentially to homogeneity of the land fee. Only the difference in the calculated allowances for depreciation and various miscellaneous expenditures is responsible for the small variation in total fixed costs per hectare depicted in the budget tables. The average magnitude of fixed costs was estimated at 26,560 MF per hectare.

Variable costs are higher in Sahel and average 41,383 MF per hectare compared to 37,900 MF and 19,780 MF for Kolodogou and Kolongo. The part of operating costs allocated to seeds and fertilizer increases with the size of holding in each casier, except for Sahel where farmers spent approximately 50 percent in each stratum. This may be attributed to the fact that farmers with larger assets have the financial means which allow them to apply seeds and fertilizer at higher rates relative to small farmers. The average expenditure on seeds and fertilizer for the

TABLE 5-14. Comparison of Per Hectare Variable and Fixed Costs in Rice Production by Casier (in MF)

	Kolodogou		Sahel		Kolongo		Survey area[a]	
Size group I (0-5 ha)								
variable costs (1)	37,865		38,206		21,146		30,539	
seeds and fert.[b]	11,842	(31%)	19,935	(52%)	10,070	(48%)	12,250	(40%)
fixed costs (2)	25,780		25,411		26,598		26,087	
ratio (1)/(2)	1.47		1.90		0.80		1.23	
Size group II (5-10 ha)								
variable costs (1)	42,501		36,091		21,108		31,691	
seeds and fert.[b]	16,017	(38%)	17,115	(47%)	12,861	(61%)	14,919	(47%)
fixed costs (2)	26,176		25,906		25,607		25,864	
ratio (1)/(2)	1.62		1.39		0.82		1.23	
Size group III (10-15 ha)								
variable costs (1)	33,336		49,853		17,084		34,779	
seeds and fert.[b]	15,414	(46%)	25,090	(50%)	11,260	(66%)	17,601	(51%)
fixed costs (2)	29,362		27,918		24,799		27,740	
ratio (1)/(2)	1.14		1.79		0.60		1.25	

Source: Derived from Tables 5-11a, b and c.

[a]Averages weighted by the number of farms in each size group and by casier.

[b]Urea and ammonium phosphate together.

overall survey area is about 46 percent of total operating costs. One reason why operating costs in absolute values are higher in Sahel is the higher charge for threshing of paddy which is a function of yield.

Repair and maintenance expenses of farm equipment seem to vary directly with the number of hours of utilization in Kolodogou and Kolongo and inversely in Sahel as shown in Table 5-15. A larger proportion of old equipment (bought before 1976) may be the explanation for the high level of repair expenses among Sahel settlers in size group I.

3. Net Enterprise Incomes and Returns to Land, Family Labor and Management

Net enterprise income is calculated by subtracting total costs from the total value of rice production or by deducting fixed costs from the gross margin as is the case in Table 5-16. This is the principal measure of the enterprise profitability and represents the reward for the labor, capital (including land) and management contributed by the farm family during the year.

Net enterprise income differences between farm size groups and across the three rice casiers reflect the variation in yields and in the amount of noncommitted expenses[14] such as seeds, fertilizer, repairs and maintenance expenses and salaries paid to seasonal labor. As anticipated this measure of enterprise efficiency was the highest in Sahel and the lowest in Kolongo where only farms of small size (below 5 ha)

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[14]As contrasted to threshing charge and land fee which are considered as committed expenditures.

TABLE 5-15. Repair and Maintenance Expenses and Hours of Equipment Use

Item	Kolodogou			Sahel			Kolongo			Survey area		
	I	II	III	I	II	III	I	II	III	I	II	III
Use of equipment (hours/ha)	116	156	147	121	184	247	149	107	85	128.7	149	159.7
Repairs and maintenance (MF/ha)	3136	5062	2304	5790	2287	2360	4092	1736	1894	4340	3028	2186
Mean expenses by casier (MF/ha)		3500			3480			2574			3185	

Source: Derived from Tables 5-11a, b and c.

TABLE 5-16. Gross Margins and Returns Per Hectare in Rice Production by Casier and Farm Size Group (MF)

Item	Kolodogou	Sahel	Kolongo	Survey area[a]
Size group I (0-5 ha)				
gross margin	66,051	59,948	27,409	48,106
net enterprise income	40,271	34,537	811	22,019
returns to family labor and management	34,391	28,805	-2,361	18,675
Size group II (5-10 ha)				
gross margin	62,143	72,458	21,672	47,151
net enterprise income	35,967	46,552	-3,935	21,287
returns to family labor and management	29,591	41,138	-7,101	16,533
Size group III (10-15 ha)				
gross margin	54,486	72,871	16,456	51,107
net enterprise income	29,362	44,953	-8,343	25,133
returns to family labor and management	20,124	37,473	-10,905	18,150

Source: Tables 5-11a, b and c.

[a]Averages weighted by the number of farms in each size group by casier.

were able to earn a positive net income. Average net enterprise incomes were 42,014 MF, 34,200 MF and -3,822 MF in Sahel, Kolodogou and Kolongo, respectively.

Net enterprise incomes per man-day of family labor are compared to the average wage rate for unskilled labor which prevailed in each zone during the survey season (Table 5-17). The net return per man-day of family labor is lower than the average market wage of 700 MF per day paid to unskilled labor. The highest remuneration per man-day under current technology and prevailing yield potential is found to be close to 430 MF per working day. Farmers in Kolodogou have the highest daily remuneration in the settlement, while those in Kolongo experience negative returns. Although larger labor inputs in Sahel are associated with the highest returns per hectare in the survey data, they depress the remuneration per man-day relative to what is obtained in Kolodogou.

4. Management Income

The return to management is a separate efficiency criterion which should be distinguished from the total returns to family labor and management shown in Table 5-16. The latter measure is derived from net enterprise income by subtracting the opportunity cost of land (assumed to be zero)[15] and the opportunity cost of operating capital.

Management income is obtained by imputing an opportunity cost to family labor and subtracting it from the net returns to family labor and

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[15]Developed land has an opportunity cost when viewed from the Office management or the national economy standpoint. The farmer has no alternative use of land by the nature of the contract he signs to join the O.N. settlement.

TABLE 5-17. Returns Per Man-Day of Family Labor and Market Wage Rate For Unskilled Workers in the Survey Area (MF)

Item	Kolodogou			Sahel			Kolongo			Survey area		
	I	II	III	I	II	III	I	II	III	I	II	III
Net income/man-day	384	429	309	231	345	312	8	-61	-222	208	238	166
Average per casier		389[a]			306[a]			-36[a]			220[b]	
Market wage rate (MF/day)		718			781			598			699	

Source: Survey data.

[a]Average weighted by the number of farms in each size group.

[b]Overall arithmetic average of means per casier.

management. Theoretically it stands as a reward to the farmer after he had paid for all resources used in production including family labor, capital and amortization. In practice the magnitude reflects the ability of the farmer to pay for his risk-taking and management functions in farm operations.

Opportunity costs of family labor were taken to be equal to the average off-farm wage rate prevailing in each zone. These were 718 MF, 781 MF and 598 MF per man-day in Kolodogou, Sahel and Kolongo, respectively. Management income estimates were found to be negative in each size group, per casier and for the entire O.N. survey area.[16] In economic terms this means that O.N. settlers in the survey area did not generate a return above the financial and opportunity costs of all resources, i.e., they were not in a position to reinvest or increase their current level of consumption out of their earnings from the production of rice alone in 1979-80.

5.4 Rice Fields "Hors-Casier": Performance and Discussion of Issues

1. Introduction

In this section, the data collected on hors casier (HC) rice fields is analyzed. As already defined in Chapter 2, HC fields are irrigated rice plots that farmers maintain outside their official holdings.

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[16] A table displaying management incomes was not constructed. However, estimates of opportunity costs of family labor were 67,851 MF, 11,363 MF and 47,711 MF for Kolodogou, Sahel and Kolongo, respectively. In each case these magnitudes are higher than total net returns to family labor and management arrived at in Table 5.16.

Irrigation of HC fields is made possible either through diversion of the water stream from drainage canals or from leaks (some intentionally made) in the dikes of supply structures. Cultivation of these fields is a clandestine activity. It allows settlers to produce rice at low cost because of the possibility to avoid payment of/or to pay a lower land fee.

From the Office standpoint, HC cultivation causes physical defects to the irrigation infrastructure and competes for the utilization of the family scarce labor available for legal holdings. For these reasons the Office charges a 240 kg per hectare fee (in contrast to 400 kg on "casier" fields) when HC fields are discovered. At the same time, mechanical threshing of the harvest is provided if the field size is large (1 ha or more).

HC fields were counted as part of the rice farm where their existence was confirmed by the enumerators. This was in an effort to include every possible source of revenue and provide an accurate estimate of farm incomes and expenditures.

Hypothesis testing here addresses three main issues: (1) Whether there exists a conflict in the use and the distribution of labor among "casier" and HC fields, and if such a competition exists, when is it likely to be felt during the cropping season? (2) Is labor productivity higher on HC than on legal fields? (3) Why are settlers still engaging in HC cultivation even in zones such as Sahel where yields are known to be high?

Precise answers to these issues would have required mounting a specific survey of HC rice fields during an entire season in order to generate comparable data. This was not considered when the farm management survey was launched in April 1979; however, random sampling of farmers provided data on settlers with varying degrees of involvement in HC cultivation. Therefore the subsample of HC fields raises a number of questions: (1) Is it representative of the actual "population" of HC fields whose total area has been recently estimated at some 15 percent of the rice land in the Office?[17] (2) How reliable the information collected through interviews with farmers, on activities performed on fields they recognized were illegal, can be?

The representativeness of the subsample of HC field raises less concern than the reliability of the data collected because it was derived from a large random sample of settlers who were stratified so as to represent major conditions prevailing on the entire zone of the Office. As can be seen from Table 5-18, with Kolongo excluded[18] the proportion of the area planted in HC within the farm management sample itself was 4 percent, which is substantial given the sample size.

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[17] O.N. 1979-80 records show that 8 percent of the rice area was planted in "hors casier." This is, however, the best guess usually advanced by the Office management because it has not as yet made a formal survey to estimate with known degree of precision the total area under this activity. A World Bank mission overflying the O.N. area in 1976 put its estimate at 15 percent of the area planted to rice.

[18] Incidentally no HC field was reported by selected farmers in Kolongo. It is known however that the sector has the largest proportion of farmers with HC fields owing to the defectiveness of the irrigation and drainage network.

TABLE 5-18. Area Planted in H.C. and Percentage of Total Sample Area for the Surveyed Farms

Survey Zones	(1) Number of Farms in Sample	(2) Total Area of Farms (ha)	(3) Number of Farms With H C Fields	(4) Total Area of H C (ha)	(5) Percentage (4)/(2)	(6) Average Size of H C
Kolodogou	36	268.45	17	20.77	8.0	1.22 (0.82)[a]
Sahel	20	169.50	6	5	3.0	0.83 (0.74)[a]
Kolongo	36	248.90	--	--	--	
Total	96	686.85	23	25.77	4.0	

Source: Survey data.

[a]Standard deviation.

Reliability of the data depended on the type of information gathered. On HC fields where harvest was mechanically threshed by the O.N., a large proportion of nonlabor cost data was objectively secured. This referred to such cost components as threshing charge (which was the same as on legal fields), salaries paid to hired labor particularly at harvest time, estimates of field losses and quantities of seeds planted. Fixed costs were also objectively provided because the land fee levied on "recognized" HC fields amounted to 240 kg per hectare and was null on unreported fields.[19] It was in the domain of labor use that risks of underreporting were higher because of the tendency of farmers to downplay their involvement in HC field cultivation.

Estimates of the output of HC fields were generated in the same manner as those from casier fields, i.e., by adding to the amount marketed through the official channel an allowance for family consumption and total gleanage on fields. Though the output was valued at the official producer price of 60 MF per kilo, it is believed that part of it was sold at higher prices to private traders so that the gross value of output reported in the budget is understated.

2. Labor Use

Reliability of the labor data depended on the degree of confidence the respondent had with respect to the enumerators. In general after a

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[19]Some settlers reported the existence of HC fields to enumerators only on the provision that the information should not be used against them.

good rapport was established between enumerators and farmers, the amount of underreported data did decline. Still the data have to be treated with caution.

Table 5-19 depicts the magnitude of labor use on HC fields by activity for the two casiers. Standard deviations were computed for each activity in order to assess the amount of variation around the mean value. The total labor per hectare amounts to 53.6 man-days in Sahel and 81.2 man-days in Kolodogou. How significant is the difference in labor inputs per hectare between hors-casier and legal fields? To answer the question statistical analysis of the difference between the two means was undertaken. The procedure follows that outlined in Snedecor and Cochran [1976] when the sample sizes are different.

The ordinary method of finding confidence limits and making tests of significance for the difference between the means of two independent samples assumes that the two population variances are the same. This was the hypotheses used in section 5.2 to show that the pairwise differences between mean labor inputs per hectare for Kolodogou, Sahel and Kolongo were significant at both 1 and 5 percent level. For the comparison of hors-casier versus casier labor inputs per hectare, there is reason to believe that the samples came from two different populations, therefore one would expect their variances to be different as well. Though the sample size is very small in Sahel, the obvious wide difference between the means supports the hypotheses. The results of the statistical analysis (shown in Appendix C) confirm that for Kolodogou the mean labor input of 81.2 man-days per hectare in hors-casier is not significantly different from that of 116.7 man-days on fields in casier (t' statistic was 1.16, which is less than 2.10, the critical

TABLE 5-19. Labor Utilization on
Hors-Casier Rice Fields

Field Activity (man-days)	Kolodogou		Sahel	
Land preparation	27.3	(19.6)	17.8	(11.5)
Sowing	2.5	(1.8)	1.8	(1.9)
Fertilization application	1.5	(1.8)	---	
Irrigating	0.6	(.8)	---	
Care/cultivation (weeding)	15.0	(14.9)	10.5	(8.4)
Harvesting and stacking	27.6	(4.7)	21.6	(17.8)
Manual threshing and treatment	2.5	(4.3)	1.5	(.8)
Others	4.2	(9.4)	.4	(.8)
Total	81.2		53.6	

Source: Survey data.

level of t' at the 5 percent level).[20] For Sahel, however, the results show a significant difference between the mean labor in hors-casier (53.6 man-days) compared to in casier fields (139.6 man-days) ($t' = 5.72 > 2.53$ at the 5 percent level).

Thus farmers' involvement in HC activities in Kolodogou is important and may create a real conflict as far as the use of family labor is concerned. This can be argued on the ground that the opportunity for additional income from HC fields in Kolodogou is a real one, particularly when the output is clandestinely sold to private traders given the proximity of the center of Niono. The significantly low involvement in HC activities of Sahel settlers can be substantiated on two main grounds: first, Sahel is more distant with respect to the center of Niono making it relatively difficult for farmers to gain access to private traders. This would decrease the incentive to invest more labor in HC activities. Second, and perhaps more importantly, the Sahel zone has a high potential for yield improvement and farmers may find it logical to devote more labor to casier fields in order to reap a larger harvest.

From a production theory point of view, it can be argued that farmers prefer to invest additional labor in HC cultivation only because it is profitable to them to do so. This is shown in Figure 5a and 5b which present two ways of looking at the problem.

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[20]For this kind of analysis the ordinary t statistic is replaced by the quantity $t' = (\overline{X}_1 - \overline{X}_2)/\sqrt{(s_1^2/n, + s_2^2/n_2)}$ where $\overline{X}_1$ and $\overline{X}_2$ are means of labor inputs for casier and HC fields, s_1 and s_2 are sample estimates of variance and n_1 and n_2 their respective sizes [Snedecor and Cochran, 1967, p. 115].

One way is to visualize a production function of rice with labor as the unique variable input and other inputs being held constant. Assuming that land, fertilizer, seeds and oxen power are being held a certain level, the function can be written as follows:

$$Y = f(X_1 | X_2{=}a,\ X_3{=}b,\ X_4{=}c) \tag{1}$$

in which X_1 is family labor and X_2 is the amount of rice land for the legal holding, X_3 and X_4 representing the other inputs. Farmers are assumed to be rational and therefore producing in stage II of the production function drawn in Figure 5a. Involvement in HC activities therefore implies that additional land is brought under cultivation. This certainly increases the fixed input X_2 to $X_2 = a + \Delta a$. From the settler's point of view, the production function has shifted up a little bit and with the same amount of labor his marginal physical product (MPP) is higher than it was when he was only cultivating "casier" fields. This argument, however, assumes that the farmer faces only one production function.

The second way of looking at the problem assumes that the farmer has two production functions of rice, one for the legal holding which is higher and the second for HC fields where the yield potential is lower because production is undertaken on a nonimproved land. As shown in Figure 5b, in both cases the farmer is producing in stage II and attempting to maximize his total value of output by equating marginal value products (MVP) of labor between the legal and illegal holding. This condition is satisfied when

$$\frac{MVP_{X_1(Y_1)}}{P_{X_1}} = \frac{MVP_{X_1(Y_2)}}{P_{X_1}} \tag{2}$$

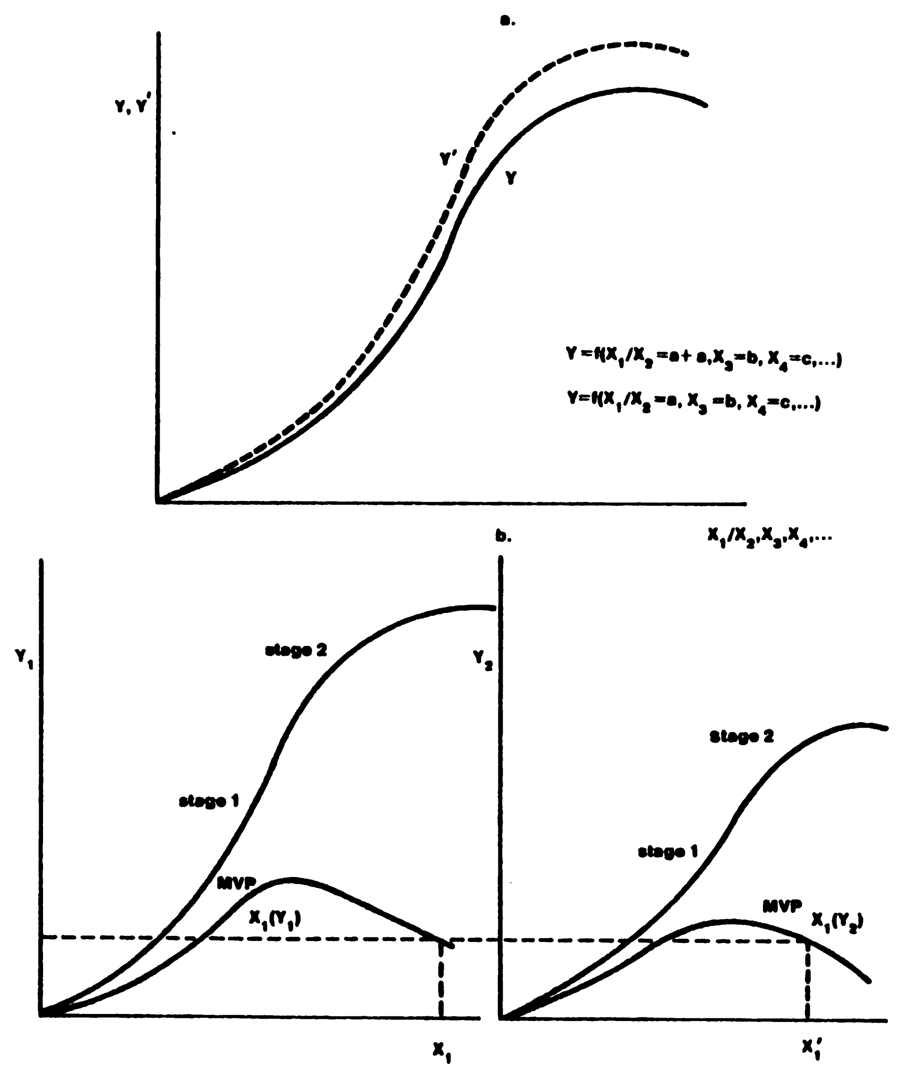

Figure 5

Production Function of Rice Involving Hors-Casier Cultivation

in which Y_1 and Y_2 stand for rice produced at two levels of technology in casier and HC and P_{X_1} is the opportunity cost of family labor. Therefore farmers are maximizing their total value product when family labor yields the same marginal value product of Y_1 and Y_2.

Equation (2) can be expanded in terms of marginal physical products to demonstrate that despite the lower marginal physical output on HC fields, farmers still find it profitable to cultivate illegal plots because of the opportunity to sell at a higher price. Simplifying equation (2) to $MVP_{X_1(Y_1)} = MVP_{X_1(Y_2)}$ gives the following equality

$$MPP_{X(Y_1)} \cdot P_{Y_1} = MPP_{X_1(Y_2)} \cdot P_{Y_2} \qquad (3)$$

$MPP_{X_1(Y_2)}$ is usually less than $MPP_{X_1(Y_1)}$ but the total value product (TVP) is maximized because P_{Y_2} is greater than P_{Y_1}, the official producer price of paddy. Even if the extra output is home-consumed farmers do value it at its opportunity cost which is equal to the market price P_{Y_2}.

Therefore, when perceived from a production theory standpoint, the issue of farmers' involvement in HC can be tackled through a technological improvement which would shift up the production function of Y_1 to a level that makes it unnecessary for settlers to look for additional output outside their legal holdings. The same result could be obtained by raising the official producer price P_{Y_1} above P_{Y_2} or by lowering the cost of production on legal fields.

The above discussion points to the possibility of competition between HC and casier fields, particularly in areas near the Niono center, where the difference in the mean value of labor input between HC and casier fields was not significant as shown earlier. By comparing Table

5.12 and 5.19 it becomes clear that land preparation activities constitute an area where competition between the two types of rice fields could be the most felt. Farmers seem to spend relatively little time in other pre-harvest activities on HC than on legal fields.

3. Cash Expenditures and Net Returns on HC Fields

Except for hired labor and the Office threshing charge of 120 kg of paddy per metric ton, there was enough inconsistency in the data on cash expenditures for HC fields to warrant a formal analysis. But it is probable that the total cost picture in general is much lower on HC fields compared to legal fields, thus creating the incentive for farmers to cultivate HC fields in the first place. Fertilizer is not usually applied to HC fields and seeding rates vary widely. Yields are usually low and can be objectively estimated at 1000 kg per hectare.[21] Assuming that a fee of 240 kg of paddy is levied, an average budget for a HC field can be worked out as in Table 5-20.

With a low cost structure (half as much) compared to legal fields, and a yield achievement around 1000 kg per hectare, the incentive to go into HC cultivation seems to be substantiated. A net income of nearly 30,000 MF per hectare and per year on HC fields in Kolodogou is much higher than what the average settler makes in Kolongo. As the Office management provides threshing services and levies a land fee on HC fields, the practice is certainly bound to continue so long as the settlers find it profitable to do so.

[21]No yield plots were specially mounted for hors-casiers fields. The estimate is based on farmers' own reporting.

TABLE 5-20. Typical Rice Enterprise Budget for a Hors Casier Field in Kolodogou or Sahel

Item	Quantity	Value (MF)
Value of production	1,000 kg @ 60 MF per kg	60,000
Seeds[a]	100 kg[a]	7,000
Threshing charge	120 kg/mt.	7,200
Animal power use		1,000
Hired labor		700
Total operating cost		15,900
Land fee	240 kg	14,400
Depreciation		500
Total charges		30,800
Net return to land, family labor, capital and management		29,200

Source: Survey data.

[a]Assumed at lower than the recommended level of 120 kg.

5.5 Financial and Economic Cost of Producing One Metric Ton of Rice in the O.N.

1. Introduction

The purpose of this section is to adjust the private costs of resources used in rice production in order to determine the economic cost of producing one metric ton of paddy in the Office du Niger. The stratification of farm size group outlined earlier is important for analysis of the relationship between economic costs and size of holding and in the identification of farm characteristics associated with high returns to the economy.

Cost-price schedules for rice produced under different techniques in Mali are prepared for the government agricultural commission which convenes in May of each year to set guidelines for agricultural price policy.[22] Thus each year the Office du Niger's Bureau of Economic Affairs prepares a budget based on a hypothetical (but "objective") average farm from which the cost price of one metric ton of paddy is

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[22]The commission comprises representatives from the Ministry of Economy and Finances, the Institut d'Economie Rurale of the Ministry of Rural Development, the Office du Niger and development agencies known as "Operations."

derived.[23] The effect of size of holding on the unit cost and more importantly the variation in the level of resource utilization on farms is not taken into account for lack of data. Besides there is still some confusion at the Office as to how cost magnitudes are examined, i.e., costs to the farmer, to the O.N. management, or to the economy.

The cost estimates in this section are derived from data collected on the actual level of resource use through interviews with farmers and direct field observations. These financial costs were compiled in the series of rice budgets presented in section 5.3. Economic or social costs are then derived by correcting for subsidies and taxes, by imputing opportunity costs to nonvalued resources, and to capital resources engaged in rice production on the basis of its current opportunity cost in the Segou region.

Specifically the shadow price of labor (family and nonfamily) is set equal to the market wage paid to unskilled labor in the Segou region,

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[23]Although the estimate arrived at provides a good basis for suggesting the appropriate producer price, there is room for overstatement of some cost items in order to justify the need for a producer price increase from which the Office management derives its sale price to OPAM, the national trading agency for agricultural products. For instance, in 1979 the report prepared for the 1980-81 government pricing commission estimated the total cost per hectare at 176,836 MF, including the opportunity cost of farm family labor at 1,000 MF per man-day. Cost items where overestimation was obvious included the draft animal feed ratios (quantities assumed at research station level), the amounts of fertilizer which assumed that recommended levels are adopted by all, and the years of life of farm implement (set at 5 years which is lower than the actual average of 7 to 9 years reported by farmers). In addition, the average farm size is drastically reduced to 5.5 ha as contrasted to 8 ha, which results in higher per hectare costs.

where the demand for hired labor in irrigated rice and sugar cane production is strong. The year-around average was 700 MF per man-day however locational differences existed and were retained in the evaluation of labor. Direct subsidies on farm equipment such as plows, carts and harrows existed in the past but were removed in the 1976-77 crop season [McIntire, 1979]. Fertilizer and fungicides are still subsidized. The shadow price of land in the O.N. area is the residual return to land in the production of sugar cane. As shown later this assumption is crucial in determining whether or not an economic return is generated in the O.N. Interest rate on capital in the private commercial banks in Mali is 13 percent but ranges from 15 to 20 percent in the informal rural credit market.[24] A shadow price of capital of 15 percent is retained for this analysis.

After reviewing the distribution of financial costs of rice production in the settlement, transfer payments incorporated in prices of inputs are identified and deducted from the financial cost to arrive at the economic cost of production. Finally the import substitution price of rice in the Office du Niger area is used to evaluate the net economic return by survey zone and by farm size group.

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[24]The capital market in Mali is segmented. Capital is available for development agencies at a concessionary rate of 7.5 percent; it is 2.5 percent on public irrigation works. For a more detailed discussion of shadow prices in the Malian agricultural economy, see Scott R. Pearson, J. Dirck Stryker, Charles P. Humphreys and others, in Rice in West African Policy and Economics, Stanford Press University, 1981.

2. Financial Costs of Rice Production

Table 5-21 depicts financial costs of production per metric ton by rice casier. These were derived by dividing the overall average cost in each farm size group by the average gross yield.

The financial cost per metric ton of paddy is shown to be virtually the same throughout the survey area. This is due to the fact that in areas such as Kolongo where the gross yield is lower, financial costs per hectare are also lower as a result of a limited use of nonlabor resources. The overall average cost in the settlement is shown to be about 33,240 MF per metric ton. Thus the uniformity of the financial cost per unit of output conceals the wide variation in costs and returns per hectare mostly determined by yield differences across the scheme.

3. The Economic Cost of Production

Economic analysis is concerned with flows of real resources, valued in terms of their opportunity costs, which may be different from their market prices. Taking into account all possible adjustments from financial to economic values would lead us too far. Emphasis is given only to those adjustments to the financial accounts which are likely to make a perceptible difference in the evaluation of real costs to the national economy [Brown, 1979].

Seeds

In addition to differences in the rates of seeding per hectare, farmers in the three casiers also used varying proportions of improved seeds in planting their fields. As shown earlier these proportions were

TABLE 5-21. Total Financial Cost of Rice Production Per Metric Ton in the O.N. Survey Area, by Size of Holding[a] (in Malian Francs)

Item	Kolodogou I	Kolodogou II	Kolodogou III	Sahel I	Sahel II	Sahel III	Kolongo I	Kolongo II	Kolongo III	Survey area[c] I	Survey area[c] II	Survey area[c] III
Farm cost per hectare[b]	63,645	68,677	62,698	73,617	61,997	75,771	47,744	46,715	41,883	58,096	57,555	61,852
Average gross yield[d]	2.06	2.14	1.77	1.79	2.01	2.34	1.28	1.32	1.34	1.71	1.82	1.82
Cost of production/metric ton	30,896	32,092	35,423	41,127	30,844	32,381	37,300	32,390	31,256	33,974	31,624	33,985
Average by zone[e]		33,606			33,425			32,560			33,237	

Source: Computed from enterprise tables in section 5.3.

[a]Size group I = below 5 ha, II = 5 to 10 ha, III = 10-15 ha.

[b]Source is Table 5-14.

[c]Averages were weighted by the number of farms in each size group.

[d]Source is Table 5-3.

[e]Weighted by the mean holding size in each group.

respectively 98, 81 and 40 percent for settlers in Sahel, Kolodogou and Kolongo.

Selected seeds were sold to farmers at the official price of 70 MF per kilo. The actual cost-price, however, is known to be 105 MF per kilo.[25] Expenditures on seeds were therefore adjusted for the percentage of subsidy (33 percent) included in the official price and according to the above proportions of farmers who used selected seeds.

Fertilizer

In 1979-80 urea and phosphate were sold to farmers at 120 MF and 140 MF per kilo respectively. Their real cost-prices are estimated at 145.6 MF and 154.6 MF per kilo which translates into an 18 and 9 percent subsidy for urea and phosphate of ammonia, respectively.[26] Thus an average of 16 percent subsidy weighted by the quantities of each fertilizer used was added to farmers' total expenditures on fertilizer to approximate its real economic cost.

Depreciation on Farm Capital

As pointed out earlier, depreciation on farm equipment was also calculated on the basis on the actual level of utilization during the survey period. This is different from a project analysis approach in which the purchase price of equipment is amortized over its estimated lifetime.

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[25]Source is O.N.'s Bureau of Economic Affairs.

[26]The source of cost-price information is McIntire [1979]. The figures are in line with the 1976-77 estimates of fertilizer economic costs provided in the World Bank Identification project report for the Office du Niger intensification program.

Purchase prices of farm equipment in 1979,[27] however, were used to convert individually owned farm equipment from their historic purchase prices into their current market values. This process took account of both the age of the piece of equipment and an inflation factor over its past years of existence. Data on years of remaining life were obtained through interviews as shown earlier in Table 5-4 and depreciation values were computed out of current market values of equipment.[28]

Direct subsidies on capital equipment such as plows, carts, and harrows existed in the past but were removed in the 1976-77 crop season. Nearly half of the settlers' equipment in the sample was bought prior to that year and thus was subsidized at purchase prices prevailing at that time. Those subsidies amounted to 8, 43 and 18 percent for plows, harrows and carts, respectively.[29] A weighted average subsidy of 21 percent was used to adjust the depreciation charge in the estimation of its

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[27]These were respectively 180,000 MF for a pair of oxen, 53,000 MF for a plow, 43,000 MF for a harrow and 84,700 MF for a donkey-tailed cart.

[28]Values of farm equipment depreciation such as shown in the enterprise budgets presented earlier were internally computed by the FMDCAS package using a linear amortization equation with nonzero salvage values.

[29]Sorting out the number of pieces of equipment owned by selected farmers revealed that 55 percent of plows, 57 percent of harrows and 43 percent of carts were bought before 1976. Because of the difficulty to disaggregate the global value of depreciation on farm equipment as computed by the program, it was assumed that nearly half the total purchase value of equipment was subsidized at a weighted average rate of 21 percent, the weight being the total number of individual pieces of equipment in the sample, i.e. 117 plows, 75 harrows and 50 carts. For the amount of subsidy, the source of information is McIntire [op. cit.].

economic value. Calculation of the per hectare economic cost of ownership is detailed in Table 5.22.

Repairs and Maintenance

The financial cost of operating farm equipment including animal feeds expenses was presented in the rice enterprise budgets of section 5.3. Only an opportunity cost of 15 percent for operating expenses was added on to the financial cost to arrive at an economic cost.

Land Improvement Cost, Extension and Administrative Overhead

The cost of land improvement in the Office is now assumed sunk, i.e. the invesment costs of irrigation and drainage works installed some 30 years ago are considered as fully amortized.[30] The land fee of 400 kg of paddy per hectare valued at 24,000 MF still does not cover the administrative overhead (supervision) and extension charge of the O.N. management, which is currently estimated at 33,521 MF [O.N., BAE, 1978], leaving a per hectare subsidy of 9,521 MF.[31]

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[30]The termination of the Markala dam construction in 1947 can be considered as the commencement of normal operation of the scheme. The assumption of sunk capital costs is relevant only for the current production system and should be contrasted with the cost of redeveloping the O.N. infrastructure now underway in the framework of the intensification project. Estimates given are around 220,000 MF per hectare [WARDA, 1977] which, if annualized over 25 years at 2.5 percent would be 11,880 MF per hectare.

[31]This administrative and extension overhead is only a fraction of the annual O.N. recurrent cost per irrigable hectare which ranges from 46,566 to 63,905 MF [CILSS, Club du Sahel, 1980] and which is the O.N. own estimate of desirable expenditure on maintenance. This figure however includes maintenance costs for the irrigation infrastructure serving sugar production as well. It was not possible to obtain a breakdown of the recurrent cost figure.

TABLE 5-22. Estimation of Economic Cost of Ownership of Farm Equipment in the O.N. Survey Area (in Malian Francs)

	Kolodogou			Sahel			Kolongo			Survey area		
	I	II	III	I	II	III	I	II	III	I	II	III
Opening values												
farm durables	100,500	108,000	133,600	83,100	115,800	128,700	62,200	84,400	93,000	81,044	99,692	121,817
draft animals	102,700	282,100	390,700	89,200	89,300	353,300	91,900	121,400	255,000	95,950	165,711	286,933
Total	203,200	390,100	524,300	172,300	205,100	482,000	154,100	205,800	348,000	176,944	265,403	408,750
Incoming values												
farm durables	7,500	16,800	---	---	---	---	---	8,000	---			
draft animals	---	---	---	---	---	120,000	---	---	---			
Outgoing values												
farm durables	---	---	---	---	---	---	700	4,300	---			
draft animals	---	23,300	16,800	---	---	---	4,000	8,600	---			
Depreciation												
on farm durables w/subsidy	8,200	12,900	17,400	9,200	11,700	15,700	4,700	11,300	13,200			
without subsidy[a]	9,290	14,615	19,713	10,423	13,255	17,787	5,325	12,802	14,954	7,707	13,500	17,881
on draft animals	14,500	46,900	66,600	11,000	45,000	59,800	12,500	23,000	68,700	13,103	56,103	64,858
Depreciation without subsidy	23,790	61,515	86,313	21,423	58,255	77,587	17,825	35,802	83,654	20,810	49,603	82,739
per hectare	6,261	8,202	7,193	5,101	7,872	6,109	5,093	5,078	7,089	5,429	6,780	6,801
plus opportunity cost capital @ 15%	940	1,230	1,080	766	1,180	916	764	762	1,064	814	1,018	1,020
Economic cost of ownership[b]	7,201	9,432	8,273	5,867	3,052	7,025	5,857	5,840	8,153	6,243	7,798	7,821

Source: Calculated from survey data and farm tables

a. Weighted average subsidy of 21 percent on half the purchase value of plows, carts, and harrows was added to the depreciation value.

b. Or economic fixed cost of utilization of farm equipment.

Though capital costs are sunk, the economic cost of the O.N. land can still be estimated by considering its current alternative use as far as sugar production is concerned.[32] This activity takes only 8 percent of the area planted to rice but the net revenue per hectare from sugar cane production is higher enough to be considered a viable alternative to rice. In this sense the opportunity cost of the O.N. hectare of rice land can be estimated at 8 percent of the net benefit the government of Mali would earn by converting rice into sugar cane plantation. This estimate was valued at about 10,400 MF per hectare.[33]

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[32]Cotton production was suspended in the O.N. in the early 70's for agronomic and drainage problems. It has been recently demonstrated that for cotton to be a competitive alternative to rice, yields must reach a level of 2.1 mt per hectare, which under present conditions cannot be achieved. For this reason cotton cultivation is not considered a competitive alternative to rice.

[33]The assumption is sustained on the ground that all the rice land could not be converted to sugar cane on a 1 to 1 basis. Estimating the net benefit foregone in sugar production required data on gross benefit and costs. The author was unable to obtain direct data on the cost of sugar production in the O.N. It is believed, however, that until after a second sugar plant came into production at Siribala in 1976, the O.N. ex-factory cost of production was still higher than the sugar import substitution price estimated at 260 MF at 1979 prices (CIF Bamako). Adjusting for transport costs and marketing margins, the corresponding import substitution price of sugar would amount to 320-350 MF per kilo. This higher limit is taken as an estimate of the ex-factory cost of producing granulated sugar in the O.N. area. Recent improvements in sugar cane yields have resulted in yields of granulated sugar of about 4.2 mt per hectare (which is the average for the last 3 years). In 1979-80 the ex-factory sale price of sugar was 375 MF per kilo, leaving a net benefit of at least 25 MF per kilo. Thus the corresponding net benefit per hectare amounts to some 130,000 MF. Eight percent of this value i.e. 10,400 MF is taken to be the foregone value of sugar by cultivating one hectare of rice land.

Machine Threshing Costs and Other Shadow Prices

The threshing charge of 120 kg of paddy per metric ton has been calculated so as to cover actual cost of the Office du Niger. It is believed however that this cost is overstated by some 5 percent since the Office is exempt from fuel taxes and agricultural equipment is duty-free [World Bank, 1978]. Other taxes on wages and salaries, and additional duties included in the prices of vehicles, petroleum products, projects and construction services bought from local suppliers were not available.

The opportunity cost of capital was maintained at 15 percent in the Office du Niger area. Private banks lend at 13 percent and the interest rate ranges anywhere from 15 to 20 percent in the informal rural credit market.[34] Although the shadow price of unskilled labor was 700 MF on the average, locational differences were counted in the evaluation of labor. Table 5-23 presents the components and the total economic cost of producing one metric ton of paddy in the Office du Niger based on the current level of resource use and the assumptions discussed in the preceeding paragraphs.

4. Net Economic Returns by Location and Size of Holding

The import substitution price of paddy at the Office du Niger has been estimated at 90,326 MF per metric ton in constant 1977 prices for the 1980-85 horizon. The details of the calculations are shown in Table

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[34]Many villagers in the survey area claimed the nonexistence of any interest on borrowed capital on religious ground. But it is known to exist among traders and was substantiated through personal interviews made by the author.

TABLE 5-23. Calculation of the Economic Cost of Rice Production Per Metric Ton
(in Malian Francs)

	Kolodogou			Sahel			Kolongo			Survey area		
	I	II	III	I	II	III	I	II	III	I	II	III
1. Total value of labor[a]	82,800	70,488	73,440	118,170	106,470	119,340	65,400	39,420	41,580	80,325	65,806	80,775
2. Seeds	8,584	11,092	12,346	15,197	13,221	19,363	6,318	8,502	9,594	8,557	10,490	13,997
3. Fertilizer	7,301	11,913[b]	8,141	11,558	9,960	14,393	5,913	6,231	4,326	7,315	8,981	4,474
4. Interest and depreciation on farm equipment[c]	7,201	9,432	8,273	5,867	9,052	7,025	5,857	5,840	8,153	6,243	7,798	7,821
5. Repairs and maintenance[d]	3,606	5,821	2,650	6,660	2,630	2,714	4,706	1,996	2,178	4,991	3,482	2,514
6. Machine threshing	11,820	11,929	10,014	10,657	11,785	13,325	5,109	4,877	3,529	8,688	8,845	9,496
7. Land fee and O.N. overhead[e]	33,521	33,521	33,521	33,521	33,521	33,521	33,521	33,521	33,521	33,521	33,521	33,521
8. Opportunity of O.N. land[f]	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400
9. Total economic cost per ha	165,233	164,596	158,785	212,030	197,039	220,081	137,224	110,787	113,281	160,040	149,333	162,998
10. Economic cost per metric ton	80,210	76,914	89,709	118,453	98,029	34,052	107,206	83,930	84,538	93,591	82,046	89,559
Average by zone		82,278			103,512			91,891			88,398	

[a]Both family and hired labor valued at the zone market wage rate.

[b]Includes the market value of cattle manure.

[c]See Table 5-23.

[d]As in Table 5-15 including a 15% interest on capital.

[e]See explanation in the text.

[f]See footnote 33 in the text.

[g]Total economic cost divided by gross yield as shown in Table 5-22.

5-24, based on data from the 1978 World Bank Identification Report for the Office du Niger Intensification program.

Table 5-25 shows net economic returns across the settlement and by size group. Given the rates of subsidy on seeds, fertilizer, overhead and extension charge as calculated above, the economic costs of production were three times the financial costs when economic prices were used to value all factors of production. The results indicate that rice production in the O.N. area generated an economic return of nearly 2,000 MF per metric ton of pabdy considering the actual level of resource utilization during the 1979-80 crop season. This level of economic return however is dependent upon a crucial assumption made earlier concerning the opportunity cost of improved land in the Office, estimated as a small fraction (8 percent) of the residual return per hectare of sugar cane. In addition if the uncovered portion of the total O.N. recurrent costs of rice production is counted for, no actual economic return will be generated. The sensitivity of these two assumptions raises serious questions about the comparative advantage position that Mali is reported

TABLE 5-24. Import Substitution Price of Paddy for the 1980-85 Horizon at the O.N.

Item		Value
Thai rice 25-35% brokens, FOB in constant 1977,[a]	$/mt	273
plus sea-freight, insurance	$/mt	30
plus cost CIF Dakar	$/mt	273
Cost CIF Dakar in MF/mt		148,470
plus port handling/stevedoring		3,740
plus transshipment to rail		2,000
plus rail transport Dakar-Bamako		18,220
plus raod transport Bamako-O.N. zone[b]		7,800
plus unloading O.N. zone		500
Wholesale price O.N. zone (MF/mt)		180,730
less milling cost		10,430
subtotal		170,300
Paddy equivalent[c]		110,696
less paddy and rice bags		4,250
less transport to mills		4,260
less collection of paddy		5,860
less losses (10%)[d]		6,000
Economic price of paddy @ farm level (MF/mt)		90,326

Source: Adapted from World Bank--"Office du Niger Identification Report" 1978.

[a]Derived from World Bank forecasts.

[b]Three-hundred km at 26 MF per km.

[c]At the average milling rate of 65%.

[d]Based on recent estimates (harvesting and threshing losses [Kamuanga and Spencer, 1981].

TABLE 5-25. Estimated Net Economic Returns by Size Group in the Survey Area

	Kolodogou			Sahel			Kolongo			Survey area		
	I	II	III	I	II	III	I	II	III	I	II	III
Economic cost per mt	80,210	76,914	89,709	118,453	98,029	94,052	107,206	83,930	84,538	93,591	82,046	89,559
Economic value	90,326	90,326	90,326	90,326	90,326	90,326	90,326	90,326	90,326	90,326	90,326	90,326
Net returns	10,116	13,412	617	-28,127	-7,703	-3,726	-16,880	6,396	5,788	-3,265	8,280	767
Average per zone		8,048			-13,185			-1,565			1,927	

Source: Table 5-24 and 5-25.

to have from rice production in the Office du Niger.[35]

Abstracting for the treatment of recurrent costs, locational distribution of net economic returns in Table 5-25 invites some comments. An economic loss per metric ton of nearly 13,200 and 1,600 MF is incurred in Sahel and Kolongo, respectively. In Sahel this is due in particular to the fact that total opportunity costs of labor were higher as a result of a larger family labor inputs and a higher wage rate found in the area. Sahel farmers, however, earned the highest net private return in the survey area as indicated earlier in Table 5-16. In Kolongo low labor inputs and a low proportion of subsidized material inputs relative to other zones failed to result in a substantial decline in the estimated economic unit cost of production because of lower yields.

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[35]Mali's comparative advantage in rice production is documented in a number of WARDA/FRI Stanford studies. The most recent by J. McIntire in "Rice in West Africa-Policy and Economics," (Scott R. Pearson, J. Dirck Stryker, Charles P. Humphreys, 1981) uses the resource cost-ratio methodology to assess private and social profitability of various rice production techniques in Mali. Private profitability is defined only at the farm level and measures the incentives provided to farmers in rice production by government policies. Net social profitability is equal to the c.i.f. price of imported rice minus tradeable input and domestic factors costs, valued at their world prices. It is calculated to combine the cost of collection and milling of rice and represents the natural comparative advantage in rice production of a country, as defined by its resource endowments, geographic position and technical efficiency of production with respect to a given set of world prices. At 1976 prices Mali is shown to derive its comparative advantage in rice production from the current O.N. technique of gravity irrigation, animal power and some level of fertilizer use. Despite the lack of data on alternative use of the Office improved land, this study does not show explicitly how the Office recurrent cost of up to 64,000 MF per hectare is dealt with in the calculation of social profitability.

In all zones, however, economic returns are higher and economic losses are lower for the group of medium sized farms (5 to 10 hectares). This seems to indicate the size of holding where resources are used more efficiently and where comparative advantage is the greatest.

Summary

Three zones or "casiers" were distinguished in the analysis of resource utilization in the production of rice. Net enterprise incomes per hectare are the highest in Sahel and the lowest in Kolongo. This is due to a higher yield potential in Sahel and a generally higher level of resource utilization relative to other casiers. However, the remuneration per man-day of labor both in terms of average products and net income are the highest in Kolodogou and significantly lower in Kolongo. The failure for Sahel to surface with the highest average and net incomes per man-day is due to the labor intensive nature of rice cultivation there.

The issues of surrounding the settlers' cultivation of hors-casier rice fields were also presented and discussed in some detail. It was shown that unless yields are raised on legal holdings and the official producer price adjusted to its free market level, the practice is bound to continue.

One major finding of this chapter is that rice production is most efficiently undertaken in the medium sized group of farms, i.e., those with holdings between 5 and 10 hectares. This is confirmed in both the financial and economic analysis. The latter indicates also that economic costs of production are the highest in Sahel and the lowest in Kolodogou, where are generated the only positive economic returns in the survey area, in accordance with the assumptions developed about the opportunity cost of land and the noninclusion of O.N. recurrent costs.

CHAPTER 6

THE LIVESTOCK ENTERPRISE

6.1 Introduction

Animal husbandry is a secondary farm activity and has developed over the years in view of the importance that animal traction has taken in the Office du Niger. Interactions between the processes of rice and animal production have not yet reached a stage where the system could be characterized as "mixed farming," but fertilization of rice fields with cattle manure and the use of rice by-products (straw, bran and rice flour) as animal feeds are already a step in that direction. In addition, some settlers derive a substantial monetary profit by fattening oxen when the animals' working career is over. Farmers with large herds may resort to supplementary feeding and train young steers as work animals to replace the stock of old and exhausted oxen. The importance of livestock production is also revealed by the Office's own large scale operation of a commercial feed lot in which about 2,000 head of cattle 4 to 9 years are fattened each year.

The purpose of this chapter is to provide some information on resource utilization in animal production by O.N. settlers within the limitation of the available data which was collected during the farm management survey. Specifically, an attempt is made to assess the amount of cash and non-cash incomes accruing to farmers as a result of their involvement in livestock activities, the types of outputs produced and inputs used, the distribution of livestock ownership and its contribution to income disparities among settlers.

Labor use was the most difficult to quantify with precision because some of the animal husbandry activities could hardly be separated from the category of general farm activities as defined in Chapter 4. In addition, for those settlers with relatively large herds, the practice of entrusting cattle to Peul herdsmen for an extended period of time (six months to a year) was not itself amenable to quantification. This restricted the reported labor inputs and other resource use to what could actually be observed on farms during half the season. The data were also deficient with respect to values of home-consumption.

In an environment where cattle are largely held for tradition and social prestige, output categories were also limited to what could be measured. In general, in addition to cow milk and home-made butter, farmers keep goats and sheeps for meat, reproduction and sale.[1] They also keep poultry flocks consisting of chicken, ducks and Guinea-fowl. The flock is often self generating and farmers sell table eggs and live poultry when production is above family consumption needs.

6.2 Distribution of Livestock Ownership Among Selected Farmers

The number of head of cattle and small ruminants can be used to stratify farmers in assessing the distribution of livestock among the sampled farmers. This is only possible, however, if one is dealing with one single species of livestock. In order to compare herds with varying proportions of cattle and sheeps/goats in the sample, it is customary in animal husbandry to evaluate the herd in terms of livestock units (LSU). The LSU denotes a standard live weight of animal usually

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[1]Goat milk is practically unknown or non-valued.

within the limits of 300 to 500 kg. In this study the conversion factor is taken as one for a head of cattle and 0.13 for sheep or goat.[2]

Table 6-1 depicts the size distribution of livestock in the sample, with no reference to location in the Office area. Five strata were determined in terms of the total stock owned by settlers including those with only poultry. The data show that 31 percent of settlers in the sample did not keep either cattle or small ruminants. Forty percent had a stock of less that 5 LSU with an average of 1.80 per farm. Fifteen percent had between 5.01 and 10 LSU with an average of 7.2 LSU. There were 8 and 6 percent of settlers with stock between 10 and 20 and above 20 LSU, respectively. All settlers with either cattle or small ruminants also kept poultry of a varying importance on their farms. The value of poultry shown in Table 6-1 was the mean of opening and ending values recorded during the survey period. Its wide variation within strata is shown by the ratio of means to their respective standard deviations.

Two interesting features are also revealed in Table 6-1. First, fifteen percent of settlers own 66 percent of the total number of cattle in the sample, and second, as the size of the herd increases its composition changes toward a higher proportion of cattle relative to sheeps/goats.

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[2]The FAO Production Yearbook (1974) recommends the following LSU conversion factors for different species: 1.0 for buffaloes, horses and mules; 1.1 for camel, 0.8 for cattle and asses; 0.2 for pigs and 0.1 for sheeps and goats. Because only two species are involved here, it was reasonable to set the conversion factor for cattle equal to 1.0 and adjust that for sheeps/goats accordingly.

TABLE 6-1. Size Distribution of Livestock Ownership in the Sample at the O.N.

Size groups (LSU)[a]	Mean herd size (LSU)[a]	Number of settlers	Percentage of total	Total composition of herd (head)		Mean value of poultry (MF per farm)
				cattle	ruminants	
None		30	31			5,610 (7,860)
Less than 5	1.8 (1.58)	38	40	58	78	9,056 (11,785)
5 to 10	7.2 (1.67)	14	15	69	17	5,836 (5,140)
10 to 20	14.6 (2.92)	8	8	85	21	4,050 (5,596)
Above 20	41.7 (26.64)	6	6	166	6	19,125 (21,041)
Total survey area		96	100	378	122	

Source: Survey data.

[a]Livestock unit denotes a standard live weight of animal 300 to 500 kg. In this study the conversion factor is 1.0 for cattle and 0.13 for all small ruminants.

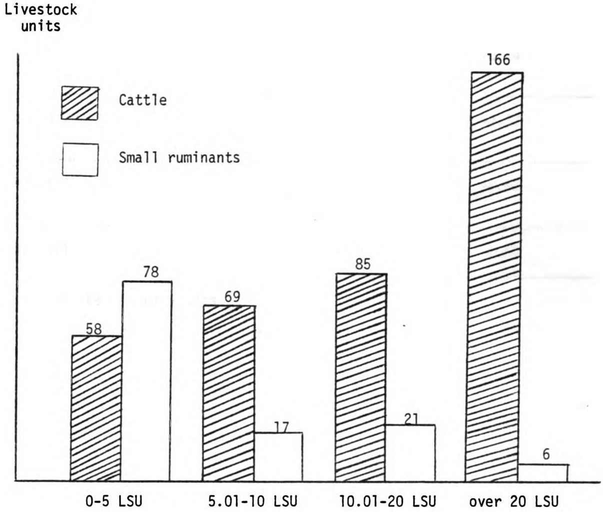
Note: Standard deviation in brackets.

Because cattle is held also as a store of wealth, such distribution of ownership across the sample is strongly indicative of the potential for income disparity among settlers. Figure 6 illustrates this skewness in livestock distribution among selected farmers.

Data on the number of animals of each species were more accurate than that collected on the age structure. In fact there was some confusion on the part of farmers about the age of their animals; what is known represented only the best guess by the enumerators. In general, cattle ages ranged from 4 to 12 years with an average of 5.6 years. Small ruminants were relatively younger, ranging from 2 to 5 years with an average of 3 years.

An attempt to correlate the size of the herd and the amount of land planted to rice in the sample showed a low positive coefficient (0.12) for the 40 percent group of settlers with 1 to 5 LSU, while the highest correlation (0.62) was found among the 6 percent group of settlers with over 20 LSU. Correlation coefficients were respectively -0.24 and -0.32 for the two remaining groups in the middle (Table 6-2). For the sample as a whole the overall correlation coefficient was found positive but low at 0.42. Thus, the association between the farm sizes and the stock of productive animals kept on farms is more than weak. Large farms are associated with large family sizes and a larges resource base for rice production, but not necessarily with increased livestock activities, though this seems to prevail for the group of farms with holdings above 10 ha.

This finding confirms the wide variation in gross value of livestock output within each size group farms as discussed in farm budget analysis of Chapter 4. In the following sections, analysis of resource



Distribution of Cattle and Small Ruminants Owned
by Settlers in the O.N. Survey Area

FIGURE 6

TABLE 6-2. Correlation Between Farm Sizes and Number of Animals Kept on Farms

Size of Herd (LSU)	Average size of rice farm[a]	Correlation coefficient
1 to 5	7.4 (4.3)	-0.12
5 to 10	7.3 (4.4)	-0.24
10 to 20	10.5 (4.1)	-0.32
Above 20	19.1 (7.1)	+0.62
Overall	11.08	0.42

Source: Survey data.

[a]Standard deviation in parentheses.

use in livestock production is restricted to the group of settlers with stocks below 20 LSU. This group has 63 percent of settlers and represents those with less than 20 head of cattle and a large stock of sheeps/goats. It was purposively chosen to provide an objective assessment of resource use in animal husbandry within the O.N. grazing area, thus eliminating the bias introduced on larger farms by the practice of entrusting cattle to herders.

6.3 Costs and Revenues in Animal Husbandry

Livestock revenues accrue to settlers both in the form of cash and subsistence production. Consumption and sale of cow milk[3] and other dairy products (mostly home made butter), mutton, eggs and poultry were the most common modes of disposition of livestock output. Beef consumption and sale was rare on the settlement mostly because farmers keep cattle for social prestige and as a store of wealth. Sheep and goats, however, were transacted more frequently particularly during the Muslim feasts of Ramadan and Tabaski. This is because small ruminants are a faster maturing store of wealth and can easily be sold.

The data collected on the value of livestock products has underestimated the value of home consumption. For this reason the net livestock income presented later in Table 6-4 refers only to cash returns obtained by deducting the total cash costs of production from the reported cash receipts during the 1979-80 season.

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[3]Much of the fresh milk is home-consumed and additional production beyond family needs is usually sold in the form of a yogurt-like curdled milk which keeps well in the heat.

Fixed costs were negligible for the group of settlers studied because settlers do not pay rents and the cost of repairs and maintenance of corrals was extremely low. This was not the case for farmers with larger herds where paddocking is a necessity. Variable expenses were of four main types: (1) feeds, roughage, provision of minerals and salt licks; (2) veterinary costs; (3) the cost of hiring labor; and (4) settlers' outlay for animal replacement. Rice straw was produced on the farm with a zero opportunity cost.

Labor Utilization

Table 6-3 summarizes the labor requirements among settlers with herds of different sizes. For the average household, the data indicate that eighty percent of the farm labor in animal husbandry was devoted to herding. The weighted average was 4.7 man days per LSU. The labor requirement per LSU declines with herd growth when less than 20 animals are kept. This should be expected as the overhead cost of corral maintenance and supervisory labor and the total labor for herding is divided by a large number of LSU.

Net Household Cash Income from Livestock

Derivation of the average net cash return from livestock is shown in Table 6-4. The ratio of mean values of individual items included in the budget to their respective standard deviations strongly suggests that livestock as an enterprise is characterized by a wide variation in the use of non-labor resources. A weighted average for each item was computed in order to determine the value of cash incomes and expenses more likely to be applicable to a household with the sample mean of 7.0 LSU. The average gross cash income amounted to 30,658 MF. If expenses

TABLE 6-3. Labor Use by Stratum of Animal Stock Owned

	1-5 LSU[a]	5-10 LSU	10-20 LSU	Average[b]
Total (man-days)	24.2 (31.6)	42.3 (43)	45.2 (46.7)	42.7
of which herding	20.2	33.4	36.6	34.4
Labor use per LSU[c]	13.4	5.9	3.1	4.7

Source: Survey data.

[a]Standard deviations in parentheses.

[b]Weighted by the average number of livestock units in each group. The LSU conversion factors were 1.0 for cattle and 0.13 for all small ruminants.

[c]Total divided by the mean number of LSU in each group.

TABLE 6-4. Net Household Cash Income from Livestock
(in Malian Francs)

Item	1-5 LSU	6-10 LSU	11-20 LSU	Average[d]
Gross cash income	30,967 (29,932)	16,990 (23,306)	37,360 (63,690)	30,658
Cash operating costs				
feeds, roughage and concentrates	4,350 (4,610)	2,623 (2,855)	5,730 (4,839)	4,677
minerals[b]	3,570 (2,179)	-[c]	1,550 (760)	1,772
veterinary care	960 (486)	480 (404)	1,058 (699)	874
animal replacement	41,911 (54,558)	33,100 (29,551)	106,300 (82,400)	79,057
hired labor	6,843 (4,607)	4,340 (2,110)	700 (-)[d]	2,279
others[e]	-[c]	2,115 (-)[d]	2,669 (-)[d]	2,486
Total	57,634	40,543	115,338	88,118
Net cash flow	-26,667	-23,553	-77,978	-57,460
without animal replacement	15,244	9,547	28,332	21,597
Net cash return per LSU	8,469	1,326	1,940	2,734

[a]Average weighted by the mean number of LSU's in each size group.

[b]Includes salt licks.

[c]Data was insufficient to secure a meaningful average figure.

[d]Average figure indicative of the order of magnitude, standard deviation could not be computed for insufficient data.

[e]Includes such items as cords and yokes to attach animals.

on animal replacement are excluded, the average cash expenses amounted to 12,088 MF. This compares to an estimate of 17,772 FCFA (i.e. 35,544 MF) provided by Delgado [1979] for a group of semi-sedentary Fulani herdsmen in Southern Central Upper-Volta with an average herd size of 43 head of cattle.

The animal replacement expenditure across the sample takes up 89 percent of total cash expenditures. Purchases of young calves, heifers, goats and sheeps is commonly a way of building up the stock of productive animals, and as such should be considered an investment outlay whose stream of benefits can be expected for a number of years. The remaining cash expenses represent the actual value of resources used up in animal husbandry (assuming zero fixed costs) and with animal replacement costs excluded, the balance is a positive net cash return. The results also indicate that the unit cash return is higher on farms with relatively small herds. The highest return was approximately 8,470 MF per LSU. The lowest was estimated at 1,940 MF. The settlement weighted average was evaluated at 2,734 MF per LSU.

In sum, cash flow statements are negative only if the financial outlay for animal replacement is counted for. This however, should not be interpreted as an indication of poor farm efficiency in livestock operations because, as shown above, farmers keep large animals (cattle mostly) for tradition and social prestige and invest their savings in large animals to build up their stock. Negative cash flows for livestock across farms with varying herd sizes is partly responsible for the wide variation in the farm net cash flows discussed earlier in Chapter 4. Therefore the data on net cash returns cannot be adequately interpreted without an assessment of the value of the stock of productive animals. This is done in the next section.

6.4 The Herd Inventories: A Store of Wealth and its Variation Among Sample Farms

Opening and ending values of productive animals kept on farms are shown in Table 6-5 by size of herd. Incoming values refer to births and livestock appreciation which occurred during the season of April, 1979 through March, 1980. The data represent the total present values of cattle, goats/sheep and poultry owned by farmers in the sample. The value of purchased animals used to build up the stock was also entered to arrive at total ending values. The data indicate that there was a net increase of 65 percent in the value of the productive stock for the group with less than 5 LSU, 25 and 38 percent net increases for the two remaining groups, respectively. For the sample as a whole the values increased from 329,277 MF to 447,766 MF, or 36 percent. Its mean value during the survey year was 388,522 MF per farm. Thus the mean gross cash income generated in animal production represents only 13 percent of the average value of the stock of productive animals in the O.N. area.

In summary, livestock as an enterprise is characterized by (1) a skewed distribution of ownership of animals, (2) a wide variation in resource use among settlers and (3) overall minimal contribution to farm cash incomes.

TABLE 6-5. Inventories of Productive Animals by Size of Herds in the O.N. Sample (in Malian Francs)

	1-5 LSU	6-10 LSU	11-20 LSU	Average[a]
Opening values	80,303 (76,326)	198,775 (153,661)	424,330 (281,118)	329,277
incoming values	10,041 (24,395)	17,450 (32,216)	54,220 (160,318)	39,432
purchase of animals	41,911 (54,558)	33,100 (29,551)	106,300 (82,400)	79,057
Ending values	132,255	249,325	584,850	447,766
Percentage change in value at end of season	65	25	38	36

[a]Weighted by the mean number of LSU in each group.

Note: Standard deviations in parentheses.

CHAPTER 7

PROSPECTS FOR INTENSIFICATION AT THE O.N.: ASSESSMENT OF THE PILOT PROJECT AND RESULTS OF A LINEAR PROGRAMMING MODEL OF THREE REPRESENTATIVE FARMS

Preamble

The intensification program currently underway at the Office is perceived as a long-term and continuous process during which the potential of the scheme is to be realized in stages. These stages are presented in more details in the 1977 WARDA identification report. They are summarized here as follows:

(1) Preliminary stage of testing and assessing the existing potential. This requires land levelling and trials to determine appropriate techniques and equipment for minimizing costs. Also farm level trials have to be conducted to test settlers' receptiveness to improved techniques. Yields are expected to reach 2.5 mt per hectare and be maintained around that level.

(2) First intensification stage targeted at 4.0 mt per hectare if the preliminary stage is successful. Land levelling is expected to proceed with a reduction in the size of settlers' holdings to about 6 or 7 ha.

(3) Second intensification stage whose implementation presupposes results from additional research to change the current farming system

into a double cropping of rice,[1] at least on a limited portion of the land. Crop diversification is also envisaged, but would depend on the results of the first stage and from research.

To date land levelling and rehabilitation of irrigation and drainage works are being implemented as part of the preliminary stage, financed by the World Bank.[2] Improved practices such as high dosages of fertilizer and line seeding are being introduced at the farm level. A review of the pilot intensification project and discussion of preliminary results is presented in the next section.

7.1 Results of the Pilot Project at Foabougou

1. Background

A total of 160 ha were leveled in 1979-80 for the intensification trial program in the village of Foabougou (Niono, Partiteur G3). Improvements were done with considerable delays and the Office management found it necessary to take possession of the land and allocate it to the settlers, so avoiding another year of reduced receipts due to nonuse of the land as was the case during the 1978-79 season.

In addition to technical improvements made to the Foabougou casier, fields were drastically reduced in size to ensure that each pilot would

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[1]For instance varietal improvement should seek to obtain nonphotosensitive, short-stemmed varieties.

[2]The total area to be redeveloped under the Bank program is to cover some 1,500 ha respectively in the following O.N. sectors: Molodo (Partiteur M2: 500 ha), Niono (Partiteur G3: 250 ha), N'Debougou (Partiteur 56: 260 ha) and Kourouma (Sous-Distributeur Banivi: 500 ha).

be properly irrigated and drained.[3] The largest plot was 3 ha compared to 10 ha previously. The 25 farmers settled in Foabougou were then allocated varying sizes of plots depending on the number of working men (adult males) available in each household.[4] The monitoring survey in Foabougou started in August 1979 soon after the settlers began working on their plots. Fertilizer was homogenously and effectively applied at the O.N. recommended rates of 50 kg of urea and 50 kg of ammonium phosphate per hectare, including 200 kg of Tilemsi phosphate.

Labor data were collected until the beginning of the 1980-81 season in order to capture the activities of land preparation and sowing which were mechanically done by the Office during the 1979-80 season. Output was estimated through the usual yield plot method on a per farm basis.

2. Enterprise Budget for the Average Farm at Foabougou

A complete enterprise budget per hectare which includes the seasonal distribution of labor is shown in Table 7-1, in its original form from the FMDCAS package. The average size of holdings was 6.4 ha (SD = 2.4) with a range from 3.8 to 10.5 ha. There were 2.0 W.M. per household and total labor use per hectare amounted to nearly 90 man-days. This figure, however understates slightly the actual demand for labor

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[3]The new layout of the network also suppressed the need for field level embankments of the "piano-key" type. Plots are smaller and equipped with subirrigators and corresponding drains. Also a double row system of water channels allows the inundation of the bund-separated plots.

[4]The pattern of land allocation also followed the suggestions put forward by the research team. This was done in an attempt to assess the size effect on farmers' revenues in order to determine an optimal norm for land allocation. This issue is discussed later after the results of linear programming models are presented.

TABLE 7-1. Enterprise Budget and Labor Utilization for the Average Farm at Foabougou[a]

Source: Farm Survey data.

[a]Labor inputs, animal power inputs and quantities of other non-labor inputs are weighted by the size of fields, all values are in 100 MF.

[b]The heading refers to transportation of seeds.

[c]Total of variable and fixed costs divided by yields in hundred kg. does not include opportunity of family labor.

CROP ANALYSIS (PER AREA) 16 OPEN POWER SURVEY(25 OBSERV)

COUNTRY	REP OF MALI	DATA SOURCE		
PROVINCE/REGION	SEGOU 4TH REGIO	FARM-LEVEL AGRO-ECON		
VILLAGE/SUBREG.	N O.N. CONCESSIO	OMIC SURVEY OF RICE		
		PRODUCTION AT THE OF	TYPE OF TENURE	0
LONGITUDE	N 13	FICE DU	FARMERS SHARE,PERC	0
LATITUDE	W 7		CULT.SIZE	6.39
ALTITUDE,M	0		CULT.PRACT.	0
DRAINAGE	0	AUTHOR	PLANT.METH.	0
IRRIGAT. SOURCE	0 METHOD 0	MULUMBA KAMUANGA	ROT.1YEAR AGO	0
SOIL TYPE	0 0 0	YEAR OF OBSERV.1979	2YEAR AGO	0
	BROWN CLAY LOAM		3YEAR AGO	0
CLIMATE TYPE	SUBTROP-SAHE			

CLIMATE	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM	724	0	0	3	9	20	94	282	239	127	27	3	0
TEMPERATURE MEAN		2.4	26.6	29.7	32.1	32.7	30.3	27.5	26.4	27.0	28.5	27.3	24.4
HIGH													
LOW													
HUMIDITY PERC													
LABOUR INPUTS (HD)													
SEEDBED/NURSERY[b]	.2					.0		.1	.0				
SOIL PREPARATION	13.2		.1			.7	.6	10.9	.8	.0			.0
CLEARING													
DIGGING	.0								.0				
PLOUGHING	9.5					.5	.2	8.4	.3	.0			.0
SOWING/PLANTING	.8					.0	.1	.1	.6				
APPLY FERTILIZER	1.9		.3	.5	.1	.1		.1	.3	.3	.4		.0
APPLY PESTICIDES													
IRRIGATING	1.1			.1	.0	.0	.1	.0	.6	.0	.0	.1	.0
CARE/CULTIVATION	22.7		.2	.1	.1	.1	.2	.0	6.0	7.9	6.2	1.5	.4
WEEDING	17.4		.2	.0	.1		.0	.0	5.4	7.7	3.9		.1
HOING													
THINNING	.1								.0		.1		
HARVESTING/PROC.	31.7	3.4	2.2	2.7	.3	.6	.4	.3	.3	.2	.1	6.7	14.5
CUTTING	27.9	2.7	1.7	2.1	.2	.0			.1	.1		6.7	14.2
THRESHING	.8	.1	.2	.1	.1	.1	.0		.0	.0	.0	.0	.1
SORT/PACK.	.2	.1	.0						.0				.1
OTHERS	18.0	1.3	1.0	.2	.0	.4	.3	.1	1.3	1.3	4.1	7.3	.2
TOTAL	89.5	5.3	3.8	3.5	.6	1.8	1.9	11.7	9.9	9.7	10.7	15.6	15.1
POWER INPUT(HOURS)													
ANIMAL SOIL PREP.	66.4		1.6	2.9	.4	4.0	2.3	52.8	2.5		.0		
------ CULTIVAT.													
HARVESTING													
OTHERS	3.3	2.4						.5	.0				.4
TRACTOR SOIL PREP.													
------ CULTIVAT.													
HARVESTING													
OTHERS													
IRRIGATION WATER													

		NO.TREES	AGE
1ST CROP		0	0
2ND CROP		0	0
3RD CROP		0	0

YIELD AND OUTPUT		AMOUNT	PRICE	VALUE
1ST CROP	MAIN PROD.	1928	.60	1162.98
	BY-PRODUCT			.08
2ND CROP	MAIN PROD.			
	BY-PRODUCT			
3RD CROP	MAIN PROD.			
	BY-PRODUCT			
TOTAL				1163.05

VARIABLE COSTS		AMOUNT	PRICE	COSTS
1ST CROP:SEED/PLANTS		125	.70	87.83
2ND CROP:SEED/PLANTS				
3RD CROP:SEED/PLANTS				
FERTILIZERS	ORGANIC			
	MINERAL	104	1.33	138.38
	N			
	P2O5			
	K2O			
	CAO			
PESTICIDES	INSECT.			
	FUNGIC.			
	RODENT.			
	HERBIC.			
	TOTAL			
PACKING MATERIAL			2.00	.09
TRANSP/MARKET CHARGE				127.33
SEAS.HIRED LABOUR		6	4.31	25.00
ANIMAL POWER,HIRED		1	6.25	3.76
	OWN	70	.13	9.37
TRACTOR POWER,HIRED				
	OWN			
OTHERS				
TOTAL				391.84

OVERHEAD COSTS	COSTS
RENT,VALUE SHARECRO.	239.96
DEPRECIATION	39.62
INTERESTS	
OTHERS	33.33
TOTAL	312.91

ECONOMICS	VALUE
VALUE OF PRODUCTION	1163.05
GROSS MARGIN	771.22
NET EARNINGS	458.30
PRODUCTION COSTS/100[c]	36.56

because data collection in April 1980 was incomplete.[5] The average gross yield was estimated at 2.36 mt per hectare (SD = 0.5) for the 1979-80 season. Attempts to aggregate the results of two crop seasons were deemed unsatisfactory.[6] All magnitudes calculated in the budget of Table 7-1 (in 100 MF) refer to the net yield per hectare derived as in Chapter 5.

Although only some elements of the improved package were implemented (higher fertilization rates, land levelling), the results indicate that the Foabougou settler on the average, was in a better financial position than his counterpart of other casiers in Niono. Net earnings of 45,830 MF per hectare are indeed as high as those reported earlier for the best farmer in Sahel with an average holding of 7 ha.

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[5]Infrastructural works on Foabougou casier continued during the 1980 off-season from March to April. This gave farmers actually little to do on their rice fields. In a normal year April would be devoted to repairs and maintenance of field canals and drains and some land preparation operations.

[6]A first layout of yield plots (supervised by the research team) from November 22 to December 20, 1979 led to yield estimates reported in Appendix D. A second implantation in December 1980 after the research team had left Mali was supervised by the O.N. Bureau of Economic Affairs. However only less than half the sample was covered. The O.N. secured estimate for 1980-81 season is reported to be 1.7 mt per hectare (SD = 1.0) (Official communication by letter from O.N. Direction Générale). This author's experience with O.N. yield plot approach prompted the decision to retain only the survey results for the 1979-80 season, also considering the fact that resource use by Foabougou farmers remained virtually the same for the two crop seasons. Besides, the December 1979 crop cut was made at the proper time of field maturity, thus avoiding bird damages which became quite a problem late in the harvesting season at Foabougou. The Office estimate of 1.8 mt that year still did not accord with the research team results.

3. Productivity Differences Between Incoming and Old Settlers at Foabougou

Eighteen of the sample farmers at Foabougou were colonists moved from other casiers in Niono while 7 were new settlers with no previous experience in rice cultivation. Statistical analysis of the two sub-groups could not be undertaken given the smallness of subsamples, but also because the selection of farmers was not the result of a random choice. However a simple comparison of mean values of selected farm variables shown in Table 7-2 suggests that actual differences in the population may exist. For instance, labor use and animal power per hectare are lower by respectively 13 and 49 percent for the new settlers. Yields, gross margins and net enterprise earnings are also less than those of old colonists (9, 6 and 7 percent lower). Lack of experience and problems of adjustment to the O.N. environment could be hypothesized as important factors explaining the low performance of new settlers at Foabougou.

4. Assessing the Results

The above results have to be interpreted with caution for the following reasons: first, data collection overlapped two crop-years, but output estimates derived from yield plot measurements referred only to the first year. Second, the sample size was determined by the Office staff to conform with the area of newly developed land available. The research team had no information as to the criteria used by the Office to select the settlers to be installed.

However, there is reason to believe that the potential output of the two crop seasons was similar as resource utilization and the

TABLE 7-2. Per Hectare Resource Use and Productivity Differences Between Old and New Colonists at Foabougou[a]

Item	Old Colonists n = 18	New Settlers n = 7	Overall n = 25
Labor use (man-days)	93.8	81.4	89.6
Animal power use (hours)	84.0	43[b]	71.0
Yield (kg)	1979	1830	1928
Gross margin (00 MF)	787.0	741.2	771.2
Net earnings (00 MF)	469.8	436.5	458.3

[a]Mean values were weighted by the size of holding per household. Fertilizer and seeds applications were similar on all farms.

[b]The variation around the mean was also wide (SD = 81.4).

management practices of settlers remained virtually the same. The average gross yield of 2.36 mt was certainly the result of both the improved land potential, the effective application of fertilizer at recommended rates and the more or less intensive campaign by the Office staff in Niono who had certainly wanted the project to be a success.

The technique implemented at Foabougou can be considered as a first step in a range of improved practices the adoption of which will measure the success or the failure of the intensification program at the O.N. A detailed inventory of these techniques is provided in the next section.

7.2 Prospects for Intensification: Improved Techniques and Their Implications for Resource Requirements and Outputs

1. Introduction

Intensification of production at the Office is not novel. In Chapter 2 it was indicated that attempts to increase output per hectare and consolidate the infrastructure could be traced back to the late 1940's. By 1958 however the record of the O.N. was on balance very disappointing. Lack of manpower, persistence of irrigation and drainage difficulties, and farmers' doubts about the profitability of new practices are cited among major factors which limited the success of past intensification campaigns [de Wilde, 1967].

Today's stepwise approach to intensification departs fundamentally from previous attempts. It is expected that resources will be mobilized in each stage to attain its targets and prepare the ground for success in the next stage. This chapter unfolds along the view that adoption of intensification techniques at the farm level will also be a step-by-step process. Therefore a primary task is to provide a detailed inventory of the techniques now considered as part of the technological know-how at the Office. The exercise is essentially aimed at deriving input-output relationships to be used in a linear programming model that will help examine the feasibility, profitability and practicability of intensification at the farm level (Section 7.3). This approach is based on the understanding that if a proper choice of practices has to be recommended for intensification, much more must be known about (1) the specific increases in yields that can be obtained under a particular combination of practices; (2) its labor and nonlabor resource requirements; (3) the seasonal pattern of labor use as dictated by the above requirements; and (4) the availability of labor and nonlabor resources throughout the cropping season.

Following Byerlee, Collinson et. al. [1980], we define <u>technique</u> as being the combination of all management practices for producing rice. A technique is determined by the timing, amount and types of various technological components such as seed-bed preparation, rates of fertilizer application, all of which constitute its <u>attributes</u>. The term <u>technology</u> is used to represent a set of techniques available or being used at any given time period, for producing a given crop or crop mixture. Some of the attributes of techniques described in this section have been tried in the past at the Office (for instance transplanting of rice seedlings), others are being implemented or contemplated (row seeding, animal power weeding).

Techniques are considered individually, each with its main attributes and its implications for resource demand are summarized in the form of enterprise budget that includes the associated labor requirements. Underlying assumptions are stressed where necessary and applicable.

2. Delineation of Techniques and Expected Resource Demand

Enterprise and labor budgets for alternative techniques are summarized at the end of this section (Tables 7-6 to 7-8) after a discussion of technique's attributes and resource requirements is carried out.

Current Technique (CT)

This heading refers to cultivation practices now in use at the Office and which constituted the subject of the report in Chapter 4 and 5. The main attributes of CT can be summarized as follows: (1) fertilizer use is below the recommended levels and averages 37 kg of urea and 20 kg of ammonium phosphate per hectare; (2) seed broadcasting; (3) hand and/or hoe weeding; and (4) average gross yield and land fee are respectively 1740 kg[7] and 400 kg per hectare.

Levels of resource requirements under CT are derived from the results of the 1979-80 farm survey. Therefore labor used per hectare and per task shown earlier in Table 5-12 is taken as a requirement. Changes in the level of non-labor resources required for other alternative techniques will depend on the types of practices to be considered. In

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[7] This estimate is an average arrived at from yield plot measurements effected on all sample farms. Incidentally the magnitude is close to the O.N. average of 1759 kg per hectare for all sectors as indicated in the annual report for the 1979-80 crop season (Rapport de Fin de Campagne, Service Agricole, pp. 11-14). Although the 1979-80 yield was the lowest in 7 years, it still represents the actual average over the last 10 to 15 years. It is this generally low level of yields at the O.N. which is the main reason for the intensification program in the first place.

general the most affected budget item is the use of farm equipment (draft animals and implements) dictated by the introduction of new implements and/or increased demand for use on old ones. Table 7-3 depicts the cost of utilization of farm equipment under CT. Requirements and assumptions discussed for other techniques in regard to the cost of using farm equipment stem from the consideration of Table 7-3.

Intensification Technique 1 (IT1)

IT1 summarizes the findings of the technique discussed for Foabougou in Section 7-1. In particular the rate of fertilization (50 kg of urea and 50 kg of ammonium phosphate, 200 kg of Tilemsi phosphate) and the related yield assumption (2.4 mt/ha). Other attributes of IT1 remain as in CT, in particular seed broadcasting, hand/or hoe weeding.

For all intensification techniques, land levelling and consolidation of the irrigation/drainage networks are assumed to have been undertaken and farmers would be charged 600 kg per hectare in land fee.[8] Labor requirements are assumed to remain at their CT level, except for harvesting and a small increase in the requirement for fertilizer application. The cost of utilization of farm equipment also remains as in CT because no actual change in cultivation practices occur from CT to IT1.

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[8]This is the expectation of the Office management to account for the improved potential made possible by the infrastructural works.

TABLE 7-3. Estimation of Cost of Utilization of Farm Equipment (at 1980 Prices) Under CT[a]

Equipment	Number	Cost to the Farmer (MF)	Years of Life[c]	Annual Depreciation (MF)	Amortization per ha (MF)
1. Fixed cost[b]					
Oxen[d]	2	200,000	7.5	10,667	1,422
Yoke	1	7,500	7.5	1,000	133
Plow	1	53,000	10	5,300	707
Harrow	1	48,000	10	4,800	640
Cart[e]	1	130,000	10	10,500	1,400
Total depreciation		438,500		32,267	4,302
2. Variable costs					
Repairs and maintenance					2,000[f]
Feeds and veterinary costs					1,800[g]
3. Total fixed + variable costs					8,120
4. Cost of capital at 7.5%[h]					608
5. Total user cost per hectare					8,710

[a]Calculated on the basis of an average farm size of 7.5 hectare which reflects a more efficient level of resource use. The source of prices is WARDA, Mission Report, Dec. 1979. It is also assumed that the average farm owns the basic set of equipment.

[b]In its most complete form, the fixed cost includes depreciation, opportunity cost, interest on investment, insurance and housing. However no interest or insurance is presently charged on farm equipment in the office and housing charge is unknown.

[c]The years of life were averages actually reported by farmers during the survey as shown in Table 5-4. For durable implements the average life was rounded to 10 years.

[d]It is assumed that one of the two oxen ends its life by natural death and the other has a salvage value at least equal to its purchase price; this value was set at 120,000 MF to account for animal appreciation.

[e]Including the cost price of a donkey at 50,000 MF with a salvage value equal half its purchase price.

[f]The estimate represents an average of the actual repairs and maintenance cost of 3,200 MF per hectare obtained from the survey data where the equipment was in use for a number of years (see Table 5-15), and the cost of 1,000 MF per hectare from Foabougou farms where the set of equipment was new.

[g]Estimate is from survey data and is taken to represent the current situation where farmers provide supplement feeds at less than the required number of fodder units.

[h]This is concessionary rate of interest on farm equipment for participating farmers in government projects. Given that the O.N. settlers receive the equipment credit free of interest charges, it was reasonable to maintain 7.5 percent as the opportunity cost of farm equipment in the survey area. The interest rate of 15 percent (used in the economic analysis of Chapter 5) is an average cost of capital in the rural credit market and would have overstated the financial cost of capital to the O.N. settlers.

Intensification Technique 2 (IT2)

IT2 assumes the adoption of row-seeders by farmers. Sowing in line has been introduced in the settlement since 1977. In the 1979-80 season, about 4 percent of the cultivated land was sown in line. Field trials using "Nodet Gougis" seeders have resulted in saving of 40 kg of seeds per hectare i.e. seeding rate of 80 kg as compared to 120 kg per hectare in broadcasting [O.N., Service Agricole, 1980]. Fertilization rates under IT2 are assumed at 75 kg of urea and 75 of ammonium phosphate per hectare.[9]

The yield assumption under IT2 is 20 percent higher than the IT1 level, at 2.88 mt per hectare. In addition to the higher rate of fertilization, this assumption is sustained on the ground that weeding will be eased by sowing in line, a practice reported to result in abundant plant tillering and more effective bird scaring. The assumption also falls in line with the results of the cross-tabulation of seeds and fertilizer rates shown earlier in Table 5-10 (Chapter 5).

Increases in labor requirements per hectare under IT2 are to reflect the additional demand implied in the new practices. For instance, it is estimated that sowing labor will increase to 3.1 man-days per hectare while requiring an additional 15 hours of oxen work.[10] Application of the extra fertilizer requires a 10 percent increase in labor over the

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[9]It is expected that fertilization rates will increase progressively as farmers adopt more intensive cultivation practices.

[10]According to experiments conducted in Casamance (Senegal), it requires 5 man-days and 1.5 oxen-days to row seed 1 ha of rice. The results are based on a 5 hour day [Mayer, J. and R. Bonnefond, 1973 p. 65]. This translates into 3.1 man-days for an 8 hour day and 15 hours (1.5 x 2 x 5) of oxen work.

CT level. The extra 20 percent increase in yield will also require 27 percent more labor at harvest and post-harvest treatment.[11] Weeding labor is expected to remain at its CT level of 12.4 man-days, on average.[12]

The fixed cost of utilization of farm equipment will increase by an amount equal to the depreciation charge for the row-seeder whose purchase price is around 70,000 MF.[13] The cost of repairs and maintenance is assumed to increase in proportion to the extra animal power required as a result of the activities of row-seeding and the extra hauling at harvest time. Additional feed for draft animals is also a prerequisite for intensification. Hence for all intensification techniques requiring increases in animal power use over the CT level, it is assumed that the WARDA recommended daily ration shown in Table 7-4 will be supplemented. Feed costs are calculated on the basis of 100 working days per animal and an average farm size of 7.5 ha. The <u>total cost of utilization of farm equipment</u> is depicted in Table 7-5.

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[11]The sources of the estimates for the percentage increase in harvesting labor are Spencer [1975] and WARDA [1977].

[12]Usually weeding takes anywhere from 10 to 40 man-days per hectare for a maximum of 3 passages. [Mayer and Bonnefond, op. cit]. Although row seeding facilitates weeding, it does not necessarily cut it down. It is realistic to treat the 12.4 man-days average from the survey data as a minimum requirement. In this way farm level conditions are well represented. High level of fertilization may also stimulate weeds growth and increase labor requirement. However, there is no data to quantify the likely changes.

[13]This and other prices for agricultural equipment were fixed by SCAER (Sociéte´de Crédit et d'Equipment Rural), a state agency.

TABLE 7-4. Feed Ration Composition and Cost for Draft Animals under Intensification

Feeds	Weight (kg)	Price (MF/kg)	Content		
			Dry Matter (kg)	Energy (fodder units)	Digestible Nitrogen Nutrient (DNI)
Rice straw	5	0	4.75	1.75	0
Rice bran	1	12	0.90	0.30	30
Rice flour	1	17	0.90	1.10	70
Cotton seeds	2	27	1.90	2.20	210
Salt	.025	--	--	--	--
Total/animal/day	9.025	83	8.45	5.35	310
Cost per farm (MF)		16,600[a]			
Cost per hectare (MF)		2,213[b]			

Source: WARDA [1977, pp. 64-65], and O.N. Bureau of Economic Affairs.

[a]83 MF per ration times 100 days for two oxen.

[b]Cost per farm divided by the average farm size of 7.5 ha.

TABLE 7-5. Per Hectare Cost of Utilization of Farm Equipment Under IT2

Item	Cost (MF)
1. Fixed costs	
depreciation (at CT or IT1 level)	4,302
including row-seeder	933
subtotal depreciation	5,235
2. Variable costs	
repairs and maintenance (2,000 MF x $\frac{158}{140}$)[a]	2,257
feed and veterinary costs (at CT or IT1 level)	1,800
supplement under intensification	2,213
subtotal feed and veterinary costs	4,013
3. Total	11,505
4. Cost of capital @ 7.5%	863
5. Total user cost per hectare	12,368

[a]CT level of expenditure is adjusted upward by the ratio of animal-hours required under IT2 and CT.

Intensification Technique 3 (IT3)

IT3 assumes the adoption of animal drawn cultivators (multiculteur) for mechanical weeding. Row seeding and mechanical weeding constitute the main attributes of IT3. Other intensification prerequisites are assumed to apply and fertilization rates are expected to reach 100 kg of urea and 100 kg of ammonium phoshpate.[14]

The yield assumption under IT3 is 3.46 mt per hectare, also attributable to expected better organization of farm operations. For instance early sowing, timely operations and effective bird damage control. Efficient use of animal drawn weeders is expected to result in a 70 percent reduction in weeding labor to 3.7 man-days per hectare compared to hand/hoe weeding [Mayer and Bonnefond, 1973]. According to experiments undertaken in Casamance, however, mechanical weeding with oxen will require an additional 10 hours of animal power per hectare. As shown under IT2, the expected yield increase of 20 percent will also necessitate 27 percent more labor at harvest time. Manual threshing and post-harvest treatment are expected to reflect the increase in output per hectare. The total labor required per hectare under IT3 amounts to 130.2 man-days (Table 7-7).

The cost of utilization of farm equipment is adjusted by (1) the depreciation charge for the use of a multiculteur (Official purchase price was 89,000 MF in 1979) and (2) the increase in repairs and maintenance proportionate to the additional demand in animal hours under IT3. The total user cost is summarized as follows:

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[14]These rates are in line with research station results and farm level trials undertaken on certain locations in the O.N. area [O.N., 1978].

Depreciation	(MF)
at IT2 level	5,235
including multiculteur	1,187
subtotal	6,422
Repairs and maintenance (2,257 MF x $\frac{178}{158}$)	2,543
Feeds and vet. and supplement	4,013
Cost of capital	966
Total user cost per hectare	13,944

Intensification Technique 4 (IT4)

IT4 considers the introduction and adoption of transplanting of rice seedlings to raise yields. Although this practice is not presently considered at the Office, it has already been tried in the past and enjoyed a modest measure of success. Therefore IT4 is an alternative as valuable as other intensification techniques.

In accordance with what was done in the past, nursery planting, care and fertilization is assumed to remain the responsibility of the Office management. Farmers would be provided with seedlings at a cost of 100 kg of paddy per hectare planted, and required to apply 80 kg of ammonium sulfate at the time of transplanting and 40 kg later when rice comes into ear. This would bring the total quantity of fertilizer per hectare to 220 kg, assuming that 100 kg of ammonium phosphate is maintained as a source of soluble phosphate. IT4 is also expected to involve mechanical weeding.

When transplanting was introduced in Kolongo in the early 1960's, it is reported that yields increased from 1.2 to 2.2 mt per hectare at the farm level [de Wilde, 1967]. The implied percentage increase (about 80) is retained for the level of yield under IT4 relative to IT1 (4.3 mt), on the basis of past experience and comparable rates of fertilization.

As to <u>labor requirements</u> under IT4, emphasis is on transplanting which is said to require 35 man-days on average [Mayer and Bonnefond, 1973]. Past experiences in Kolongo have also shown that although transplanting reduces the need for weeding at full plant development, the required pre-irrigation before seedlings are transplanted often stimulates an early growth of weeds. Therefore transplanting does not eliminate the need for weeding, rather it advances this need in time. Only the use of <u>multiculteur</u> in animal powered weeding (as recommended here under IT4) will help reduce the amount of weeding labor to 3.7 man-days as in IT3. On the other hand, 80 percent increase in yields over the IT1 level will necessitate 108 percent increase in harvesting labor as shown earlier. The increase in harvesting labor shown in Table 7-7 amounts to 90.2 man-days per hectare under IT4. Manual threshing and post-harvest treatment will require additional labor in proportion to the expected higher level of output per hectare.

As transplanting suppresses the need for a row seeder, the user cost of farm equipment is assumed to remain at CT level of 8,102 MF per hectare. There are however additional costs to be incurred to account for: (1) a depreciation charge for the weeder (1,187 MF); (2) a proportional increase in the expenses for repairs and maintenance (2,000 MF x 150/140) to reflect the extra 10 hours of use of oxen in weeding; (4) a feed supplement charge (2213 MF); and (4) cost of capital of 874 MF. This brings the user cost of farm equipment under IT4 to a total 12,519 MF per hectare.

Intensification Techniques 5 (IT5)

Double cropping of rice is the main attribute envisaged under IT5 which also includes row seeding, mechanical weeding and appropriate levels of fertilization. The guidelines for intensification drawn in the 1977 WARDA report call for double cropping to be introduced on a limited scale during the second intensification stage (see Preambule to Chapter 7). Hence IT5 is considered also an alternative technique and a part of the technological know-how available to the Office. Other prerequisites of intensification such as land levelling and higher feed rations for draft animals are assumed to apply.

For two crops of rice to be feasible, it is appropriate for the second crop to be planted in January and harvested in May. This however subsumes that the Office will have a much bigger threshing capacity to allow for the main crop to be started in June. Yield assumptions are 4.0 and 2.4 mt per hectare for the first and second crop, respectively. These assumptions conform with results from research undertaken in the mid 1970's at the Kogoni research station.[15]

Labor requirements for the main crop are assumed to follow the pattern established under IT3, a technique which also involves line-seeding

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[15]Research undertaken from 1974 to 1976 at Kogoni has shown the yield of the second crop to be 40 percent lower than the June crop, for both long and short stemmed varieties. Examples of such varieties are: KADING-THANG (long stemmed) with main crop yield of 4.9 mt, D52-37 (long stemmed) with off-season yield of 2.24 mt, IET 2911 (short stemmed) with 4.48 mt in main season, and IKP (short stemmed) with 2.21 mt in off-season. [O.N., Service Agricole, 1978]. The lower yield for the second crop is also attributable to the risk involved by planting in January when temperatures are low and can considerably delay or even stop germination; high April and May temperatures are also known to cause sterilization of pollen particularly in a dry air atmosphere.

and mechanical weeding. Labor demand for the second crop was figured out as follows: (1) land preparation at 60 percent of the requirements under the main crop. This is based on the assumption of effective shallow irrigation in January and the fact that much of the work in June and July for the main crop would make January tasks less difficult; (2) sowing, fertilizer application and weeding are likely to demand as much labor as for the main crop; and (3) harvesting and post-harvest labor demand however will be reduced in proportion to the size of the second crop. These assumptions conform with experiences from the Philippines and Southeast Asia in general, where the off-season crop is reported to require 30 percent less labor [Angladette, 1966].

Because IT5 involves the use of a row-seeder and a cultivator (multiculteur) for weeding, the fixed cost of equipment utilization is as in IT3 at 6,422 MF per hectare. Oxen feed supplements however are calculated for a total of 140 days (rather than 100) to account for the need for animal power in the second crop cultivation. The total cost of utilization of farm equipment under IT5 is composed as follows:

	(MF)
Depreciation	6,422
Feeds, supplements and vet. costs	4,900
Repairs and maintenance (2,543 MF at IT3 level plus 60% for the second season or 1530 MF)	4,073
Cost of capital	1,155
Total (MF per hectare)	16,550

Synthesis

On the basis of the discussion carried out in the preceding pages, Table 7-6 and 7-7 summarize the expected changes in resource utilization in the form of rice enterprise and labor budgets for all the techniques

TABLE 7-6. Rice Enterprise Budget Per Hectare Under Alternative Intensification Techniques

Item	Unit	CT Amount	CT Value (MF)	IT1 Amount	IT1 Value	IT2 Amount	IT2 Value	IT3 Amount	IT3 Value	IT4 Amount	IT4 Value	IT5[g] Amount	IT5[g] Value
Average gross yield	kg	1,744		2,400		2,880		3,460		4,300		6,400	
field losses @ 10%[a]	kg	174		240		288		346		430		640	
Net yield	kg	1,570		2,160		2,592		3,114		3,870		5,760	
Value of production			94,200		129,600		155,520		186,840		232,200		345,600
Committed Costs													
Depreciation & opp. cost[b]			4,908		4,908		6,098		7,388		6,361		7,388
Threshing charge	kg/mt	188	11,304	259	15,552	311	18,662	374	22,421	464	27,864	691	41,472
Land fee	kg	400	24,000	600	36,000	600	36,000	600	36,000	600	36,000	800[h]	48,000
Repairs & maintenance			2,000		2,000		2,257		2,543		2,143		4,073
Subtotal			42,212		58,460		63,017		68,352		72,368		100,933
Non-committed Costs													
Seeds	kg	120	9,600	120	9,600	80	6,400	80	6,400	--	6,000[f]	160	12,800
Fertilizer[c]	kg	57		100		150		200		220		300	
of which: urea @ 120 MF	kg	37	4,440	50	6,000	75	9,000	100	12,000	--		150	18,000
amm.ph. @ 140 MF	kg	20	2,800	50	7,000	75	10,500	100	14,000	100	14,000	150	21,000
Tilemsi ph. @ 20 MF[d]	kg	--	--	200	4,000	200	4,000	200	4,000	200	4,000	200	4,000
sulf. of amm. @140 MF[e]	kg	--	--	--	--	--	--	--	--	120	16,800	--	--
Oxen feeds & veter. costs			1,800		1,800		4,013		4,013		4,013		4,900
Subtotal			18,640		28,400		33,913		40,413		44,813		60,700
Labor requirements	m-day	104		109		120.4		130.2		183.5		226.2	
Animal power requirements	hour	140		140		158		178		150		258	
Total charges			60,852		86,860		96,930		108,765		117,181		161,633
Net income			33,348		42,740		58,590		78,075		115,019		183,967
Return per man-day			321		392		487		600		627		813

[a]Source is Kamuanga and Spencer, 1981.

[b]Depreciation value for the basic equipment package (2 oxen, 1 plow, 1 harrow and 1 cart). Opportunity cost at 7.5 percent as discussed in footnote h of Table 7-3.

[c]Quantity shown is the sum of urea and ammonia phosphate or sulfate of ammonia.

[d]Actual cost of Tilemsi phosphate is 60 MF per kg. As a build up fertilizer its effects on the soil quality can be felt for at least 3 years. Therefore its cost is entered at one-third of its price.

[e]Assumed to be purchased at the same price as ammonium phosphate.

[f]Cost of rice seedlings assumed to be purchased at the equivalent value of 100 kg of paddy per ha at 60 MF per kg.

[g]Budget is for the 2 crop seasons.

[h]With double cropping the land fee is expected to remain at 400 kg of paddy per ha, this is in accordance with guidelines for intensification [WARDA, 1977].

Note: CT is current technique; IT1 is an improved CT with higher fertilization rate; IT2 assumes row-seeding; IT3 is as IT2 plus mechanical (animal drawn) weeding; IT4 assumes transplanting of rice; and IT5 involves double cropping.

TABLE 7-7. Labor Requirements Per Activity Under Alternative Intensification Techniques[a] for Rice Cultivation at the Office (Man-Days/Hectare)

Field Activities	CT	IT1	IT2	IT3	IT4	IT5		
						1st Crop	2nd Crop	Total
Land preparation	21.4	21.4	21.4	21.4	21.4	21.4	15.0	36.4
Sowing	1.1	1.1	3.1	3.1	35.0[b]	3.1	3.1	6.2
Fertilizer application	2.6	2.8	2.8	3.0	3.0	3.0	2.0	5.0
Irrigating	1.8	1.8	1.8	1.8	1.8	1.8	1.8	3.6
Weeding	12.4	12.4	12.4	3.7	3.7	3.7	3.7	7.4
Harvesting & stacking	38.8	44.8	56.8	72.1	90.2	72.1	51.0	123
Manual threshing and treatment	3.5	4.4	4.5	5.7	6.6	5.7	4.4	10.1
Miscellaneous	20	20	17.6	19.4	21.8	19.4	15	34.4
Total	104	108.7	120.4	130.2	183.5	130.2	96	226.2

[a]CT is current technique; IT1 is an improved CT with higher fertilization rate, IT2 assumes introduction of row-seeding; IT3 is as IT2 plus mechanical (animal drawn) weeding; IT4 assumes transplanting of rice; IT5 involves double cropping.

[b]The estimate is for transplanting of rice.

considered. In Table 7-8 labor requirements per field activity are converted into corresponding monthly demands. These were estimated on the basis of the characteristics of the crop calendar as to the sequence of field activities and particularly the more or less intensive demand for labor per individual task. A major assumption used here has to be underlined: the seasonal pattern of labor demand arrived at in Table 7-8 is built to reflect the variation from one month to another that prevails under the current technology for IT1, IT2 and IT3 because adjustments involved affect tasks and activities that occur in the same months as for CT. This is less evident for IT4 involving transplanting and even less so for IT5 with double cropping. For the former, it was assumed that transplanting would take place around the same period as sowing for other techniques. For IT5, labor demand for the second season crop affects the pattern which would have prevailed had only the main crop been planted. Adjustments made took account of the sequence of activities likely to occur during the two crop seasons. An example of derivation of monthly labor requirements under IT2 is given in the footnote of Table 7-8.[16]

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[16]The initial seasonal pattern of labor demand under CT is depicted in Appendix B for a representative farm in the 5 to 10 ha group. A similar pattern is shown in Table 7-1 for Foabougou farmers; it was not used here because the total labor is believed to be underestimated as indicated earlier.

TABLE 7-8. Monthly Labor Demands (Man-Days) Under Alternative Intensification Techniques[a]

	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	Total[b]
CT	7.2	11.6	10.4	8.2	8.5	7.8	10.6	12.4	10.6	6.2	5.4	5.1	103.9
IT1	7.2	11.6	11.4	9.2	8.5	7.8	11.7	13.8	10.8	6.2	5.4	5.1	108.7
IT2	8.2	12.9	11.1	8.3	8.6	8.6	14.2	16.4	13.8	6.7	5.9	5.6	120.3
IT3	8.2	12.9	11.1	4.8	3.8	9.5	19.2	21.9	18.7	7.4	6.5	6.2	130.2
IT4	18.8	26.4	22.1	4.8	3.8	10.7	23.7	27.4	23	8.3	7.3	7	183.3
IT5	39	18.3	16.0	6.1	5.1	15	20.5	42	21.2	7	16.2	19.3	225.6

[a]CT is current technique, IT1 is an improved CT with higher fertilization rate; IT2 assumes introduction of row seeding; IT3 is as IT2 plus mechanical (animal drawn) weeding; IT4 assumes transplanting of rice; IT5 involves double cropping.

[b]The total per year and per hectare is lower than that reported in Table 7-7 for rounding errors.

Note: The following is an example of derivation of labor required under IT2. May, June and July are mainly devoted to land preparation, sowing and irrigating. Total requirement for these activities under IT2 is 26.3 man-days (Table 7-7). Under CT the total for the same activities amounts to 24.3 man-days. The monthly distribution under CT for the 3 months considered gives a total of 29.2 man-days (7.2 + 11.6 + 10.4). The difference is attributable to miscellaneous activities. The monthly requirement under IT2 is figured out by solving the following equation: $29.2/24.3 = \chi/26.3$. Thus $\chi = 31.6$. To match the pattern of variation under CT, the requirements for May, June and July under IT2 would have to be 7.9, 12.6 and 11.0 man-days. These figures are adjusted upward to 8.2, 12.9 and 11.1 by redistributing residual miscellaneous activities in such a way as to make the total per year equal to 104 man-days per hectare.

7.3 Prospects for Intensification: A Linear Programming Analysis of Three Representative Farm Situations

1. Introduction

In this section a one period Linear Programming (LP) model is used to examine the profitability, feasibility and practibility of introducing the range of improved techniques whose main attributes were presented and discussed above. In particular, the model will envisage the constraints and the returns associated with the adoption of a technique or mixture of techniques in the framework of the intensification program at the O.N. From a practical point of view, one expects the LP model to help answer questions concerning (but not limited to): (1) the optimal combination of techniques in light of existing resource constraints; (2) the extent to which a particular technique or mix of techniques can be pushed for adoption at the farm level; (3) the income increasing possiilities of restricting the land to a technique or mix of techniques judged profitable; and (4) the effect on the optimal solution of increased resource levels and alternative pricing policies. First, a brief review of the basics of LP and the methodological reasonableness of the technique in its applications to African agriculture are examined. This is followed by a presentation of the LP model for the O.N. representative farms in three size groups of holding, and a discussion of their respective levels of resource constraints. Second, the base plans and subsequent sensitivity runs are discussed. Finally, LP is used to provide insights into the issue of a proper norm in land allocation at the Office.

2. The Basics of LP and its Application to African Agriculture

LP is a mathematical tool used to maximize or minimize an objective function. This requires a set of alternatives for given levels of resources or activity restrictions and for given input-output relationships between the alternative activities and the resources available. In its simplest mathematical formulation in matrix form, the LP model can be represented by the following equations [Heady and Candler, 1973]

$$\text{Maximize } Z = f(X) = C'X$$
$$\text{subject to } PX \leq S$$
$$X \geq 0$$

where Z is the objective function to be optimized
C' = n x 1 vector of prices
X = n x 1 vector of activity levels
P = m x n matrix of input-output coefficients
S = m x 1 vector of resource restrictions

For a determinate solution to obtain, several assumptions have to be satisfied: (1) additivity and linearity of activities; (2) divisibility of activities and resource restrictions; (3) homogeneity of units of inputs and outputs; (4) restrictiveness of some resources or requirements to be met; and (5) single value expectations, that is resource supplies, input-output coefficients and prices are known with certainty.

Among major limitations of the technique Beneke and Winterboer [1980] mention: (1) the restrictiveness of the assumption of linearity and additivity for real farm situations; (2) the difficulty in treating activities involving decreasing costs; and (3) that LP cannot help the manager in formulating price expectations or in generating input-output coefficients themselves.

Some critics of the use of LP in development studies point to the fact that agricultural production is typified by a wide range of input substitutions which are technically possible, not by fixed coefficients as is done with LP. One of the primary objectives of any agricultural development project indeed is to change the input-output coefficients associated with existing production practices. LP modelling founded on micro studies of a particular rural area or project uses historically derived average coefficients to extrapolate inputs or outputs in order to assess contemplated changes. This approach, however, may result in underestimation of the resource constraints imposed on some farms. Nonetheless it has been used with some success in many applications of LP techniques to African agriculture.

Norman [1973] used LP technique to assess the profitability of several adjustments in farm models based on data from northern Nigeria. Adjustments made included reallocation of existing resources, increasing labor on a year-round basis, changing crop prices and introduction of available technologies for groundnuts, sorghum and cotton. Many of these adjustments tended to increase farm incomes.

In an early application of LP to a real farm situation in the Nyeri district of Central Province in Kenya, Clayton [1963] demonstrated the flexibility of the technique in drawing up a model which included a rotational constraint of four years of cropping and three years of grass ley. His results suggested some interesting relationships between perenial cash crops and annual crops which may be of relevance on other farms in other situations. Risk and uncertainty have also been incorporated in some models of African farming. For instance Heyer [1972] used constraints and their effects on production practices of Masaii farmers in southern Kenya. Treating land and labor as being each a homogenous resource, she found that farmers' behavior could best be explained by an allocation decision based on the assumption of unfavorable conditions.

LP models have also been useful tools in regional or national studies such as those by Ogwel [1969] and Spencer [1973], and in planning farm adjustments to evaluate normative supply responses [Ogunfowora, 1970].

In this study LP is used to project the likely outcomes of introducing improved production techniques on the basis of expected input-output coefficients. The strength of the technique lies in its ability to handle a large number of interrelated variables characterizing the farming system under study [Low, 1978].

3. The LP Model for Three Representative Farm Situations at the O.N.

a. The Objective Function

The objective function is of the following form:

$$Z = \underset{(1)}{\sum_i C_i X_i} - \underset{(2)}{\sum_j C_j X_j} - \underset{(3)}{\sum_h C_h X_h} - \underset{(4)}{\sum_k C_k X_k} - \underset{(5)}{\sum_t C_t X_t}$$

It assumes the maximization of net enterprise incomes over fixed costs subject to farm level constraints (discussed in the next subsection). The activities considered in the model are specified as follows:

<u>Rice selling and consumption activities</u> (1): selling of rice (paddy) is assumed to take place in December for the main crop and May for the second crop, should double cropping (considered under IT5) come in solution. The output is assumed to be sold at the official farm gate price of 60 MF per kilo. Consumption activity is entered with a zero C_i value to allow the objective function to maximize net incomes (rather than net cash incomes).

<u>Production activities under alternative techniques</u> (2): six production activities are specified to account for all techniques discussed

above including the current technique. The C_j values entered correspond in each case to the amount of committed expenditures shown in Table 7-6.

Input buying activities (3): these are separated by type of fertilizer, seeds and seedlings. The C_j value of 24 MF for seedlings was derived from the per hectare charge of 6,000 MF (see Table 7-6 under IT4).[17] Other buying activities refer to farm equipment services at 20 MF per hour[18] and recommended quantities of oxen feeds.

Labor hiring activities (4): provision was made in the model for hiring of labor on a year-round basis to conform with the actual situation. Wage rates are 1,000 MF per man-day during the peak season (June through August, and November through January) and 700 MF in nonpeak season. This was done to reflect the prevailing market situation in the survey area and also in anticipation for higher rates in the near future.

Transfer activities (5): these are used to ensure that any unused operating capital at the end of a given month is made available in the following month.

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[17]Assuming an average of 250 units of thousand twigs per hectare with a 20 x 20 cm interspace [Dobelmann, 1976, pp. 59-60].

[18]This was derived from the current minimum rental cost of 10,000 MF charged in the O.N. zone for the work of a pair of oxen and associated implements. We also assumed an average working period of 500 hours (90 to 100, 5-hour days).

b. The Farm Level Resource Constraints

Labor

The amount of labor available on farms for the cultivation of rice was estimated following the approach discussed in Chapter 4.[19] In summary, the total slack of labor in each month was obtained by adding up the requirements for livestock, general farm and off-farm activities, then subtracting the total from the potential labor. What is left represents the sum of labor requirements for rice and the slack of unused labor. Theoretically the total slack represents an amount of unused labor from which families could draw to supply the additional demand. As rice constitutes the mainstay of the settlement, it was assumed that half the amount of slack labor in each month could be made available for rice thus leaving the second half for remaining farm and nonrice activities. Therefore the sum of labor requirements for rice and half the slack constitutes the maximum labor available for rice cultivation. Results of calculation are shown in Table 7-9.

Animal Power

More than 80 percent of animal power used in rice production goes into field preparation activities from May to July. Some demand may occur in August for late harrowing, weeding and/or thinning. The August demand indeed will increase under intensification. The seasonal pattern of demand for animal power shown in Table 7-10 was derived using the prevailing demand under CT as a reference point. Increased demand under all

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[19]Calculations here are made following a stratification by size group of holding instead of family sizes. Derivation of potential labor was based on 4.6, 6.7 and 13.4 man-equivalents in each of the 3 respective size groups.

TABLE 7-9. Upper Limits of Family Labor (Man-Days) Available for Rice Activities for Three Representative Farm Situations at the O.N.

Size group	Month												Total Year
	M	J	J	A	S	O	N	D	J	F	M	A	
I (0-5 ha)	55	53	55	49	52	54	48	47	43	44	37	56	593
II (5-10 ha)	102	86	82	92	84	92	74	81	71	67	44	106	981
III (10-15 ha)	121	131	108	117	134	137	104	95	94	115	79	129	1364

Source: Survey data.

TABLE 7-10. Per Hectare Animal Power Required for Rice Cultivation, and Upper Limits Available by Size Group of Farmers (animals-hours)

	Jan.[c]	May	June	July	August	Total[e] per Year
1. Required under						
CT or IT1[a]		24	43	28	20	140
IT2		29[d]	53[d]	30	22[d]	158
IT3		29[d]	53[d]	36	32[d]	178
IT4		24	43	28	32[d]	150
IT5	80	29	53[d]	36	32[d]	328
2. Upper limits (available)[b]						
Size group I (0 - 5 ha)	105	100	200	100	75	580
II (5 - 10 ha)	175	150	300	150	135	910
III (10 - 15 ha)	300	250	500	250	225	1525

Source: Survey data and estimation.

[a]Average level of utilization obtained from survey data.

[b]Calculated on the basis of a 5 hour animal working day. For size group I upper limits are based on the Office approximation of 95 to 100 days (20 in May and August, 40 in June and 15 in August) for a pair of oxen.

[c]January figures represent the demand for the off-season crop.

[d]Much of the additional requirement for row seeding will be used in June (10 hours). The additional requirement (10 hours) for animal powered weeding will be demanded in August (see section 7.3.1).

[e]Exceeds the sum of monthly requirements because it includes activities other than land preparation.

alternative intensification techniques is the result of additional requirements for row-seeding and/or animal weeding affecting a particular month. Estimates of upper limits of animal-hours available on farms were calculated on the assumption of 1 pair of oxen for a representative small farm, 1.5 for a medium sized farm and 2.0 to 2.5 for a large farm. These endownments are taken to conform with the findings of the survey (Table 5-4, Chapter 5).

The Consumption Requirement

In accordance with the current practice at the Office, a consumption allowance in the amount of 300 kg of paddy per household member was also introduced in the LP model. There were respectively 7, 11 and 19 members in the families composing the 3 size groups of holding. This translates in allowances of 2,100, 3,300 and 5,700 kg of paddy per year as consumption requirements for the three representative farms.

Operating Capital

Production expenses on typical inputs such as seeds, fertilizer, oxen feeds, hire of nonfamily labor and equipment services, and the range of committed costs were taken to represent farm operating capital. In order to establish the base plans, operating capital was entered on an annual basis. However, the lack of a good basis on which to fix the ceiling of operating capital led to the following approach: providing the model with an initial amount in the neighborhood of the magnitude of noncommitted expenditures (see Table 7-6) and then allowing revenues from selling activities to feed the model for meeting the demand for operating capital at that time when all committed expenditures are incurred.[20]

c. The LP Tableaus

One tableau was prepared for each of the three respresentative farms for the base runs.[21] The three tableaus differ only in the level of farm constraints (bi's) because the expected input-output coefficients (ai's) are taken as requirements for an average farm situation in the Office. Table 7-11 illustrates the LP tableau corresponding to the representative farm in the medium sized group.

4. The Base Plans

Generally the output from an LP model provides information on the objective function, the optimal combination of activities, the amount of resources used and their respective marginal value products (or shadow prices). It also shows the cost of forcing nonoptimal activities in the solution and the price range over which the optimal solution holds.

Two types of base plans are shown in Table 7-12 (a, b, c). Optimal plan 1 (PLAN 1) represents a reallocation of resources under the current

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[20]This approach was used to reflect the actual situation at the Office, where farmers are supposed to pay in cash much of the noncommitted expenditures but meet their committed costs (land fee and threshing charge) by payment in kind at the time of harvest. Allowing revenues in December to feed operating capital also makes it easier to meet the demand for capital from January through May should double cropping come in the solution. A capital borrowing activity was also an alternative, but was avoided.

[21]The algorithm used was "Agricultural Economics Linear Program Package" by Stephen B. Harsh and Roy Black, Version 2, April 1975; in Agricultural Economics Staff Paper No. 75-10, Michigan State University.

TABLE 7-11. Activities and Resource Constraints of the Farm level LP Model at the O.N.[a]

Row No.	Resources	Unit	Rice Production Activities						Rice Selling Activities		Cons. Act.	Sign	RHS (medium farm)
			A1 CT	A2 IT1	A3 IT2	A4 IT3	A5 IT4	A6 IT5	A16 SELRD	A17 SELRMY	A18 CONSR		
	Objective Function (MF)		-42212	-58460	-63017	-68352	-72368	-100933	60	60	0		
1	LAND	ha	1	1	1	1	1	1				≤	7.5
2	FLABMY	md	7.2	7.2	8.2	8.2	18.8	39				≤	102
3	FLABJU	md	11.6	11.6	12.9	12.9	26.4	18.3				≤	86
4	FLABJL	md	10.4	11.4	11.1	11.1	22.1	16				≤	82
5	FLABAG	md	8.2	9.2	8.3	4.8	4.8	6.1				≤	92
6	FLABSEP	md	8.5	8.5	8.6	3.8	3.8	5.1				≤	84
7	FLABOCT	md	7.8	7.8	8.6	9.5	10.7	15				≤	92
8	FLABNOV	md	10.6	11.7	14.2	19.2	23.7	20.5				≤	74
9	FLABDEC	md	12.4	13.8	16.4	21.9	27.4	42				≤	81
10	FLABJAN	md	10.6	10.8	13.8	18.7	23	21.2				≤	71
11	FLABFEB	md	6.2	6.2	6.7	7.4	8.3	7				≤	67
12	FLABMC	md	5.4	5.4	5.9	6.5	7.3	16.2				≤	44
13	FLABAP	md	5.1	5.1	5.6	6.2	7	19.3				≤	106
14	PRRICDE	kg	-1600	-2200	-2600	-3100	-3900	-3600	1			≤	0
15	PRRICMY	kg						-2200		1		≤	0
16	CONSRICE	kg									1	=	3300
17	SSEEDS1	kg	120	120	80	80		80				≤	0
18	SSEEDS2	kg						80				≤	0
19	SSDLG	000'tw[b]					250					≤	0
20	SUREA1	kg	37	50	75	100		100				≤	0
21	SAMPHO1	kg	20	50	75	100	100	100				≤	0
22	STILPHO1	kg	200	200	200	200	200	200				≤	0
23	SSULAM1	kg					120					≤	0
24	SUREA2	kg						50				≤	0
25	SAMPHO2	kg						50				≤	0
26	SRIBR	kg	1	1	2	2	2	3				≤	0
27	SRIFL	kg	1	1	2	2	2	3				≤	0
28	SCOTS	kg			4	4	4	5				≤	0
29	FEQSMY	hrs	24	24	29	29	24	29				≤	150
30	FEQSJU	hrs	43	43	53	53	43	53				≤	300
31	FEQSFL	hrs	28	28	30	36	28	36				≤	150
32	FEQSAG	hrs	20	20	22	32	32	32				≤	135
33	FEQSJA	hrs						80				≤	175

[a]Explanation of abbreviations is given in Appendix E.

[b]In thousand twigs.

TABLE 7-11. - Continued[a]

Row No.	Resources	Units	Seeds and Seedlings Buying Activities			Fertilizer Buying Activities						Pice Selling Activities		Feeds Buying Activities			Sign	RHS (medium farm)
	Objective Function (MF)		A11 SEEDS1 -80	A12 SEEDS2 -80	A13 SDLG -24	A7 UREA1 -120	A8 AMPHO1 -140	A9 TILPHO -20	A10 SULAM1 -140	A14 UREA2 -120	A15 AMPHO2 -140	A16 SELRD 60	A17 SELRMY 60	A24 RIBR -12	A25 RIFL -17	A26 COTS -27		
17	SSEEDS1	kg	-1														≤	0
18	SSEEDS2	kg		-1													≤	0
19	SSDLG	000'tw[b]			-1												≤	0
20	SUREA1	kg				-1											≤	0
21	SAMPHO1	kg					-1										≤	0
22	STILPHO1	kg						-1									≤	0
23	SSULAM1	kg							-1								≤	0
24	SUREA2	kg								-1							≤	0
25	SAMPHO2	kg									-1						≤	0
26	SRIBR	kg												-1			≤	0
27	SRIFL	kg													-1		≤	0
28	SCOTS	kg														-1	≤	0
34	OPCMAY	MF												12	17	27	≤	150,000
35	OPCJU	MF	80		24												≤	0
36	OPCJL	MF				120	140	20									≤	0
37	OPCAUG	MF							140								≤	0
38	OPCSEP	MF															≤	0
39	OPCOCT	MF															≤	0
40	OPCNOV	MF															≤	0
41	OPCDEC	MF										-60					≤	0
42	OPCJAN	MF		80						120	140						≤	0
43	OPCFEB	MF															≤	0
44	OPCMCH	MF															≤	0
45	OPCAP	MF															≤	0
46	OPCEND	MF															≥	150,000

[a]Explanation of abbreviations is given in Appendix E.

[b]In thousand twigs.

TABLE 7-11. - Continued[a]

Row No.	Resources	Units	Farm Equipment Hiring Activities					Labor Hiring Activities												Sign	RHS (medium farm)
	Objective Function (MF)		A19 FEQMY -20	A20 FEQJU -20	A21 FEQJL -20	A22 FEQAG -20	A23 FEQJA -20	A27 HLMY -700	A28 HLJU -1000	A29 HLJL -1000	A30 HLAUG -1000	A31 HLSEP -700	A32 HLOCT -700	A33 HLNOV -1000	A34 HLDEC -1000	A35 HLJAN -1000	A36 HLFEB -700	A37 HLMCH -700	A38 HLAP -700		
2	FLABMY	md						-1												≤	102
3	FLABJU	md							-1											≤	86
4	FLABJL	md								-1										≤	82
5	FLABAG	md									-1									≤	92
6	FLABSEP	md										-1								≤	84
7	FLABOCT	md											-1							≤	92
8	FLABNOV	md												-1						≤	74
9	FLABDEC	md													-1					≤	81
10	FLABJA	md														-1				≤	71
11	FLABFEB	md															-1			≤	67
12	FLABMC	md																-1		≤	44
13	FLABAP	md																	-1	≤	106
34	OPCMY	MF	-20					700												≤	150,000
35	OPCJU	MF		-20					1000											≤	0
36	OPCJL	MF			-20					1000										≤	0
37	OPCAG	MF				-20					1000									≤	0
38	OPCSEP	MF										700								≤	0
39	OPCOCT	MF											700							≤	0
40	OPCNOV	MF												1000						≤	0
41	OPCDEC	MF													1000					≤	0
42	OPCJA	MF					-20									1000				≤	0
43	OPCFEB	MF															700			≤	0
44	OPCMC	MF																700		≤	0
45	OPCAD	MF																	700	≤	0
46	OPCEND	MF																		≥	150,000

[a]Explanation of abbreviations is given in Appendix E.

TABLE 7-11. - Continued[a]

Row No.	Resources: Objective Function (MF)	Units	Capital Transfer Activities: A39 TRMY 0	A40 TRJU 0	A41 TRJL 0	A42 TRAG 0	A43 TRSEP 0	A44 TROCT 0	A45 TRNOV 0	A46 TRDEC 0	A47 TRJA 0	A48 TRFEB 0	A49 TRMC 0	A50 TRAP 0.001	Sign	RHS (medium farm)
34	OPCMY	MF	1												≤	150,000
35	OPCJU	MF	-1	1											≤	0
36	OPCJL	MF		-1	1										≤	0
37	OPCAG	MF			-1	1									≤	0
38	OPCSEP	MF				-1	1								≤	0
39	OPCOCT	MF					-1	1							≤	0
40	OPCNOU	MF						-1	1						≤	0
41	OPCDEC	MF							-1	1					≤	0
42	OPCJA	MF								-1	1				≤	0
43	OPCFEB	MF									-1	1			≤	0
44	OPCMC	MF										-1	1		≤	0
45	OPCAP	MF											-1	1	≤	0
46	OPCFND	MF												1	≥	150,000

[a]Explanation of abbreviations is given in Appendix E.

TABLE 7-12a. Base Plans for the Small Sized Farm

Item	Unit	Optimal Plan 1 under CT (PLAN 1)	Optimal Plan 2 (PLAN 2)
1. Production techniques[a]			
CT	ha	3.35	0
IT5	ha	0	3.3
2. Total labor used[b]	m-day	349.0	744.4
Months with hiring of labor	--	D[c]	My,Jn,N,D,Ja,Mc,Ap[c]
Proportion of hired labor to total	%	0	32.6
3. Net income			
per ha	MF	33,671.6	126,018
per man-day of family labor	MF	323.2	829.4
4. Fertilizer, seeds and seedlings			
Main crop			
urea	kg	124.1	329.8
amm. phosph.	kg	67.1	329.8
Tilemsi phosph.	kg	671.0	659.7
seeds	kg	402.6	263.9
seedling	1000 twigs		
2nd crop			
urea	kg		164.9
amm. phosph.	kg		164.9
seeds	kg		263.9
5. Hire of equipment (total)	hrs	0	208.1
May	hrs		--
June	hrs		--
July	hrs		18.7
Aug.	hrs		30.5
Jan. (2nd crop)	hrs		158.9
6. Oxen feeds			
rice bran	kg/day	3.35	9.9
rice flour	kg/day	3.35	9.9
cotton seeds	kg/day	0.0	16.5
7. Operating capital used[d]	MF/ha	41,791	175,307

[a]Techniques listed are only those which came into solution at some level: CT is the current technique, IT5 assumes double cropping.

[b]Obtained by subtracting the slack from total labor available, plus total of hired labor.

[c]D = December; My = May; Jn = June; N = November; Mc = March; Ap = April and Ja = January.

[d]Calculated as follows: initial capital supplied to the model plus revenues from selling activities minus the excess (slack) after solution.

TABLE 7-12b. Base Plans for the Medium Sized Farm

Item	Unit	Optimal Plan 1 under CT (PLAN 1)	Optimal Plan 2 (PLAN 2)
1. Production techniques[a]			
CT	ha	6.98	0
IT5	ha	0	7.15
2. Total labor used[b]	m-day	726.1	1,612.2
Months with hiring of labor	--	D,Ja[c]	My,Jn,Jl,O-Fe, Ap[c]
Proportion of hired labor to total	%	1.0	46.2
3. Net income			
per ha	MF	32,208.5	98,371.7
per man-day of family labor	MF	313.3	809.2
4. Fertilizer, seeds and seedlings			
Main crop			
urea	kg	258.3	714.3
amm. phosph.	kg	139.6	714.3
Tilemsi phosph.	kg	1,396.2	1,428.7
seeds	kg	837.7	571.5
seedlings	1000 twigs		
2nd crop			
urea	kg		357.2
amm. phosph.	kg		357.2
seeds	kg		571.5
5. Hire of equipment (total)	hrs	67.7	733.1
May	hrs	17.5	57.2
June	hrs	.15	78.6
July	hrs	45.5	107.2
Aug.	hrs	4.6	93.6
Jan. (2nd crop)	hrs	--	396.5
6. Oxen feeds			
rice bran	kg/day	6.9	21.4
rice flour	kg/day	6.9	21.4
cotton seeds	kg/day	0.0	35.7
7. Operating capital used[d]	MF/ha	43,725	219,360

[a]CT is current technique; IT5 is a technique involving double cropping.

[b]Obtained by subtracting the slack from total labor available, plut total hired labor.

[c]Abbreviations: My = May; D = December; Ja = January; Jn = June; Jl = July; O-Fe = October through February and Ja = January.

[d]Calculated as follows: initial capital supplied to the model plus revenues from selling activities minus the slack after solution.

TABLE 7-12c. Base Plans for the Large Sized Farms

Item	Unit	Optimal Plan 1 under CT (PLAN 1)	Optimal Plan 2 (PLAN 2)
1. Production techniques[a]			
CT	ha	9.82	0
IT5	ha	0	11.7
2. Total labor used[b]	m-day	1,020.5	2,647.4
Months with hiring of labor	--	D,Ja[c]	My,Jn,Jl,O-Ja,Mc,Ap[c]
Proportion of hired labor to total	%	3.6	54.2
3. Net income			
per ha	MF	29,826.2	53,650
per man-day of family labor	MF	297.7	518
4. Fertilizer, seeds and seedlings			
Main crop			
urea	kg	363.0	1,173.3
amm. phosph.	kg	196.2	1,173.3
Tilemsi phosph.	kg	1,962.2	2,346.5
seeds	kg	1,177.3	938.6
seedlings	1000 twigs		
2nd crop			
urea	kg		586.6
amm. phosph.	kg		586.6
seeds	kg		938.6
5. Hire of equipment (total)	hrs	24.7	1,173.4
May	hrs	--	90.2
June	hrs	--	121.8
July	hrs	24.7	172.4
Aug.	hrs		150.4
Jan. (2nd crop)	hrs		638.6
6. Oxen feeds			
rice bran	kg/day	9.8	35.2
rice flour	kg/day	9.8	35.2
cotton seeds	kg/day	0.01	59.6
7. Operating capital used[d]		55,167	243,853

[a]CT is current technique; IT5 alludes to double cropping.

[b]Obtained by subtracting the slack from total labor available, plus total hired labor.

[c]Abbreviations: D = December; Ja = January; My = May; Jn = June; Jl = July; O-Ja = October through January; Mc = March; Ap = April.

[d]Calculated as follows: initial capital supplied to the model plus revenues from selling activities minus the slack after solution.

technology. It was derived by constraining the model to bring all intensification techniques at a zero level in the solution. Optimal Plan 2 (PLAN 2) was obtained after allowing the model to float over the entire range of techniques envisaged. This was made possible by providing the model with an initial operating capital high enough to bring cultivated land in solution at a level close to the actual average area (taken as an upper bound) in each size group. Or alternatively, to exhaust the land constraint by leaving a negligible shadow price. In each case (and subsequent sensitivity runs), the total amount of operating capital used up in the solutions was obtained by subtracting the "slacks" from the total amount initially made available.[22]

5. Evaluation of LP Results of the Base Plans

PLAN 1

This plan is not expected to simulate the actual situation for one main reason: the LP model is normative and shows what farmers ought to do in order to maximize net incomes. Farmers may have other goals in actual practice.[23] The results of PLAN 1 indicate generally a higher net income per hectare over the actual situation (50 percent higher on

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[22]This is inclusive of the revenues from selling activities generated by multiplying the selling price by the level of production activity. The amount of labor used up in the solution was estimated in the same manner.

[23]For instance, the discrepancy between PLAN 1 and the actual situation developed in Chapter 5 is wide with regard to hiring of labor. Farmers in the survey area hired labor all year around (as shown in Appendix A). One probable reason for this difference could be that farmers find is socially satisfying to allocate their time to some nonrice activities and hire outside labor for rice even though family labor is available.

small and medium sized farms, and 20 percent higher on large farms). Farm labor is also shown to be used more efficiently (20 percent less on average). PLAN 1 will be the reference base for comparisons of alternative solutions involving one or a mix of intensification techniques proposed. Other information from the optimal solution in PLAN 1 is discussed below.

a. Marginal Value Products (MVP)

PLAN 1 brings land for all three size groups at a level slightly below the actual average which was taken as the model's upper limit. The existence of a slack on land means a zero MVP. The farmer would hence add nothing to his net income by acquiring an extra hectare of land, even though this is at no extra cost (according to the settlement contract). MVP of labor in November for both the medium and large farms were respectively 780 and 944 MF per man-day. This is less than the market wage rate of 1000 MF and suggests that farmers should not hire more labor during this period which is the beginning of harvest in practice. Shadow prices of labor in December and January are nearly equal to the market wage rate. Thus under the ceteris paribus condition, the program level of labor hiring (1 and 3.6 percent for the medium and large farm) may be considered as optimal because no increase in net incomes would be forthcoming for an extra man-day of outside labor. The same interpretation is valid for oxen feeds and hire of farm equipment services. Shadow prices for fertilizer and oxen feeds are higher than their respective marginal costs only for the small sized representative farm. For instance an extra kilo of urea bought at 120 MF would increase the objective function by 313 MF. In general the magnitude of shadow prices should be interpreted as only indicative of the proper direction of action in production decision. In practice the more or less intensive use of any input as suggested by the magnitude of its MVP in relation to its price will be finally restricted by the mix and the constraints of other resources.

b. Cost of Forcing in Nonoptimal Activities

LP provides information about excluded activities by indicating how much the returns will be reduced if such activities are forced into the solution. The higher cost the lower its competitive position in relation to other activities. Forcing PLAN 1 to hire labor at nonpeak period would reduce net income by 2,611 MF for the small representative farm. It would cost relatively less (1000 MF) to do so in December.

PLAN 2

In all three size groups PLAN 2 brings only IT5 into solution. This suggests that double cropping is the most profitable of all intensification techniques now available. The same conclusion was suggested through budgeting (see Table 7-6). As was the case for PLAN 1, this plan was also derived by providing the model with an initial operating capital large enough to bring land in solution at its actual level in each size group. Because two crops are expected to be planted on the same land area in one year, the level of resource mobilization required is practically difficult to achieve, unless credit is made available to farmers. For instance, although net income for the small farm is shown to reach nearly 830 MF per man-day (of family labor), the model would require an annual operating capital of 175,300 MF per hectare. This amount would be necessary to pay for 33 percent of the required annual labor (2 crops), hire nearly 210 hours of farm equipment services, and maintain draft animals at a daily ration of 37 kg (twice as much would be required on medium sized farms).

Resource constraints on large farms would make double cropping less profitable relative to the lower size groups. As shown in Table 7-12c, only 520 MF per man-day in net income would be generated, while the need for operating capital would be nearly quadrupled compared to PLAN 1 (243,853 MF per hectare).

In sum, under the current situation and probably within the horizons of a near future, a technique involving, double cropping of rice is not feasible although it is shown to be the most profitable. This is because the level of resource demand required to plant an area of land equal or close to the current average can be met only if enough operating capital is made available through credit. It is possible however to restrict the practice on a very limited area. The practicability of other intensification techniques is discussed below.

6. Feasibility and Practicability of Alternative Intensification Techniques

To examine the feasibility of other intensification techniques and bring some realism into the model, the activity (IT5) involving double cropping was forced to appear in the solution at zero level. This allows the model to float and choose among remaining alternatives. The results are shown in Table 7-13 which depicts optimal Plan 3 (PLAN 3).

TABLE 7-13. Optimal Plan 3: Resource Allocation and Net Incomes With IT5[a] at Zero Level

Item	Unit	Size Group I (0-5 ha)	Size Group II (5-10 ha)	Size Group III (10-15 ha)
1. Prod. technique in solution				
IT4[b]	ha	2.48 (1.32)[c]	3.71 (3.79)[c]	4.96 (7.04)[c]
2. Net income per hectare	MF	98,320	105,394	106,493
per man-day	MF	614	631.4	633.8
3. Resource hired[d]				
Non-family labor	%	13	11.2	11.9
Farm equipment services	%	1	0	0
4. Inputs with MVP > MC[e]		--	--	--
MVP < MC[e]		SEEDS1, HLJL[f]	SEEDS1, HLJL[f]	SEEDS1, HLJL[f]
5. Operating capital (upper limit)	MF/ha	125,444	138,237	177,336
percent change from PLAN 1	%	+200	+216	+185

[a]IT5 is intensification technique involving double cropping of rice.

[b]IT4 is intensification technique involving transplanting of seedlings.

[c]Unutilized land (or slack) in bracket below the optimal amount in solution.

[d]Limited to resources hired above farm availability level.

[e]Marginal cost or cost price of the input under consideration.

[f]Abbreviations SEEDS1 is selected seeds in season 1; HLJL is hired labor in July.

The amount of operating capital used up in the solution in PLAN 3 is a maximum beyond which the second most constraining resource (family labor) became operative.[24] Although net income per man-day arrived at is three times as higher under PLAN 3 than PLAN 1, the model leaves a substantial slack of land, implying a reduced gross revenue per farm.[25]

The main technique in solution (IT4) involves transplanting of rice seedlings. It was indicated earlier that this technique was indeed introduced in the settlement in the past, but succeeded only to a limited extent.[26] As transplanting was done entirely by hand, labor became a bottleneck. The same labor constraint is demonstrated in the model leading to PLAN 3, in addition to the capital requirements (average 147,000 MF per hectare) already judged impractible with 40 percent of it used to hire outside labor. Examination of shadow prices indicates no single resource with an MVP greater than its marginal cost (MC). Seeds in June (SEEDS1) and hired labor in July (HLJL) have MVP less than their marginal MC.

The next plan considers the feasibility of IT1, IT2 and IT3 by forcing the program to bring IT4 and IT5 at zero level. The results are discussed under optimal plan 4 (PLAN 4 in Table 7-14). IT2 and IT3 are shown to be profitable techniques for the small and medium sized

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[24] Successive optimal plans beyond this level failed to bring more land into the program.

[25] One reason why farmers prefer large holdings is the possibility to increase total production, i.e. increase their returns to labor.

[26] In 1962 at its widest degree of adoption transplanting covered only 3 percent of the rice land. [de Wilde, 1967, pp. 264-66].

TABLE 7-14. Optimal Plan 4: Resource Allocation and Net Incomes With IT4[a] and IT5[a] at Zero Level

Item	Unit	Size group I	Size group II	Size group III
1. Prod. techniques in solution				
IT2[a]	ha	0.67	0.57	0.0
IT3[a]	ha	2.90 (0.14)[b]	6.09 (0.84)[b]	10.15 (1.85)[b]
2. Net income per ha	MF	54,845	54,255	50,270
per man-day	MF	428.7	517.2	508.5
3. Resource hired[c]				
non-family labor	%	16	19	24
farm equipment services	%	11	46	20
4. Inputs with MVP > MC		HLN, FERT, EQ, FD, SEEDSI	HLN, FERT, EQ, FED, SEEDSI	--
MVP < MC		HLJN	HLJN	HLJN
5. Operating capital (upper limit)	MF/ha	101,072	107,011	147,240
percent change from PLAN 1	%	+142	+145	+136

[a]Abbreviations IT4 is intensification technique with transplanting; IT5 involves double cropping; IT2 is intensification technique with row-seeding; IT3 is as IT2 but also involves animal drawn weeding.

[b]Unutilized land (or slack) in brackets to the right of the amount of land in solution.

[c]Limited to resources hired above farm availability levels.

[d]FERT, EQ, FD refer respectively to all types of fertilizer, equipment hire in all months and all types of feeds; SEEDS1 is selected seeds in season 1 (June); NLH is hired labor in November, HLJN is hired labor in June.

representative farms. IT3 is the only profitable activity in solution for the large farm model. The main attributes of these techniques comprise row-seeding and/or animal powered weeding, including high rates of fertilization as indicated in the budget table of Section 7.2. Net incomes per hectare and per man-day (of family labor) are lower under PLAN 4 than PLAN 3 but higher than the level achieved under PLAN 1. There is however more income increasing possibilities under PLAN 4 as indicated by the number of inputs with MVP greater than their respective MC. Such flexibility is lacking for the large sized farm as more resources have shadow prices equal to their acquisition costs. The upper bound for operating capital in PLAN 4 is also less than twice the required level under PLAN 1.

Thus a case can be made from the results of PLAN 4. First, the maximum operating capital required (average 120,000 MF per hectare) could well be supplied through the current system of in-kind payment which cover much of the committed costs. Cash expenditures for hiring of labor and farm equipment services estimated at 70 percent of the operating capital however, would still remain a constraint, unless off-farm revenues are high enough to overcome the cash constraint for labor hiring at harvest time. Second, the additional investment outlay on a row-seeder and a cultivator[27] can be provided through the Office credit system as is now the case for plows and harrows. Third, the major techniques in PLAN 4

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[27]In the form of a toolbar with multiple attachments that can serve for weeding and ridging as well.

(IT2 and IT3) are already being tried at the farm level,[28] although progress will of necessity depend on increased extension contacts and farmers' training in the use of new equipment.

7. Land Restriction Runs Under CT and IT1

On the basis of the above considerations, it is assumed that row-seeding and/or mechanical weeding are likely to be adopted. This part brings some realism into the modelling effort by also assuming that introduction of IT2 and/or IT3 will be made step by step, as this would be the case in practice. The premise for discussion is laid out in Tables 7-15 (a, b), derived from PLAN 4 and PLAN 1, respectively. The objective is to demonstrate the requirements in operating capital and the income increasing possibilities under intensification.

In Table 7-15a the area under CT is reduced from 100 to 10 percent. This is a way to simulate a progressive introduction of improved techniques on the ground that intensification will of necessity evolve out of the existing situation. It was indicated earlier that IT1 has the same attributes as CT but differs from the latter only in that all divisible inputs are assumed to be applied at their O.N. recommended rates. Thus IT1 logically appears to be the first step in the direction of intensification at the O.N. Both CT and IT1, however, are nonoptimal activities because they are not part of the solution in either of the "floating" optimal plans (PLAN 2, 3 and 4). Table 7-15b considers the outcome

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[28] In the 1979-80 season there were 149 seeders owned by settlers and row-seeding covered some 4 percent of the rice land [O.N., Service Agricole, 1980].

TABLE 7-15a. Land Restriction Runs: Decreasing the Portion of Land Under CT[a]

Land restrictions under CT %		% of land use for alternative technique in solution			Shadow price of land (MF)	Net income (MF)		Required operating capital (MF/ha)
		IT3	IT2	slack		per ha	per m-day	
Small Farm	100[b]	--	--	--	--	36,672	223	41,791
	80	20	0	0	40,197	37,345	354	63,039
	60	40	0	0	20,978	42,912	402	70,303
	40	60	0	0	20,397	47,302	443	78,741
	20	80	0	0	20,397	51,676	484	87,191
	10	77	13	0	7,940	55,715	518	92,739
Medium Farm	100[b]	--	--	--	--	32,208	313	43,725
	80	20	0	0	5,323	33,706	336	73,959
	60	40	0	0	5,323	37,097	371	81,787
	40	60	0	0	768	40,383	406	89,720
	20	80	0	0	218	42,847	452	92,815
	10	79	9	2	0	46,321	512	97,977
Large Farm	100[b]	--	--	--	--	29,826	298	55,167
	80	12	0	8	0	30,457	306	90,510
	60	31	0	9	0	33,768	349	98,155
	40	49	0	11	0	38,268	393	106,192
	20	67	0	13	0	42,908	438	114,442
	10	15	0	15	0	47,269	484	121,826

[a]CT is current technique.

[b]Source is PLAN 1, Table 6-12.

TABLE 7-15b. Land Restriction Runs: Increasing the Portion of Land Under IT1[a]

% of Land Under IT1 Forced in Solution		% Land Under CT in Solution	Slack	Shadow Price of Land (MF)	Net Income (MF) Per ha	Net Income (MF) Per man-day	Required Operating Capital (MF)
Small Farm	0[b]	88	12	0	33,672	323	41,791
	10	90	0	20,229	34,960	336	47,815
	30	70	0	20,229	37,765	363	48,967
	50	50	0	20,229	40,569	390	50,119
	70	30	0	20,229	43,373	417	51,271
Medium Farm	0[b]	93	7	0	32,209	313	43,725
	10	83	7	0	33,716	328	47,208
	30	63	7	0	36,995	340	49,878
	50	43	7	0	39,744	387	51,116
	70	23	7	0	42,760	416	55,219
Large Farm	0[b]	72	18	0	29,826	298	55,167
	10	72	18	0	31,594	315	55,983
	30	52	18	0	35,028	349	57,393
	50	32	18	0	38,461	384	58,804
	70	12	18	0	41,896	418	60,214

[a]IT1 is intensification technique with same attributes as current technique except that fertilization rate is higher.

[b]Source is PLAN 1.

of PLAN 1 (where CT was the only activity) if IT1 is forced in successively to cover 10, 30, 50 and 70 percent of the land.

For the representative small farm, reducing the area under CT to 10 percent of the available land results in 52 and 132 percent increase in net incomes per hectare and per man-day, respectively. More than twice the current level of operating capital (41,791 MF per hectare) will be needed. Similar percentage increases obtain for the medium and large farms.

There is however a significant difference between the three farm situations when shadow prices of land are examined. As more land under profitable techniques (IT2, IT3) is substituted for CT, the shadow prices of land for the small farm remain positive (though declining). Their modal value is about 20,400 MF. This suggests that the small farmer could increase his income by bringing in one additional hectare of land. The shadow price of land is zero on the large farm. A zero shadow price (viz MVP) implies idle resource and no change in net income should an extra unit of input be brought into solution. On the medium sized farm shadow prices are extremely lower and tend to zero as more land under improved techniques is brought in.

Sensitivity runs constraining PLAN 1 to bring IT1 in solution at an increasing rate of land use produced expected results. For the small farm land is used up completely and any additional hectare would increase net income by a constant amount of 20,229 MF. Substantial portion of the rice land (18 percent) would have to remain idle on large farms where the requirement for operating capital is also the largest. Successive profitable plans for the medium farm would leave only 7 percent of the land idle. In all cases however, net incomes would increase by 30 to 40 percent of the initial plan situation.

8. Possibility for Higher Farm Incomes: Small Versus Large Holdings

This section ties together scattered results from the LP modelling as to the possibility for income increases on small, medium and large sized farms. First, comparison of PLAN 1 with the actual situation revealed that resources used in rice production could be reallocated more efficiently to result in higher farm incomes in all size groups. The results indicate however that net incomes per hectare would increase by 50 percent on small and medium farms, but only 20 percent on large farms. Return to labor would be the highest on small farms (323 MF per man-day) and the lowest on large farms (298 MF per man-day). PLAN 1 also indicated that MVP of divisible inputs (seeds, fertilizer, oxen feeds etc.) were higher than their marginal costs only on small farms.

Second, PLAN 2 brought in solution only the technique involving double cropping of rice. Although this technique was shown to be infeasible under present conditions, expected net returns per hectare and per man-day would be the highest on small farms with more than a 2 to 1 margin with regard to large farms.

Third, the results of land restriction runs, assuming that intermediate techniques (involving row-seeding and/or mechanical weeding) are introduced progressively, indicate strongly that there is more scope for increases in incomes (per hectare and per man-day) on small and medium sized farms than on large farms. These findings accord on one point: organization of rice production in large holdings (above 10 ha) will not be profitable either to the farmer (lower returns to labor) or to the Office (lower returns to land).

9. Sensitivity of the Optimal Plans to Change in Prices

PLAN 1 and PLAN 4 were finally tested for a change in the prices of rice and selected inputs (seeds, fertilizer and oxen feeds). For practical reasons, the runs were restricted to the representative medium farm to reflect the present target size of farm (5 to 7 ha) considered under the intensification program.

First, the paddy rice was adjusted to its market level of approximately 95 MF per kilo [CILSS, 1979]. Seeds, fertilizer and oxen feeds were imputed their cost prices.[29] Second, the paddy price was increased to its competitive level of 110 MF in neighboring countries.[30] This also required adjusting the price of selected seeds to 115 MF. The results of price sensitivity runs are summarized in Table 7-16.

There is some labor and equipment-hours available in PLAN 1 to allow the model to increase the portion of land use by 6 percent. Both types of net incomes increase by one and half times their current level if the price of paddy is raised to 95 MF simultaneously with other inputs mentioned above valued at their economic costs. Raising the paddy price to its competitive level prevailing in other Sahelian countries would

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[29] Urea at 160 MF, ammonium phosphate and sulfate of ammonia at 150 MF, Tilemsi phosphate was arbitrarily costed at 30 MF; improved seeds at 100 MF, and animal feeds at respectively 14, 20 and 32 MF per kilo for rice bran, flour and cotton seeds.

[30] At 1976 prices the official producer prices per kilo of paddy in equivalent Malian francs were 120 MF in Senegal, and 108 MF in Niger and Upper Volta [Humphreys and Perason, 1979].

TABLE 7-16. Sensitivity of PLAN 1[a] and PLAN 4[b] to Changes In Prices of Output and Selected Inputs

Item	Unit	PLAN 1			PLAN 4		
		Initial[c]	Paddy Price per kg		Initial[c]	Paddy Price per kg	
		@ 60 MF	@ 95 MF	$ 110 MF	@ 60 MF	@ 95 MF	@ 110 MF
Land area in solution	ha	6.98	7.38	7.38	6.66	6.66	6.66
Change over PLAN 1	%		+6.0	+6.0			
Change over PLAN 4	%					0	0
Net Income per ha (1)	MF	32,209	80,454	102,669	54,255	140,778	180,675
Change over PLAN 1	%		+150	+219			
Change over PLAN 4	%					+159	+233
Net Income per m-day	MF	313	796	1,016	517	1,299	1,667
Change over PLAN 1	%		+154	+225			
Change over PLAN 4	%					+151	+222
Operating Capital (2)	MF/ha	43,725	101,819	125,836	107,011	181,236	222,334
Change over PLAN 1	%		+133	+188			
Change over PLAN 4	%					+79	+108
Ratio (2)/(1)		1.36	1.27	1.23	1.97	1.29	1.23

[a]PLAN 1 represents the optimal allocation of resources under the current technique. It was derived by constraining all intensification techniques at zero level (see Table 7-12b).

[b]PLAN 4 assumes the adoption of row seeding and mechanical weeding. It was shown to be the most acceptable plan (in terms of feasibility and profitability) under intensification and was derived by eliminating double cropping (IT5) and transplanting (IT4) from the solution (see Table 7-14).

[c]Source is Table 6-12b and 6-14.

improve net farm incomes by more than twice their current levels. In the two price situations, the need for operating capital to bring about the contemplated increase in net incomes is relatively reduced (in percentage terms). This is illustrated by the ratios of operating capital per hectare to net income per hectare which drop from 1.36 to 1.27 under PLAN 1, and from 1.97 to 1.23 under PLAN 4 (Table 7-16).

The initial PLAN 4 was shown earlier to be more profitable than the current situation because improved techniques (IT2 and IT3) are assumed. Resources other than operating capital (labor, equipment-hours) become so constraining in some periods to prevent the plan to use the land beyond its initial level in PLAN 4. Income increasing possibilities shown under the two price assumptions subsume the adoption of the techniques mentioned above. In any case these could be generated with relatively less operating capital (in percentage terms) compared to the initial optimal plan. This is illutrated by the ratios of operating capital per hectare to net income per hectare which drop from 1.36 to 1.27 under PLAN 1, and from 1.97 to 1.23 under PLAN 4 (Table 7-16).

10. Side Issues

a. Determination of the Land Allocation Norm

The modelling effort in this chapter provided another opportunity to address the issue of land allocation in an attempt to suggest an optimal norm. First, a brief background of the problem is given below.

The Office management has used varying criteria to allocate land to all incoming settlers. In the past, improved land was alloted on the basis of 1 ha per working man (WM). Difficulties to meet the land fee payment seemed to have prompted the administration to move to a higher norm. Recently an allotment varying from 2 to 3.5 ha per WM is being used. In any case it is recognized that land attribution is not based on economic or statistical criteria.[31] In some cases, this has led to a situation where holdings of different sizes are attributed to families with similar manpower bases.

When a new group of farmers was settled in Foabougou for the pilot intensification project at the beginning of the 1979-80 season, the Office management in Niono found this an opportunity to assess the impact of land sizes on farmers' revenues. Settlers were allocated varying sizes of land per WM in an effort to determine an optimal allocation norm after production data were turned in at the end of the season.[32] Because of the smallness of the sample (25 settlers), calculated mean enterprise incomes failed to reveal a significant difference among two of the large strata under different norms (loosely defined).

The Foabougou sample, however, had the characteristic of being homogenous with respect to resource use (fertilizer and seeds rates, farm capital etc.).[33] It was therefore used to provide the input-output coefficients which formed the basis of the improved technique baptized as

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[31]This is the viewpoint of authorities at the Service Agricole and Bureau de Paysannat of the O.N.

[32]Although this attempt followed the suggestions put forward by the research team, its implementation by the O.N. staff in Niono failed to result in clear-cut allocational norms. Examination of the data indicates that 12 and 18 families received an allotment averaging 3 and 4 ha per WM, respectively; there were 3 families with an average of 2 ha per WM and the remaining 2 settlers were allocated approximately 5 ha per WM.

[33]Low standard deviations referred to in Section 7.1 justify this claim.

IT1. To determine an optimal norm of land allocation, these input-output relationships were re-examined in light of the known farm level constraints. The base model (shown in Table 7-11) was used to approach the problem.

First, the plan was constrained to bring all techniques but IT1 at zero level. Second, all labor and farm equipment hiring activities were constrained at zero level to allow the model to use only family resources. Third, the land constraint was turned inoperative to permit the model to bring IT1 in solution at the highest level determined by family resources. Operating capital was fed to the model to a point where most MVP of resources were equal to their marginal costs.

The results in Table 7-17 indicate that a maximum area of 5.36 ha can be efficiently brought into cultivation given the amount of resources available to the average farm family. The average farm requires 108 man-days of family labor, and has about 2.5 WM.[34] This suggests an optimal allocation of 2.14 ha per WM.

b. The Consumption Allowance and its Impact on Net Cash Incomes from Rice

An allowance for own consumption of 300 kg of paddy[35] per member of family is instituted at the Office to ensure the settlers against food scarcity during the off-season. To the Office management food security

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[34]This is an overall average and modal value for the O.N. given in official reports.

[35]In practice the Office takes account of the estimate of total family gleanage and adjusts the allowance with additional bags of paddy (after threshing) to make up the equivalent of 300 kg per person in a family.

TABLE 7-17. Family Resources and Optimal Size of Holding

Item	Units	Per Hectare	Farm
Maximum land area in solution	ha	--	5.36
Family labor available	man-days	108	556
Fertilizer used: urea	kg	50	267.8
amm. phosph.	kg	50	26.8
til. phosph.	kg	200	1,071.4
Seeds	kg	120	642.8
Oxen feeds: rice bran	kg/day	--	5.36
rice flour	kg/day	--	5.36
Net income	MF	47,633	255,311
Net income per man-day	MF	--	459.2
Operating Capital	MF	60,192	322,628

Source: Derived from LP model.

for the settlers' families is an incentive for farmers to deliver more paddy for marketing. When home consumption is valued at its opportunity cost and subtracted from the net enterprise income, the magnitude left represents a net cash income from rice production. Table 7-18 depicts the amount of net cash incomes arrived at in the current situation (PLAN 1) and expected magnitudes under PLAN 4. Price assumptions are respectively 95 MF and 110 MF per kilo of paddy.[36]

Under PLAN 1 only the representative farm of medium size is able to generate a positive net cash income of 26,815 MF per year. This translates into an average monthly net cash income of 2,235 MF. For paddy prices of 95 MF and 110 MF per kilo, optimal solutions lead to substantial increases in net cash incomes for all three representative farms. Under PLAN 4 which involves the use of improved techniques, net cash incomes are shown to remain positive across all three farm situations. Thus when the official paddy price is adjusted to its market level, the model indicates the possibility of real improvements in the net cash position of farmers at the Office du Niger. This possibility explains the tendency for settlers to sell part of their harvest in parallel markets, where competitive prices exist.

Summary

Chapter 7 laid out the prospects for intensification of rice cultivation at the Office du Niger. First, preliminary results of a pilot

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[36]Net incomes at these prices are the results of sensitivity analysis performed on initial optimal plans (PLAN 1 and PLAN 4). Assumptions for prices of selected inputs are as in Table 7-16.

TABLE 7-18. Net Cash Incomes Under Alternative Price Assumptions for Paddy (in Malian MF)

	PLAN 1[a]			PLAN 4[b]		
	Initial	Paddy Price per kg		Initial	Paddy Price per kg	
	@ 60 MF	@ 95 MF	@ 110 MF	@ 60 MF	@ 95 MF	@ 110 MF
Small Farm						
Net Income	112,800	316,671	418,006	195,797	480,447	606,212
less value of consumption (2,100 kg)[c]	126,000	199,500	231,000	126,000	199,500	231,000
Net Cash Income/Year	-13,200	177,171	187,006	69,797	280,947	375,212
Average per month	-1,100	14,764	15,584	5,816	23,412	31,268
Medium Farm						
Net Income	224,815	593,751	757,697	361,338	937,581	1,203,295
less value of consumption (3,300 kg)[d]	198,000	313,500	363,000	198,000	313,500	363,000
Net Cash Income/Year	26,815	280,251	394,697	163,338	624,081	840,295
Average per month	2,235	23,354	32,891	13,612	52,007	70,025
Large Farm						
Net Income	292,895	865,802	1,131,886	510,241	1,314,965	1,577,451
less value of consumption (5,700 kg)[e]	342,000	541,500	627,000	342,000	541,500	627,000
Net Cash Income	-49,105	324,302	504,886	168,241	773,465	950,451
Average per month	-4,092	27,025	42,074	14,021	64,455	79,204

[a]PLAN 1 represents the optimal allocation of resources under the current technique. It was derived by constraining all intensification techniques at zero level (see Table 7-12b).

[b]PLAN 4 assumes the adoption of row seeding and mechanical weeding. It was shown to be the most acceptable plan (in terms of feasibility and profitability) under intensification and was derived by eliminating double cropping (IT5) and transplanting (IT4) from the solution (see Table 7-14).

[c]Assuming family size of 7 members.

[d]Assuming family size of 11 members.

[e]Assuming family size of 19 members.

project which concerned only a small sample of 25 settlers, were briefly reviewed. There is indeed some indication that gross yields can be increased when fertilizer and seeds are applied at recommended rates, and when the potential of the irrigation infrastructure is improved through land levelling and revitalization of works. However the results from one single crop season should not constitute the basis for final conclusion.

A number of improved techniques of rice production are now available at the Office. They certainly form the technical knowledge base out of which intensification of production will evolve. A detailed analysis was undertaken in section 7.2 to determine the specific increases in yields that can be expected under alternative techniques. Budgets for labor and nonlabor resources for each technique were presented. The input-output relationships derived were based on agronomic data, results from studies conducted elsewhere on similar production systems and a number of realistic assumptions. Then a one period linear programming model was constructed to assess the feasibility and profitability of intensification at the farm level in light of present resource constraints.

Results from the modelling exercise indicate clearly that a technique involving double cropping of rice is the most profitable at the farm level. To be feasible in practice, this technique subsumes that credit and/or other source of cash incomes are available to farmers. This is because the degree of resource mobilization required to cultivate the current area of improved land is extremely high. A technique involving transplanting of rice seedlings is also shown to be highly profitable. However, labor demand for transplanting is so constraining to allow only a small area (considerably below current average sizes) for cultivation. Intermediate techniques are relatively less labor and capital intensive and involve the kind of practices currently being pushed into the Office settlement (row-seeding and/or mechanical weeding). For these techniques, the model indicates possibilities for further income increases through intensified use of fertilizer, seeds, oxen feeds, hired labor and farm equipment, if the operating capital constraint (average of 120,000 MF per hectare) can be alleviated. Some realism was brought into the model by examining what would happen to farm incomes and farm land if the techniques involving row seeding and/or mechanical weeding are introduced progressively. The land restriction runs resulted in a major finding: there is scope for increases in returns to labor and to land on both small and medium sized farms, thus indicating the nonprofitability of organizing rice production on the basis of large holdings (above 10 ha). In all three farm size groups, however, net incomes would increase by progressively reducing the size of land under the current technique, shown to be the least profitable of all. In Chapter 4 and 5, resource utilization under the current situation was shown to be more efficient on the medium sized farms. The results of LP model indicate that intensification will be more profitable to the farmer and the Office management if rice production is organized in holdings of less than 10 ha, in particular 3 to 7 ha.

One of the basic constraints on the development and intensification of production at the Office du Niger is the paddy farmgate price, generally acknowledged to be too low. At the market price of 95 MF per kilo, net incomes of farmers can be more than doubled. When this price is adjusted to its level in neighboring Sahelian countries, more than a threefold increase in net incomes can be expected. Official collections of paddy are not increasing at the expected pace partly because O.N.

settlers find it profitable to channel part of their produce into private markets where competitive prices are paid.

CHAPTER 8

THE OFFICE DU NIGER ECONOMIC ENVIRONMENT: UNDERCAPITALIZATION, RISK MANAGEMENT AND INDEBTEDNESS

8.1 Introduction

Economics of rice production at the O.N. was the main theme developed in this study. Chapter 8 addresses two fundamental issues of the settlement economic environment: (1) undercapitalization and associated risks and (2) farmers' indebtedness.

As indicated in Chapter 2 all incoming settlers receive a medium-term credit for the purchase of farm equipment consisting of a pair of oxen, a plow and a harrow.[1] The 1975-76 O.N. records indicate that 18 percent of settlers had only one or no work oxen and 5 percent had no plows. By 1978-79 the proportion of settlers with no oxen had increased to 21 percent. The situation is no better now than two years ago. How do some settlers' families lose their equipment in the first place? How do they obtain equipment for cultivating their fields? Why is the lost equipment not replaced and what is in general the socio-economics of animal traction at the Office? These questions need to be answered before the Office embarks on its intensification program.

[1]The term equipment refers only to those mentioned above. But a distinction will be made between oxen and traction implements (harrow and plows).

The issues alluded above are part of a much deeper problem facing some settlers at the O.N. i.e., their indebtedness and the way it has developed over the years. Historically, conditions in the settlement have made it difficult to reconcile the interests of the settlers and the financial obligations of the Office as an enterprise. From the beginning the Office was mandated to carryout development works through opening of new lands, leveling, construction of housing for the settlers, development and maintenance of the irrigation infrastructure. For a long time however the Office has never been able to finance even its recurrent cost [deWilde, 1967; CILSS, 1980].[2] The major source of revenues is the water and extension charge (commonly referred to as land fee) of 400 kg of paddy per hectare. From the farmer's standpoint the land fee is a real burden. As shown earlier in Chapter 5, it takes anywhere from 20 to 80 percent of the gross value of production across the settlement.

Apart from the fact that a constant land utilization fee fails to cover the enterprise recurrent costs, its uniformity across the settlement affects the economic performance of those settlers in areas such as Kolongo with a low yield potential. The occurence of low yields in those areas over a number of years, the relatively higher level of land fee with respect to other parts of the settlement, the requirement to

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[2]The Office own estimate of desirable expenditure on maintenance ranges from 46,566 MF to 63,905 MF per hectare of irrigable land. Major sources of revenues are the water and extension charge of 400 kg of paddy per hectare currently valued at 24,000 MF, and the value of in-kind payment by farmers to cover threshing costs, and other indirect taxes. At current prices the total revenues from rice amounts to 36,000 MF per hectare approximately. [O.N. Bureau of Economic Affairs, 1979].

repay the equipment loan within the prescribed three year schedule, are among major factors whose combined effects result in increased level of farmers' indebtedness to the enterprise.

For that particular group of settlers, this cumulative indebtedness imposes constraints on their ability to make the right investment decisions in farm equipment and for capital replenishment in general. At worse, some will lose all equity in capital stock. It is to this particular group of Office settlers with no means of production that Magasa [1978] points his frank observations:

> ". . . they are landlords without land, employ production means they cannot own; they are agricultural laborers disguised as small holders" (p. 135).

This chapter begins with a summary discussion of how some settlers are underequipped. The discussion is based on the use of a multiperiod budget technique to account for the financing of farm equipment. Next, the data from a survey of underequipped[3] settlers in the sector of Kolongo is analyzed. This is followed by an application of the decision tree model in order to understand and generalize the process of undercapitalization. Lately, the chapter deals with the development of farmers' indebtedness based on data obtained from the Office du Niger records for the past decade.

8.2 Analysis of the Net Benefit to Investment in Farm Equipment

Table 8-1 sets out farm budgets with financing of farm equipment over a 10 year horizon for a medium sized farm of 7.5 ha in three theoretical yield zones (2.0 mt, 1.5 mt and 1.0 mt per hectare).

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[3]The term is used for settlers with inadequate equipment.

TABLE 8-1. Multiperiod Farm Budget with Financing of Farm Equipment (Animals and Implements) (in 1,000 MF)

[a]Assuming a 120 kg per ha rate at 70 MF per kg.

[b]Fertilizer is assumed to be applied at the average level of utilization revealed in the survey data (40 kg of urea/ha, 20 kg of phosphate/ha at 120 and 140 MF/kg, respectively.

[c]It is assumed that the average farmer would hire 5 percent of the labor needed in agricultural operations (see Table 5-6). The average wage rate in the survey area amounted to 700 MF per man-day.

[d]At 120 kg per metric ton threshed.

[e]Includes oxen feeds as well. It is assumed that the expenses on repairs and maintenance would increase steadily from the first to the third year during which it is assumed that the current level of about 3,200 MF per ha is reached. The cost in year 1 is taken from the data on Foabougou village where settlers received new equipment and used them for one year during which data was collected.

[f]Miscellaneous fixed expenses such as bags, small tools.

[g]Total of 180,000 MF for a pair of oxen, 53,000 MF for the plow and 40,000 MF for the harrow.

[h]O.N. credit on farm equipment is interest-free.

[i]Values of first credit and values of foodstuffs are not counted.

[j]Assuming the farmer receives a second three-year loan for two oxen.

Item	Yield Zone: 2.0 mt/ha Year 0	1	2	3	.. 7	.. 10	Yield Zone: 1.5 mt/ha Year 0	1	2	3	.. 7	.. 10	Yield Zone: 1.0 mt/ha Year 0	1	2	3	.. 7	.. 10
Revenue																		
Value of rice production	540	900	900	900	900	900	450	675	675	675	675	675	360	450	450	450	450	450
Sale of salvage of oxen					90						90						90	
Sale or salvage of implements						0						0						0
(1) subtotal	540	900	900	900	990	900	450	675	675	675	765	675	360	450	450	450	540	540
Variable Costs																		
Seeds[a]	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63
Fertilizer[b]		57	57	57	57	57		57	57	57	57	57		57	57	57	67	57
Wage labor[c]		27.3	27.3	27.3	27.3	27.3		27.3	27.3	27.3	27.3	27.3		27.3	27.3	27.3	27.3	27.3
Threshing cost[d]	648	108	108	108	108	108	54	81	81	81	81	81	43.2	54	54	54	54	54
Use of farm equipment[e]		9.3	17.6	17.6	25.8	25.8		9.3	17.6	17.6	25.8	25.8		9.3	17.6	19.6	25.8	25.8
(2) subtotal	127.8	264.6	272.9	272.9	281.1	281.1	117	237.6	245.9	245.9	254.1	254.1	106.2	210.6	218.9	218.9	227.1	227.1
Fixed Costs																		
Land fee	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
Others[f]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Purchase of animal (yr 7) and implement (yr 10)					180	93					180	93						93
(3) subtotal	182	182	182	182	362	275	182	182	182	182	362	275	182	182	182	182	182	275
Financing																		
(4) First Credit on equipment[g]	273						273						273					
(5) Annual loan repayment[h]		91	91	91				91	91	91				91	91	91		60
(6) Food allowances credit year 0	180						180						180				180[j]	
(7) Food loan repayment		60	60	60				60	60	60				60	60	60		
Net Benefit after Financing																		
(1 + 4 + 6) - (2 + 3 + 5 + 7)	230.2[i]	302.4	294.1	294.1	346.9	343.9	151[i]	104.4	96.1	96.1	148.9	145.9	71[i]	-93.6	-101.9	-101.9	-49.1	-52.1

These zones are chosen to represent the actual situation as reported in Chapter 4 and 5. For instance, the 2.0 mt per hectare zone is applicable to Sahel, while the low yield zone actually represents conditions prevailing in Kolongo sector.

The budgets can be described as follows. In year 0 the farmer receives a credit for farm equipment. Because of delays in delivery, the land is usually plowed and sown for him by the Office. He also receives foodstuff valued at 180,000 MF, for the nourishment of his family during year 0.[4] Owing to problems of adjustment, it is reasonable to expect lower yields in year 0. These are assumed at 1.2 mt, 1.0 mt and 0.8 mt per hectare for the three different yields zones, respectively. It is also assumed for year 0 that no outside labor is hired and no fertilizer is applied.

The variable and fixed costs shown in year 1 through year 10 represent the actual level of resource utilization as presented in Chapter 4 and 5. In year 7, one of the two oxen dies and the second is salvaged at its initial purchase price. These animals are replaced out of the settler's own funds or through acquisition of a second equipment credit. All farm implements (harrows, plows) have a 10 year life with zero salvage value.[5]

Net Present Values (NPV) calculated for the average farmer in these zones at 15 percent discount rate were 1,378,280 MF, 613,180 MF

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[4]This assumes an average family size of 10 members and an allowance of 300 kg of paddy (valued at 60 MF per kilo) per member, in accordance with the current practice at the O.N.

[5]This accords with data from the survey reported in Chapter 5 (Table 5-4), the average lifetime was rounded to 10 years for ease of calculation.

and -320,880 MF, respectively. There is a 2 to 1 ratio in the NPV between the first two yield zones, much higher than the ratio of their respective yields. Discounted future cash flows for the average farmer in the low yield zone results is a large negative value which indicates clearly that rice farming does not pay at all in these zones. Where the net yield is barely 1.0 mt per hectare, the three-year repayment schedule of the farm equipment credit imposes a real financial burden upon the settler. The 10 year budget exercise also shows that for investment in farm equipment to be profitable to the settler, a minimum yield of 1.5 mt per hectare needs to be achieved.

Failure of settlers in low yield zones such as Kolongo to realize a net benefit after repaying the equipment loan, has several consequences. It increases their indebtedness to the Office. To meet financial obligations the settlers may sell the farm equipment before payments fall due. These settlers may also revert to capital borrowing in-kind or in-cash to meet consumption needs. The causes of underequipment and the range of risk management strategies employed by settlers were the subject of a special survey in Kolongo. The survey approach and the findings are presented in the next section.

8.3 Settlers' Under Capitalization and Risk Management Strategies

Concurrently with the farm management study a survey focusing on risks and undercapitalization was undertaken. A primary objective was to gain understanding on the problem of underequipment and to examine risk adjustment practices of settlers faced with underequipment. A secondary objective was to capitalize on the information gathered and present in a meaningful way the origin, the facts, the process and the consequences of underequipment of some settlers.

Data Collection

A questionnaire approach and informal inverviews were combined to obtain the data on underequipment and its associated risks. First, informal discussions were held with a selected number of old settlers in different villages of the Kolongo sector. Respondents ranged in age from 50 to over 70 with an average of 30 years of seniority as settlers. The inverviews improved the researcher's understanding of the nature of undercapitalization and provided the background necessary for the design of open-ended questionnaires. The latter were pre-tested in October-November 1979 and administered between January and March 1980 to a purposive sample of 31 underequipped settlers. The selection was made through a two-stage sampling procedure described below.

In the first stage, a list of all Kolongo villages each with its equipment count was secured. All villages in which the ratio of number of oxen to plows was less than 2 were retained.[6] Three villages (Lafiala, Louta and Kayo) fell in that category. Their farming population was respectively 47, 20 and 16 families. At the second stage, respondents were selected in each of the three villages if they had (1) no work oxen, (2) one work ox, (3) no plow and/or no harrow, and

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[6]This approach was suggested by the Office authorities in Kolongo. Villages in which the number of oxen was less than twice the number of plows were likely to inhabit the majority of underequipped settlers. It takes two oxen to trail a plow or a harrow. Settlers with one or no oxen are in a much critical position than those with no plows or harrows. Also a plow is considered more important than a harrow.

(4) any combination of the above criteria. A cross-tabulation of frequency counts within the sample is shown in Table 8-2. Many respondents had to be visited twice or three times for a consistency check.

Results and Interpretation

Repayment of Equipment Credit, Salvage and/or Loss of Equipment

Sixty-three percent of respondents acknowledged they were able to repay the initial equipment credit in the required 3 year period. Of those who receive subsequent equipment credits, more than half were able to repay the loan in a timely manner. Poverty (in the general sense of the word) and low yields were two main reasons given by those (39 percent) who failed to repay the first loan in exactly three installments.

Twenty-two percent of the respondents acknowledged selling draft animals and/or implements in the past at least once. The decision to sell equipment was prompted by the need (1) to meet consumption expenditures, (2) to replace worn out or obsolete implements, (3) to rid the stock of diseased animals or animals at the end of career, (4) to generate cash necessary for repayment of loans (to the Office or to other colonists) falling due at that period. Oxen were the most frequently sold, followed by donkeys and carts. Plows and harrows were the least transacted. One out of 5 underequipped settlers who resorted to the sale of part of equipment was not able to replace it. Settlers commonly invoked poverty as the main reason for the failure to replace salvaged or sold equipment.

Causes of loss of equipment are death or theft of draft animals, theft or abandonment of obsolete implements. Fifty-six percent of

TABLE 8-2. Distribution of Equipment Among Selected Underequipped Farmers[a]

	Harrows		Total
Oxen and Plows	No Harrow	1 Harrow	
No oxen, no plow	1	-	1
No oxen, 1 plow	-	3	3
1 ox, 1 plow	5	4	9
1 ox, 2 plows	4	3	7
2 oxen, 1 plow	9	-	9
2 oxen, 2 plows	2	-	2
Total	21	10	31

Source: Survey Data.

[a]Underequipped settlers are defined as those with one or no oxen, no plow, no harrow or any combination of these.

respondents acknowledged losing one or more equipment components some time in the past. Of these, 70 percent were able to replace the lost equipment partially or totally. Only two respondents had not been able to replace their animals after their first and second pairs of oxen died of natural causes.[7] Eighteen percent of underequipped settlers who had lost part of equipment reported they voluntarily abandoned aging implements (plows, harrows) for obsolesence.

Underequipped settlers with one or no oxen acknowledged they experience delays of one to 3 weeks for land preparation operations. Owners of oxen with no plows or harrows experience few days to 2 weeks of such delays. Although all respondents were aware of the negative effect on yields caused by untimely execution of critical field operations, the majority (96 percent) attributed low yields to other causes. Most often mentioned were low soil fertility, weed infestation of fields, and lack of maintenance of the irrigation works.

Risks associated with underequipment were also assessed in terms of harvest conditions.[8] Fifty-six percent of the respondents had

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[7]The question of animals' health was consequently pursued. Settlers in the sample who currently own one or two draft animals were asked to provide an assessment of their animals' state of health. Forty-five percent acknowledged that one of their oxen was in poor health conditions. The majority of animal owners indicated that animals are often diseased after the rainy season is over. All respondents recognized the necessity of vacinations but cited cash problems among major reasons for less frequent veterinary care.

[8]Crop failure or bad harvest referred to whether or not the settler was able to pay the land fee for a particular crop season over the past 5 years. A good harvest was defined as one that permitted the farmer to pay the land fee and a large portion of the credit for seasonal inputs.

experienced a crop failure in one out of 5 recent years, which they mainly attributed to considerable delays in farm operations as a result of their being underequipped. Seventy percent acknowledged they had a bad harvest once over the last 5 crop seasons. This leaves 30 percent in the sample with a good harvest in each of the last 5 years.

In sum, the majority of respondents (63 percent) acknowledged they were able to repay their first equipment loan in the required 3 year schedule. However with yield declining or at best remaining stable but at a lower level than elsewhere, farm net incomes for many decline. Nearly one-fifth of underequipped settlers found it difficult to replenish their stock of equipment. This increases production risks. The decision to sell part of their equipment is sometimes prompted by the need to meet urgent consumption requirements or to repay loans falling due at that period.

Risk Management Strategies

Some answers to questions raised above provided an opportunity to examine more thoroughly the principal management practices that under-equipped settlers use to accommodate risk and to insure survival and maintenance of their productive capacity. Risk aversion per se was accepted a priori.[9] As Young et al. [1979] report:

> ". . . recognizing the proximity of many developing country farmers to the margin of subsistence, and the absence of institutional provisions to protect individuals from unfortunate economic outcomes, we think it is generally reasonable to assume risk aversion a priori in such settings."

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[9] However a question was asked to all selected settlers in order to assess the percentage of farmers who could be considered as risk takers. Two mutually exclusive alternatives were presented in the question: a high risky choice with a higher pay-off and a less risky alternative with a lower but certain pay-off. All but 6 percent of respondents chose the second (certain) alternative.

Early informal discussions with the elderly led to the identification of 8 most commonly used strategies by underequipped settlers. Respondents in the sample were then asked to list those strategies they had once resorted to, are currently using or would wish to use to accommodate risks and/or to cope with the consequences of underequipment. The results are compiled in Table 8-3 which depicts the proportion of respondents who acknowledged a particular management strategy.

All respondents in the sample had resorted to or mentioned contract and/or community work involving the use of missing equipment. Contract work required the payment of a minimum of 10,000 MF for the use of oxen in land preparation. Community work (or informal cooperation) is a situation where an underequipped settler works for the equipment owner who in turn rents out his equipment at no or low service charge. Informal cooperation is often interchanged among settlers with kinship ties. However 40 percent of respondents acknowledged interchanging work with friends or neighbors. Contract and community work were the most common practice. But they usually result in long delays and untimely execution of critical field operations. Low yields and subsequent income transfers increase the level of indebtedness of underequipped settlers.

Search for part-time employment, stock raising of young steers and purchase of used farm implements were also commonly mentioned by respondents. Off-farm jobs however are rare in the area and replenishment of capital stock is constrained by cash shortages.

Forty-three percent of the respondents expressed the willingness to obtain another credit for farm equipment from the Office. This

TABLE 8-3. Risk Management Strategies of Underequipped Settlers in Kolongo (O.N.)

Reported Strategies	Percentage of Respondents		
	Yes	No	Undecided
1. Contract and/or community work with others	100	0	-
2. Search for part-time off-farm job	74	26	-
3. Purchase and/or raising of young steers and used implements for stock replenishment	70	30	-
4. Application for new equipment credit from the O.N.	43	57	-
5. Engaging in profitable non-agricultural activities	35	64	-
6. Adjusting (reduction) of cropped area to conform with actual level of equipment endowment	30	70	-
7. Clandestine sale of part of harvest to private traders to exact higher price	22	77	1
8. Decision to terminate settlement contract and leave the O.N.	1	98	1
9. Others	-	26	74

Source: Survey Data.

suggests that past experiences and the difficulty to comply with the Office 3-year repayment schedule make this strategy another risky alternative in the eyes of many underequipped settlers.

A low proportion (35 percent) of respondents cited involvement in profitable non-agricultural activities such as trade, blacksmithing, tailoring as viable risk management strategies. However this low percentage can be attributed also to lack of such profitable opportunities in Kolongo in the first place. Seventy percent of underequipped settlers in the sample rejected reducing the cropped area to conform with their current level of equipment endowment as a management strategy. This outcome was expected in a zone where yields are low and settlers perceive large holdings as a guarantee for a large rice output i.e., a higher return to labor.

Channeling a part of their harvest into parallel markets as a strategy was open to bias. However 22 percent of the respondents acknowledged they certainly would resort to this practice if given the opportunity. Settlers were nearly unanimous on the alternative to terminate the settlement contract on their own will as being an unwise move. In practice however, the most underequipped who usually are also the most indebted farmers flee from the settlement to avoid court action.

In sum, perceived and real consequences of underequipment shape the underequipped settler's overall risk management strategy.

8.4 Settlers' Investment Decisions and Repletion of Farm Equipment: Application of the Decision Tree Model

The multiperiod budget in Table 8-1 indicated that NPV is negative for farmers who receive equipment credit in areas where the average net yield is 1.0 mt or less. The survey data in the preceding section has shown that farmers use preemptive and reactive measures to accommodate risk arising from underequipment. The two analyses however do not show the sequence of events and the time frame of individual choices by settlers which lead to and/or maintain the "vicious circle" of underequipment and indebtedness.

In this section a schematic representation of the settlers' decision to invest in, disinvest or replenish their equipment asset is discussed from looking at Figure 8. The diagram is based on a decision tree model [Hardaker, 1969; Singh, 1979; Gladwin, 1976 and 1979; Walker, 1980]. The model assumes that farmers do not make complex calculations of the overall utility of alternatives in this decision making process. Rather they choose among discrete features or aspects by ordering these alternatives. From this perspective a "good" decision is one that is consistent with the assembled evidence and the true beliefs and preferences of the farmer at the time he must make the decision [Singh, 1979].

The model representing the sequence of decision criteria used by settlers to invest in or disinvest in farm equipment is shown in Figure 8. Although the diagram is an <u>ex-post facto</u>, it elicits objective circumstances and implies values and beliefs upon which settlers have based their decisions in the past. The tree is made up of <u>events</u> (E_{ij}) over which the settler exerts little or no control, and <u>acts</u> (A_{ij}) willingly undertaken as discrete decisions by farmers; (events and acts in Figure 8 are depicted by rectangular and triangular boxes, respectively). For instance, receiving the first credit for equipment upon installation in the O.N. is considered an event. Occurrence of a particular level of yield is also an event. This is because yields

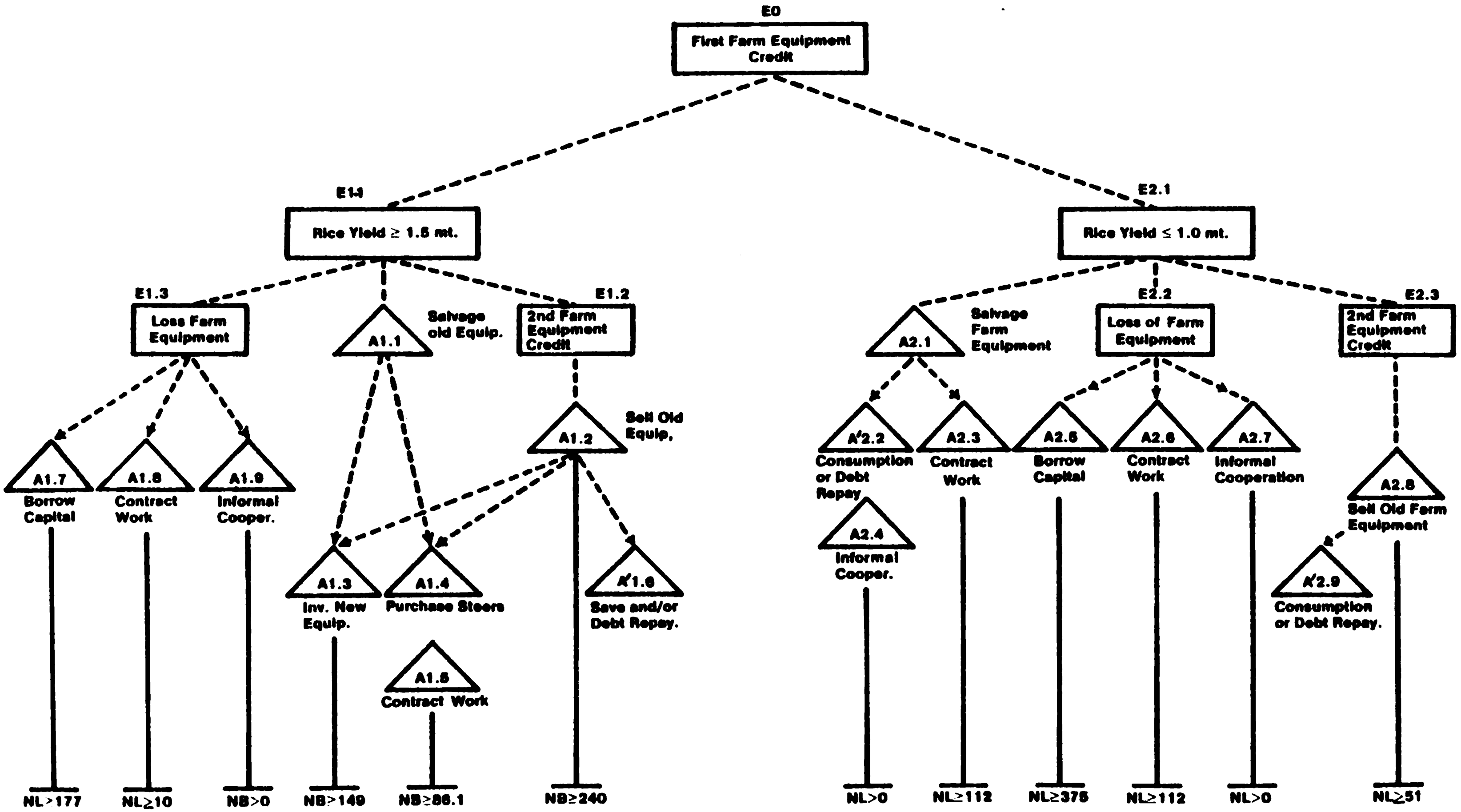

Figure 8 Decision Tree Model: Investment and Disinvestment in Farm Equipment

Note: NB and NL are in thousand MF.

cannot be determined with certainty once planting decisions have been made. Selling equipment is considered to be an act on the ground that the settler's decision is based on assembled evidences and his preferences. In general events occur and acts are undertaken. In Figure 8 acts not related to production decisions are denoted as A'_{ij}. The model's pay-offs shown at the bottom of the diagram are given in terms of net benefit (NB) or net loss (NL) directly derived from Table 8-1. Where these magnitudes could not be determined, NB or NL is simply shown to be less or greater than zero.

Event E occurs in year 0 as each settler received his first equipment credit. The credit is valued at 273,000 MF at current prices. If the average net yield remains at a minimum of 1.5 mt per hectare over some years (E1.1) the settler can either undertake act A1.1 or react to the occurrence of events E1.2 or E1.3. Act A1.1 is assumed to take place in or about year 7. The settler would need to salvage the old set of equipment. In particular oxen ending their career have to be salvaged, often at a price equal to their initial purchase price, thus taking account of appreciation of animals. The revenue from salvage of old equipment can be used to purchase a new set of equipment (A1.3). Sometimes the proceeds are not large enough and the settler would rather invest in young steers to be raised and trained on farm (A1.4). Act A1.4 leads necessarily to contract work if the settler is to undertake production activities. The sequence E1.1-A1.1-A1.3 has a pay-off of a minimum of 149,000 MF in NB as shown in Table 8-1 for year 7. Contract work or renting of equipment is charged a minimum of 10,000 MF. Thus the pay-off under the alternative sequence E1.1-A1.1-A1.4 would amount to a minimum NB of 86,100 MF (i.e., 96,100 minus 10,000).

Should the settler receive a second equipment credit (E1.2) in or around year 7 he had the opportunity to sell his old set (A1.2) and use the revenues for saving and/or repayment of debts falling due in that period (A'1.6). He can also use those revenues towards the purchase of new or used farm implements, young steers or trained animals. The pay-off of the second equipment credit would be increased to 240,000 MF or NB in year 7 through year 10.

Event E1.3 or loss of farm equipment can also occur as indicated by the survey data. Three possible acts can be undertaken by the settler. He can borrow capital for the purchase of equipment in informal markets (A1.7) in which case the pay-off would be a net loss (NL) of at least 177,000 MF (derived from Table 8-1) in year 7. Contract work (A1.8) (or renting) would result in NL of 10,000 MF at minimum and informal cooperation (A1.9) leads to untimely execution of critical field operations which may result in financial loss (NL > 0).

If the yield stays below 1.0 mt over some years, this event (E2.1) leads to one action choice (A2.1) or two possible events (E2.2 or E2.3). As shown under event E1.1 above, the settler can choose to salvage his equipment in year 7 at the latest for the same reason referred to above. Because of low yields, most settlers would use the proceeds from sale of equipment (A2.1) to increase consumption or repay debts falling due in that period. To engage in production following acts A2.1 and A'2.2 the settler would resort to informal cooperation with relatives or friends, or of necessity rent equipment (A2.3), using part of revenues from salvaging of equipment. The pay-off under the sequence E2.1-A2.1-A2.3 is a minimum NL of 112,000 MF (102,000 MF as in Table 8-1 plus a minimum of 10,000 MF for rental of equipment).

Should the settler lose his equipment (E2), capital borrowing (A2.5), contract work (A2.6) or informal cooperation (A2.7) are three possible acts he can undertake. The pay-offs are in terms of minimum NL of 375,000 and 112,000 MF, respectively for A2.5 and A2.6. However NL can be reduced to a minimum of 50,100 MF[10] should the settler receive a second credit for equipment. In all cases of contract work or informal cooperation, one has to take into account the negative impact on NB or increases in NL as a result of delays in the execution of critical field operations.

In summary, application of the decision tree model for two discrete yield situations in the O.N. settlement indicates more opportunities for financial losses than benefits (there are more NL ≥ 0 than NB ≥ 0 in the pay-offs of Figure 8). Net losses can occur even in zones where rice yields are above 1.5 mt per hectare if the settler loses his equipment and is not eligible for another credit. There is no single sequence of acts and events for farmers in low yield zones (of less than 1.0 mt per hectare) which would allow them to make a net benefit after they receive the first equipment credit. Financial losses however can be reduced through a second equipment credit and even more so if (1) the repayment schedule is extended beyond the existing three year deadline, and (2) the farmer uses the proceeds from salvaging old equipment to invest in young steers and buy additional implements. This approach would provide some continuity in the ownership of farm equipment and extraction of services from them. Farmers' indebtedness

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[10]Net revenue of 40,900 MF in year 7 less annual loan repayment of 91,000 MF (see Table 8-1).

develops over the years as a consequence of low yields, the shortness of the repayment time schedule for the medium term equipment credit and the failure to meet short-term financial obligations for other services rendered to them by the enterprise.

8.5 Development of Settlers' Indebtedness

By providing new settlers with an initial medium term credit for farm equipment, the Office management wants to avoid cash flow problems which would prevent the settlers from utilizing the costly investment at their disposal. However.as developed areas vary greatly in their yield potential, the three year repayment schedule for equipment loan and the uniformity of the land fee across the settlement, make it difficult for settlers in low yield zones (such as Kolongo) to meet their financial obligations and repay all loans falling due each year.

Table 8-4 illustrates the beginning of farmers' financial obligations to the O.N. in year 2 or year 3 after installation. Except for the farmer who can realize a net yield of 2.0 mt per hectare, the value of net output after deducting the value of consumption does not cover the sum of short-term loans and direct production charges. With most farmers in the 1.0 to 2.0 mt yield range, it is possible to expect initial debts in the range of 30,000 MF to 230,000 MF per year as shown in Table 8-4.

Development of settlers' indebtedness at the Office is depicted in Table 8-5 for the last 9 years. Debts (D) are shown by sector; in each year the value denoted as D represents the sum of short-term debts for seasonal inputs and medium-term debts (on farm equipment, foodstuffs,

TABLE 8-4. Illustration of Financial Obligations for a Representative Farmer (7.5 HA) at Different Levels of Yields (MF)

Item	Yield (mt/ha) 2.0	1.5	1.0
Short-Term Credit on Seasonal Inputs			
fertilizer[a]	57,000	57,000	57,000
seeds[b]	63,000	63,000	63,000
Production Charges			
land fee	180,000	180,000	180,000
threshing cost	108,000	81,000	54,000
Loan Repayment			
on equipment[c]	91,000	91,000	91,000
on food allowances[d]	60,000	60,000	60,000
Total Financial Charges	559,000	532,000	505,300
Net Value of Output After Consumption[e]	720,000	495,000	270,000
Financial Obligations	-	37,000	235,000

Source: Derived from Table 8-1.

[a]Assumed to be applied at the average level indicated by the survey date (i.e., 40 kg. of urea/ha and 20 kg. of phosphate/ha, at 140 and 120 MF/kg., respectively).

[b]At the rate of 120 kg./ha at 70 MF per kilo.

[c]As in Table 8-1 i.e., 273,000 MF for 2 oxen, 1 plow and 1 harrow paid in three installments of 91,000 MF each.

[d]Assuming an average family of 10 members and 300 kg. per member, totaling 180,000 MF paid in three installments of 60,000 MF each.

[e]The total allowance for consumption 3,000 kg. retained from each year's output and valued at the producer price of 60 MF/kg.

etc.) all falling due in that year. C stands for payments collected during the same year.

A collection ratio is defined as the ratio of the volume of loan collected to the volume of amount due [Tapsoba, 1981]. Table 8-5 indicates that collection ratios have improved steadily over the last decade from 73 percent to a peak of 94 percent in 1977-78. They declined to 86 and 88 percent for the last crop seasons. This pattern appears to be closely associated with the trend in gross yields over the last decade (Appendix F). When Kolongo is excluded, collection ratios for the rest of sectors improved substantially while remarkably displaying the same pattern. Nearly 70 percent of the value of the debt outstanding over the entire decade originates from settlers in Kolongo. In 1976-77 the average amount of debt outstanding per family was 216,300 MF in Kolongo compared to 53,800 MF for the overall O.N. settlement.

The percentage of portofolio in arrears for the last 3 years was also examined. This measure involves a comparison of the size of the total portofolio with the portion of the portofolio which is in arrears at a given point in time. The data indicate ratios of 13, 14 and 20 percent from 1977-78 to 1977-80. As anticipated the percentage of portofolio in arrears was 48, 47 and 50 percent for the sector of Kolongo over the last 3 years.

There is no reason to go into the details of how these two repayment performance criteria should be interpreted or their implications. It can only be claimed for the period under consideration that the credit institution at the Office du Niger is working quite well given the overall performance expressed in the above ratios. After all

TABLE 8-5. Development of Settlers' Indebtedness by Sector at the Office du Niger
(in millions MF)

	1971-72		1972-73		1973-74		1974-75		1975-76		1976-77		1977-78		1978-79		1979-80	
	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C
Niono/N'Debougou[a]	295	246	246	226	297	285	436	427										
Niono									138	135	174	170	202	195	236	290	261	247
N'Debougou									305	200	365	360	422	416	425	403	466	443
Sahel[b]															118	116	143	139
Kourouma	109	102	109	101	125	115	215	205	220	209	285	271	328	313	223	189	282	247
Dogofry[c]															212	184	260	239
Molodo	75	68	108	94	124	112	175	170	163	149	171	168	217	197	227	189	276	215
Kolongo	242	112	233	107	276	136	351	183	364	175	369	157	207	166	119	84	128	94
Kokry[d]															120	75	127	85
Total O.N.	721	528	696	528	822	648	1,177	985	1,190	978	1,364	1,126	1,376	1,289	1,680	1,449	1,943	1,709
Collection Ratio (%)		73		76		79		84		82		83		94		86		88
Total Without Kolongo	479	416	463	421	546	512	826	802	826	803	995	969	1,169	1,121	1,441	1,290	1,688	1,530
Collection Ratio (%)		87		91		94		97		97		97		96		90		91
Collection Ratio for Kolongo		46		46		49		52		48		42		80		67[e]		70[e]
Debt Outstanding	174		168		175		192		211		242		89		231		234	
of which Kolongo	131		126		140		168		188		213		41		80[e]		76[e]	
other sectors combined	43		42		35		24		23		29		48		151		158	
Debt Outstanding Average per Family (1,000 MF)	51.5		49.5		47.6		46.2		48.3		53.3		18.7		47.5		46.9	
Average per Family-Kolongo (1,000 MF)									196.8		216.3		47.2		88.8[f]		84.4[f]	

Source: O.N. Bureau de Paysanant and Calculations.

[a]Prior to 1975-76 N'Debougou was a "Unit of Production" within the Niono sector; it gained a sector status in that year.

[b]The same is true for Sahel which was detached from Niono to become a separate sector.

[c]Dogofry evolved into a new sector separate from Kourouma in 1978-79.

[d]Kokry evolved into a new sector separate from Kolongo in 1978-79.

[e]The figure is the total for Kolongo and Kokry.

[f]The number of families in those years was extrapolated from the general trend.

mechanical threshing was also dictated by the Office's desire to control the harvest of the settlers and ensure its delivery. This gives the authorities an opportunity to retain part of the farmers' grain for payment of their debts. However a higher percentage of portofolio in arrears and the lower collection ratios for Kolongo are indicative of the difficulty the Office management encounters to recover short and medium-term loans advanced to settlers in that sector.

Cumulative indebtedness adds its part to the incentive to terminate the settlement contract. Data obtained from the Division de Paysannat indicate 142 cases of contract terminations in Kolongo over the 1975-77 period. Of these, 50 families resigned, 75 fled, 1 was evicted and the remaining 15 terminations were death related. For the Office as a whole during the same period resignations and flights accounted for 61 and 30 percent of causes of terminations. Eighty percent of flights originated from Kolongo.

Summary

Incoming settlers at the Office du Niger receive medium-term credit for a pair of oxen, a plow and a harrow. They also receive short-term credit for seasonal inputs. Since both credit programs are interest free, they permit settlers to obtain equity in capital stock and avoid cash flow shortages which would arise from the rental of equipment services. This chapter addressed two fundamental issues: underequipment of some settlers including its risk related problems, and farmers' indebtedness in general.

To understand the problem of underequipment and settlers' undercapitalization in general, a conceptual framework was developed. First, a multi-period budget with financing of farm equipment was prepared for an average farm in three different yield zones (2.0, 1.5 and 1.5 mt per hectare). This provided an opportunity to assess the financial returns and costs of farming over a 10 year horizon. It also led to the conclusion that the net present value of investments in rice production is negative in areas where yields are lower (1.0 mt or below). Second, data from a survey of underequipped farmers in Kolongo were analyzed with particular reference to preemptive and reactive management strategies that these settlers use to accommodate risks associated with underequipment. Among these, contract work, informal cooperation with other settlers, search for part-time job and raising of young steers were the most frequently mentioned strategies.

Third, a decision tree model using the above information was constructed in order to represent the logical sequence of objective circumstances which impact the settlers' decision to invest in farm equipment and/or replenish their capital stock after a hazard has occurred. For existing levels of yields across the settlement, the model indicates that net financial losses are more likely to occur to settlers than net financial benefits given the mix of events and farmers' own discrete decision acts.

Settlers' increased indebtedness to the Office is a direct consequence of low yields in certain zones, a uniform land fee and loan repayment schedule for farm equipment in the face of wide differences in the yield potential of developed lands across the settlement. The O.N. data on debt collection ratios and the percentage of portofolio in arrears for Kolongo lend support to the conclusion arrived at in this chapter.

CHAPTER 9

SUMMARY CONCLUSIONS, POLICY IMPLICATIONS AND AREAS FOR FUTURE RESEARCH

9.1 Summary and Conclusions

The Office du Niger (O.N.) in the Middle Basin of the Niger River in Mali is the largest irrigated rice production scheme in West Africa. Created in 1932, the O.N. is a socio-economic organization with the primary objective of settling independent farmers. Settlers are given interest free loans and a contract to grow rice and utilize the land and have access to the infrastructure, equipment and services of the O.N. The O.N. is also a public enterprise with a comprehensive jurisdiction over agricultural, administrative and commercial activities. Although the scheme was designed to bring nearly one million hectares (ha) under cultivation, only 40,000 ha of gravity irrigated land are currently cultivated. In recent years the annual production of rice (paddy) has fluctuated between 60,000 and 90,000 metric tons (mt). The farming population is approximately 5,000 families. Rice production in the O.N. is supervised by the Agricultural Service and the Bureau of Economic Affairs which organize input delivery (seeds and fertilizer) and provide extension services. Farmers pay a fee of 400 kilo (kg) of paddy per hectare for water and land utilization, and they are required to deliver the entire harvest to the O.N. management. The government of Mali has a monopoly on national and international rice trade.

Rice consumption in Mali averages only 20 kg per capita, but it is 90 kg per capita in Bamako and other urban centers. Rice consumption is the highest in the producing areas with more than 120 kg per capita in the O.N. and in the traditional rice zones of the Delta. Approximately 70 percent of official marketing of rice in Mali is derived from the output of some 5,000 farm families in the O.N. Hence, the study of rice production in the O.N. is central to the analysis of government rice policy in Mali. This study will provide guidance to policy makers, including the impact of official rice prices on producer incentives.

A program of intensification of rice production was launched in 1978 in order to rehabilitate the irrigation/drainage networks, reduce existing farm sizes from an average of 10 ha to 6 or 7 ha, and increase the adoption of improved practices. The intensification program is drawing on numerous technical studies--past and present--and the knowledge gained over nearly half a century of experience. Since no major economic study has ever been conducted at the farm level the West Africa Rice Development Association (WARDA) recommended in 1978 that socio-economic studies should be conducted in order to identify the constraints facing rice farmers. This study was undertaken to provide a detailed account of the economics of farm production in the O.N. with emphasis on rice and livestock enterprises. The objectives were to:

1. describe the socio-economic conditions of rice production in the O.N.;
2. estimate the income and expenditures of the settlers over the course of a year and compute the real cost of producing paddy in the O.N. on the basis of current level of resource utilization;

3. estimate the total quantity of labor used on farms, its seasonal distribution and allocation of labor to farm and nonfarm activities;
4. develop models of rice farming that could increase farm income using improved technologies;
5. study the economics of under-capitalization of some O.N. settlers and the related issue or risk; and
6. discuss policy recommendations.

An eighteen month survey of 152 settlers was carried out from November 1978 to April 1980 to generate the data necessary to achieve the above objectives. The survey had three components. First, a one year farm management survey of 96 farmers provided farm level economic data. The 96 farmers were stratified by size of holdings as follows: small, less than 5 ha; medium, 5 to 10 ha and large, 10 to 15 ha.[1] Farmers were interviewed twice a week from April 1979 until March 1980. Second, twenty-five settlers who participated in the pilot intensification project were investigated to provide information on their experiences with intensification. This information was used to evaluate potential improved agronomic practices. Finally, a sample of 31 settlers, purposively selected, was used to collect information on why farmers were under-capitalized, i.e. why they lacked a full package of animal traction equipment.

The farm level survey was carried out in three representative ecological zones (or <u>casiers</u>) of the O.N.: Kolodogou and Sahel zones in

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[1] Farms with more than 15 ha were excluded from the comparative analysis of the three sizes of farms, but were included in the analysis of labor allocation.

the Niono sector along the Sahel canal, and Kolongo zone along the Macina canal. Although rice is produced under a unique system of gravity irrigation throughout the scheme, the three zones were selected on the basis of expected rice yields as determined by the potential of the irrigation/drainage networks on the scheme, but also according to their location, ethnic composition, degree of weed infestation etc. Actual estimates of yields were obtained from yield plots on all fields for each of the 96 settlers in the farm management sample. The yield plots revealed that yields ranged from 0.7 to 1.2 mt per hectare in Kolongo, 1.5 to 2.5 in Kolodogou and Sahel; the overall average was 1.7 mt. These yields are lower than the often officially reported yield of 2.0 to 2.6 mt per hectare.

A conceptual framework was developed to analyze the economics of the farm as a whole. A farm was defined to include the two dominant enterprises--rice and livestock--and a group of general farm activities. In addition the income earned by family members in off-farm employment was included in the calculation of earnings of the sample farms. Off-farm activities were defined to include social activities, small scale industries, trading, vegetable production, and the cultivation of small plots of dryland crops. Off-farm activities are not supervised by the O.N.

The data analysis was facilitated by using the FAO's Farm Management Data Collection and Analysis System (FMDCAS) to generate the farm budget estimates. Linear programming (LP) and decision tree models were used in subsequent analysis of the data. The results of the farm analysis indicate that the farm gross income per man-equivalent was 100,780 MF[2] in Kolodogou and Sahel zones and 42,300 MF in Kolongo.

A series of expenses-to-income ratios was calculated to indicate the degree to which the value of total production (i.e., farm gross income) exceeds production costs in percentage terms. The results indicate that production costs were 52 percent higher than the value of output in Kolongo, while Kolodogou and Sahel settlers earned an average net farm income of 16 MF per 100 MF of gross income. In general, the ratio of total expenses to gross income (gross ratio) was shown to increase from small to large farms. The value of farm equipment was used as a proxy for farm capital in the calculation of capital turnover ratios. The results indicate that farm capital was more productive on medium sized farms (5 to 10 ha). The above differences in farm performance criteria between the two zones along the Sahel canal and the Kolongo zone are mainly attributed to lower yields in the latter zone as a result of drainage problems, low soil fertility and weed infestation.

The analysis of family earnings i.e. the sum of off-farm revenues and net farm income, revealed that off-farm revenues on small and large farms exceeded on-farm revenues in Kolodogou and Sahel zones. In Kolongo zone, off-farm revenues constitute the major source of family earnings because incomes from rice production in this zone are extremely low and often do not cover all production costs. Net cash flows during the survey year were found negative throughout the settlement, except for medium sized farms in Kolodogou and Sahel.

[2] In 1979-80 the exchange rate was $1/420-440 MF.

The analysis of labor use was carried out by stratifying farm families into three groups of up to 7 members (small families), 8 to 15 members (medium sized families) and over 15 members (large families). Within each family group, a labor force ratio was defined as the proportion of economically active male and female members to the total family size. The results indicate labor force ratios of 80, 64 and 58 percent in small, medium sized and large families. These ratios show that there are more consumption units than work units in large families relative to small families.

The analysis of the sexual division of labor revealed that adult males contributed 55 percent, adult females 27 percent and children 18 percent of the total labor in all rice production activities. Moreover, adult males contributed 80 percent and women (adult and youth) less than 10 percent of labor in preharvest activities. However women provided 56 percent of the labor for harvesting. Adult males and youth males provided 60 percent and women 40 percent of the labor in general farm activities and off-farm activities. Analysis of the total household labor use and its seasonal variation was combined with an attempt to assess the quantity of labor available by size of family. The results show that peak season demand for harvesting activities in December and January cannot be met from the labor supply of small families. Moreover, there is little underutilized labor in both medium and large sized families from November through January. These findings show that hiring outside labor will be necessary as rice production is intensified unless capital is substituted for labor.

Input-output coefficients were derived from the analysis of rice enterprises on the sample farms in order to compare performance criteria in three representative rice zones by size of farm. The data show that all divisible inputs--fertilizer, seeds and animal feeds--are used at less than recommended levels in all three zones. The analysis indicates that net incomes per hectare are 42,000 MF in Sahel, 35,000 MF in Kolodogou and -2,820 MF in the Kolongo zone. Net returns per man-day from rice production were almost 400 MF in Sahel, 300 MF in Kolodogou and -90 MF in Kolongo. The results show that actual returns from rice per man-day are substantially below what could be earned in off-farm employment. Calculation of returns to labor by size of farm indicated that medium sized farms earned an average of 350 MF per man-day, the highest of all three farm sizes. In all cases returns per man-day, in rice production are below the opportunity cost of labor of 700 MF (year-round average).

The survey revealed also that 24 percent of the sample farmers were cultivating illegal rice fields (hors-casier) within the O.N. in order to supplement their income. There is some evidence to suggest that this practice is bound to continue because it is profitable to the settlers. Possible measures to reduce the cultivation of these fields include raising of yields on legal holdings, imposing a higher land tax, or raising producer price for paddy in general.

The financial and economic (or social) cost of producing one metric ton of paddy were computed separately. The financial cost per metric ton was found to be virtually the same in the three zones at 33,200 MF because farmers--especially in Kolongo zone--used less labor and other inputs. The economic cost per metric ton of paddy, however, was 82,300 MF in Kolodogou, 103,100 MF in Sahel and 78,500 MF in Kolongo. The average economic cost was about 83,400 MF per metric ton, two and one-half times the average financial cost. The 83,400 MF per metric ton is a conservative estimate given the assumption concerning the opportunity cost of improved land and the fact that the O.N. recurrent costs were not included in the calculation. The net economic returns were positive only in Kolodogou zone.

The distribution of livestock ownership was skewed among sample farmers. Thirty-one percent of settlers in the sample had no cattle or small ruminants. Forty percent kept less than 5 livestock units (LSU). Fifteen percent owned between 5 and 10 LSU and 14 percent had more than 10 LSU. Animal husbandry practices were extremely variable across the sample with respect to both farm and family size. No labor data were collected on herding or stall fed animals entrusted to Peuhl herders outside the O.N. area. The data from farms with less than 20 LSU indicate that 80 percent of labor (34.4 man-days) was devoted to herding within the O.N. grazing perimeter. Farmers appeared to keep cattle for social prestige and as a store of wealth but they sold goats and sheep to generate cash for farm and household needs. They also consume dairy products, mutton, eggs and poultry. Home consumption of livestock products could not be estimated. The cash value of livestock products sold amounted to 6 percent (6,700 MF) of the gross value of farm output per hectare and averaged 30,660 MF per year for an average farm within the group of settlers with less than 20 LSU. Gross cash income from livestock represented only 13 percent of the value of the stock of productive animals kept on farms.

The intensification of rice production was analyzed by studying the costs and returns of introducing the following five improved production practices (or intensification techniques) under the present price of 60 MF per kilo of paddy.

IT1: use of divisible inputs at O.N. recommended rates on the basis of results achieved under the pilot intensification project.

IT2: the adoption of row-seeding.

IT3: the adoption of animal powered (mechanical) weeding.

IT4: the transplanting of rice seedlings.

IT5: a system of production involving double cropping of rice, row seeding, mechanical weeding and optimum levels of fertilization.

A one period linear programming model was constructed to evaluate the profitability and feasibility of these five practices. The results of the model indicate that double cropping is the most profitable intensification technique. Double cropping, however, requires an expanded credit system to meet the operating capital requirements. For instance, the operating capital requirements for double cropping on small farms are 175,300 MF per hectare as compared with 42,000 MF for single cropping. Moreover, even if credit were available to farmers, double cropping still requires the availability of nonfamily labor and equipment services. It appears that double cropping is only feasible on a limited scale because of the competition with the O.N. sugar plantations for labor and the absence of a class of landless laborers. The second most profitable technique is transplanting of rice (IT4). However, adequate nonfamily labor is not available in the O.N. to implement this recommended practice.

Row-seeding (IT2) and mechanical weeding (IT3) techniques also involve intensified use of fertilizer, seed, oxen feed, hired labor and farm equipment services. The results of the model indicate that techniques IT2 and IT3 are profitable, provided that the current credit program is expanded. The results also indicate that these techniques will increase both net returns per hectare of improved land and per man-day of family labor.

The model also reveals that the progressive introduction of row-seeding and mechanical weeding techniques (i.e. substitution of intensified practices for the current technique) will yield higher return to land on both medium and small farms, while small farms will generate the highest net returns to land and to labor. In all cases, large farms above 10 ha have idle land and are less profitable than small and medium farms. Across all LP runs, there is a strong indication that the O.N. should concentrate the intensification program on small and medium sized farms.

The survey revealed that under-capitalization (i.e. lack of adequate equipment) was a major problem. Although all incoming settlers receive interest free medium-term credit to secure a pair of oxen, a plow and a harrow, our survey showed that many farmers have lost equipment or sold pieces of equipment in order to overcome cash flow problems. Under-equipment of some settlers was found to be a direct consequence of low yields and the indebtedness of settlers.

9.2 Policy Implications and Recommendations

The major policy issues which need to be addressed by the Government of Mali and the O.N. are discussed below.

Government Price of Paddy, Cost of Production and Farm Incomes

The results of the study indicate that the real cost of farmers producing one kilo of paddy is at least 83 MF, at current level of resource use and if an opportunity cost of some 10,000 MF per hectare is imputed to improved land. The present official farm level price of 60 MF per kilo is generally acknowledged to be below the cost of production of 83 MF.

The average net return per man-day in rice production was found to be in the range of 300 to 400 MF, which is about one-half the off-farm wage rate of 700 MF per day for unskilled workers in the O.N. zone. The low returns in rice production explain why many farmers are heavily engaged in these off-farm activities. Since farmers can sell their rice in black markets at 90 to 95 MF per kilo this also explains why O.N. collections of paddy are falling below government expectations, despite the existance of a system of compulsory delivery of the farmer's harvest to the O.N. management, after deducting an allowance for home consumption. Moreover, since the producer price is 128 MF per kilo in Senegal and 108 MF in Niger and Upper Volta, there is a large but unquantified amount of smuggling across the borders into these neighboring markets. In recent years many studies on grain marketing in Mali based on secondary data have recommended an increase in the government farmgate price of paddy. The results of this study lend solid support to the above recommendation.

The Land Fee

Currently the O.N. charges a uniform land fee of 400 kg of paddy per hectare. This fee, which must be paid in kind at the time of harvest, represents a charge for water utilization, infrastructure maintenance, supervision and extension service. Because of obvious differences in yield potential of lands in different zones in the O.N. it is recommended that a variable land fee policy should replace the fixed land fee. In order to implement this recommendation detailed soil studies will have to be undertaken to determine fertility indices for broadly defined categories of land in the O.N. Soil studies constitute an area of research that has so far received the least attention in the

O.N. Parenthetically it should be noted that the introduction of a variable land fee would not be an innovation because in the 1930s the quantity of rice requisitioned by the O.N. from settlers was calculated on the basis of differences in rated potential of rice casiers in the settlement. In the 1930s three groups of land were distinguished on the basis of expected yields of 2.0 mt, 1.5 mt and 0.8 mt per hectare, respectively.[3]

Size of Holdings

The survey revealed that the size of farms ranged from 1 ha to over 40 ha. Consolidation of the existing infrastructure and abandonment of approximately 5,000 ha of land in Kolongo have resulted in a decline in the average farm size from 10 ha in 1975-76 to about 6 ha in 1979-80. The results from the linear programming model show that the highest returns to labor will be obtained if intensified production is organized on the basis of 3 to 7 ha holdings. This finding is consistent with the evidence in other African countries that small scale rice production is more profitable than large scale farms [Chambers and Moris, 1973; Sparling, 1981; and Diallo, 1981].

The O.N.'s proposed reduction of farm sizes to about 6 to 7 ha is justified on efficiency grounds. However, existing farms of 3 to 5 ha must be intensified. New settlers in the O.N. should be allocated a minimum of 3 ha and a maximum of 7 ha of improved land.

Rice Production Packages

The results of the LP model suggest that seeding and mechanical weeding are profitable practices and should be encouraged provided

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[3]Source of information is O.N. Bureau of Economic Affairs.

there is an expanded credit program and on-farm trials are carried out to identify the constraints--social, economic, and technical--on their adoption. Trials on farmers' fields can ensure that technological packages are formulated and refined (e.g. level of fertilization) under actual farmers' management practices. These trials should be jointly planned and carried out by an agronomist and an economist. This recommendation will require close cooperation between the Agricultural Department (Service Agricole) and the Bureau of Economic Affairs.

Input Delivery System

The intensification of rice farming in the O.N. through row seeding and mechanical weeding requires 200 to 250 kg of urea and phosphate per hectare and increased investment in farm equipment, increased demand for seasonal labor, oxen feed and equipment services. Steps must be taken to ensure the intensification program is pursued concurrently with expansion of the agricultural credit program for settlers. But the question of free credit has to be reassessed. Presently interest free credit is extended to incoming settlers for the purchase of oxen and animal traction equipment. Interest free credit is a farm subsidy which partially offsets the low official price of paddy. There is no reason, however, for the credit to remain interest free if the producer price of rice (paddy) is substantially raised--i.e. to the black market rate of 90 MF per kilo. The precise level of interest should be determined in relationship to the official price of paddy. The current interest rate was found to be nearly 20 percent in informal rural markets in the O.N. This suggests that farmers and traders will pay interest if there are profitable investment opportunities. Interest rates also should be charged for seasonal inputs such as fertilizer, because their usage will increase under intensification.

Credit for oxen in particular should be tied to an animal insurance program because the loss of animals was shown to be a real hazard. But farmers have to be informed about the additional costs involved in such a program. This point touches an issue often neglected by the O.N. management: many O.N. decisions intended to improve settlers' welfare are often taken with little attempt to get them to understand the financial implications involved. It is not surprising that settlers' suspicions about the O.N. management often revolve around the question of money, prices and settler accounts.

Special Policy Issues Related to Kolongo Farmers

Improved land in the O.N. varies greatly in yield potential, partially because of the lack of maintenance of both the main irrigation infrastructure (the task of the O.N. management) and the terminal networks (the farmers' task). The Kolongo zone in particular is infested with rhizomatous rice (Oriza longistaminata) and the irrigation installation are known to be superficial. Therefore one could make a case on efficiency grounds to invest in high yielding zones along the Sahel canal and give low priority to the Kolongo zone. This should not be interpreted to mean that Kolongo farmers are inefficient farmers. Their current low level of resource use is certainly consistent with efficiency in resource allocation, given low returns due to inadequate infrastructure. The relocation of Kolongo settlers to more productive land on the O.N. scheme appears to one alternative. But this will entail a rupture of the ethnic homogeneity which is so crucial to the survival of settlement villages as social entities.

So long as infrastructure improvement is confined to zones along the Sahel canal, as is currently done under the World Bank financed program, the Kolongo farmers will remain impoverished. Special incentives are needed in order to assist the impoverished farmers in the Kolongo sector. These incentives include (a) a lower land fee, (b) a longer repayment schedule for the animal traction equipment loan, (c) waiving of debts contracted over a long period of time and (d) provision of other incentives which will help settlers participate in the life of the scheme and identify their interests with those of the whole undertaking.

9.3 Areas for Further Research

This study has generated a data base on the economics of rice and livestock production in the O.N. There is now a need to initiate on-farm trials and farming systems research which we have mentioned above. In addition the following activities should be carried out: (a) representative households should be monitored during all phases of implementation of the intensification program; (b) studies should be carried out on farmers' perceptions of their production environment and their attitudes toward proposed innovations; (c) studies are needed on the role of women in the household economy and the impact of technological change on the allocation of male and female labor.

Since the O.N. management and the scheme members have strongly divergent assessments of settlers' well-being there is a need for a study of the socio-economic environment and its impact on the financial standing of settlers. In particular a study is needed on income distribution and income transfers among settlers with different capital endowments.

The O.N. management keeps detailed and accurate records of many aspects of the settlement scheme. A trained agricultural economist and a statistician should be attached to O.N. Bureau of Economic Affairs in order to analyze these data. Since the O.N. headquarters at Segou is presently the only place in Mali with a 24 hour supply of electricity, the use of a micro computer for data management and analysis should be seriously contemplated.

APPENDIX A

FARM MANAGEMENT DATA COLLECTION AND ANALYSIS SYSTEM

AGGREGATE FARM TABLES FOR NIONO AND KOLONGO

A1. Aggregate Farm Table for Small Sized Farms in Niono (Values in 100 MF, area in ha)

FARM ANALYSIS [illegible] SURVEY (17 OBSERV)

COUNTRY	REP. OF MALI	DATA SOURCE	RESOURCE BASE
[illegible]	[illegible]	FARM-LEVEL AGRO-ECON	FARMER AGE 43.4, SCHOOLYEARS 1.4
VILLAGE/[illegible]	N [illegible]	[illegible] SURVEY OF RICE	FAMILY: ADULTS 4.1 PERM.LABOUR 0.0 YOUTH/OLD 1.1 CHILDREN 1.6
		PRODUCTION AT THE OF	MAN-EQUIVALENTS 4.6
LOCATION	N [illegible]	RICE [illegible]	FARMLAND AREA OWNED 3.94 RENTED OUT 0.00, RENTED 0.00, MANAGED 3.94
LATITUDE	[illegible]		CROPP.PATTERN CROP(S) AREA CROP(S) AREA CROP(S) AREA
ALTITUDE, M			16 4.00
		AUTHOR	
SOIL TYPE		MULUMBA KAMUANGA	
	BROWN CLAY LOAM	YEAR OF OBSERV. 1979	
CLIMAT TYPE	SUBTROP. [illegible]		TRACTORS 0.0 DRAFT ANIMALS 2.2 CATTLE .8 GOATS/SHEEP .8

CLIMATE	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM	7 4	0	0	4	5	20	94	202	239	107	27	3	0
TEMPERATURE MEAN		[illegible]	[illegible]	[illegible]	32.1	32.7	30.3	27.5	26.4	27.0	28.5	27.3	24.4
HIGH													
LOW													
HUMIDITY [illegible]													
LABOUR INPUTS (MD)													
CROP SEEDBED PREP.	117	2	1	1	6	14	24	38	18	11	2	1	
PLANTING	3						1	1	1				
CULTIVATION	78	1			6	2	8	6	11	17	23	3	
HARVESTING	268	50	19	14	22	13	9	10	10	9	12	29	65
OTHERS	118	9	10	10	1	1	2	2	13	9	8	41	13
TOTAL	579	62	30	25	56	29	45	56	53	46	45	75	78
LIVESTOCK ACTIVIT.	24		1		1	2	6	6	5	1	1		
GENERAL ACTIVITIES	348	39	45	62	13	14	19	23	16	20	29	41	28
TOTAL FARM	951	101	76	87	50	46	70	85	73	67	74	115	106
OF WHICH: FARMER	235	23	17	23	17	14	20	16	18	18	20	23	24
FAMILY	681	75	56	64	31	28	44	65	54	47	51	90	77
P.LABOUR	1					1							
C.LABOUR	32	3	3	1	2	2	4	3	1	2	3	2	4
OTHERS	3						1		1				
OFF-FARM ACTIVITIES	201	15	14	21	16	16	21	25	20	16	9	10	18
POWER INPUT (HOURS) ANIMALS	797	14	20	6	19	93	241	233	146	17	4		5
TRACTOR													
IRRIGATION WATER													

FARM ECONOMICS	CASH	KIND	TOTAL
FARM PRODUCTION			
CROPS	3570	2	3572.36
LIVESTOCK	52	159	215.38
TOTAL	3621	155	3787.74
VARIABLE COSTS	1319	454	1840.43
GROSS MARGIN	2302	-299	1947.31
VALUE SHARECR.			
GROSS MARGIN(ADJ)	2302	-299	1947.31
OVERHEAD COSTS			
RENT			
TAXES	925		924.71
PERM.LABOUR	48		48.12
INTEREST PAID			.02
REPAIR/MAINT.			.12
OTHERS	55		54.87
TOTAL	1029		1027.83
NET FARM EARNINGS	1274	-299	919.48
OFF-FARM EARNINGS	990	104	1104.38
FAMILY EARNINGS	2264	-195	2103.85
VALUE HOMECONSU.		164	164.21
HOUSEHOLD EXPEND.	2362		2361.98
BALANCE	-97	-359	-422.34

NET WORTH STATEMENT	FARM LAND	PERM. CROPS	BUILD-INGS	TOOLS/MACHINES	DRAFT ANIMAL	PROD. ANIMAL	TOTAL OWNED	TOTAL [illegible]	NET WORTH VALUE	PERC.
OPENING VALUE			303	945	1016	548	2812	46	2766	98.4
INCREASING				14		135	179			
DECREASING						1	1	46		
DEPRECIAT.				86	140		226			
CLOSING VALUE			303	904	876	681	2764		2764	100.0

PRODUCTIVITIES	
GROSS MARGIN/UNIT AREA (CROPS)	489.59
LABOUR (MD)/UNIT AREA (CROPS)	146.83
GROSS MARGIN/MD CATTLE	48.92
GROSS MARGIN/MD (CROPS)	3.33
GROSS MARGIN/MD (CATTLE)	1.66
GROSS MARGIN/MD (FARM)	422.34

A2. Aggregate Farm Table for Medium Sized Farms in Niono (Values in 100 MF, area in ha)

FARM ANALYSIS SURVEY (18 OBSERV)

COUNTRY	REP. OF MALI	DATA SOURCE	RESOURCE BASE
PROVINCE/REGION	SEGOU 4TH REGION	FARM-LEVEL AGRO-ECON	FARMER AGE 49.7, SCHOOLYEARS .3
VILLAGE/SETTLEMENT	N.D.N. CONCESSION	OMIC SURVEY OF RICE	FAMILY: ADULTS 5.9 PERM.LABOUR 0.0 YOUTH/OLD 1.6 CHILDREN 3.1
		PRODUCTION AT THE OF	MAN-EQUIVALENTS 6.7
LONGITUDE	N 15	FICE DU	FARMLAND AREA OWNED 7.14 RENTED OUT 0.00, RENTED 0.00, MANAGED 7.14
LATITUDE	W 7		CROPP.PATTERN CROP(S) AREA CROP(S) AREA CROP(S) AREA
ALTITUDE, M	0		14 7.66
		AUTHOR	
SOIL TYPE		MELUMBA KAMUANGA	
	BROWN CLAY LOAM	YEAR OF OBSERV. 1979	
CLIMATE TYPE	SUDANESE-SAHEL		TRACTORS 0.0 DRAFT ANIMALS 5.2 CATTLE 3.3 GOATS/SHEEP .7

CLIMATE		TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM		774	0	0	3	9	20	94	292	239	107	27	3	0
TEMPERATURE	MEAN		2.4	24.6	29.7	32.1	32.7	30.3	27.5	26.4	27.0	29.5	27.3	24.4
	HIGH													
	LOW													
HUMIDITY	PERC													
LABOUR INPUTS (MD)														
CROPS: LAND.PREP.		221		5	8	6	31	16	54	47	9	2	1	1
PLANTING		6						4	2					
CULTIVATION		177	3	3	3	9	4	8	15	19	43	64	6	
HARVESTING		340	68	53	28	22	14	14	13	10	11	8	30	68
OTHERS		146	15	17	21	1	3	5	13	14	7	8	34	8
TOTAL		892	86	79	60	38	51	88	96	92	71	82	72	78
LIVESTOCK ACTIVIT.		36	2	3	2	1	4	8	10	5	1			
OTHER FARM ACTIVITIES		513	69	73	99	21	25	25	32	23	4	30	57	35
TOTAL FARM		1441	157	155	161	60	79	121	138	120	97	112	128	112
OF WHICH:	FARMER	271	29	24	31	15	16	25	33	17	18	22	23	18
	FAMILY	1054	115	112	125	28	53	85	94	94	74	88	39	87
	P.LABOUR													
	S.LABOUR	166	13	19	6	17	8	8	10	9	4	2	4	7
	OTHERS	10					2	2	2				3	1
OFF-FARM ACTIVITIES		207	10	11	17	15	15	19	21	24	23	20	22	10
POWER INPUT (HOURS)														
	ANIMALS	1257	2	24	25	59	194	367	237	317	26	2		4
	TRACTORS													
IRRIGATION WATER														

FARM ECONOMICS	CASH	KIND	TOTAL
FARM PRODUCTION			
CROPS	8333	2	8335.71
LIVESTOCK	206	304	510.21
TOTAL	8539	306	8845.91
VARIABLE COSTS	3139	913	4045.98
GROSS MARGIN	5400	-606	4799.93
VALUE SHARECR.		-53	-53.66
GROSS MARGIN (AD)	5400	-453	4857.59
OVERHEAD COSTS			
RENT			
TAXES	1759		1759.33
PERM.LABOUR	51		50.56
INTEREST PAID	11		11.47
REPAIR/MAINT.	1		1.11
OTHERS	134		134.19
TOTAL	1957		1956.66
NET FARM EARNINGS	3444	-453	2896.93
OFF/FARM EARNINGS	1005	102	1160.81
FAMILY EARNINGS	4448	-350	4057.74
VALUE HOMECONSUM		326	326.26
HOUSEHOLD EXPEND	3439		3439.44
BALANCE	1009	-677	292.04

NET WORTH STATEMENT	FARM LAND	PERM. CROPS	IRRI-GATION	TOOLS/MACHINES	DRAFT ANIMAL	PROD. ANIMAL	TOTAL OWNED	TOTAL DEBT	NET WORTH VALUE	PERC.
OPENING VALUES	5556		200	1119	2139	1302	10319	209	10106	98.0
INCREASE						279	280			
DECREASE					166	28	183	203		
DEPRECIAT.				126	267		393			
CLOSING VALUES	5556		200	993	1717	1551	10019		10019	100.0

PRODUCTIVITIES	
GROSS MARGIN/UNIT AREA (CROPS)	688.04
LABOUR (MD)/UNIT AREA (CROPS)	124.57
GROSS MARGIN/MD CATTLE	21.91
GROSS MARGIN/MD (CROPS)	5.51
GROSS MARGIN/MD (CATTLE)	2.02
GROSS MARGIN/MD (FARM)	715.10

A3. Aggregate Farm Table for Large Sized Farms in Niono (Values in 100 MF, area in ha)

SURVEY (12 OBSERV)

COUNTRY	REP. OF MALI	DATA SOURCE	RESOURCE BASE
PROVINCE/REGION	SEGOU 4TH REGI	FARM-LEVEL AGRO-ECON	FARMER AGE [illegible] SCHOOLYEARS .[illegible]
VILLAGE/SUB-REG.	N.O.[illegible]. CONCESSION	[illegible]IC SURVEY OF RICE	FAMILY: ADULTS 11.[illegible] PERM.LABOUR 0.0 YOUTH/OLD 5.5 CHILDREN 6.[illegible]
		PRODUCTION AT THE OF	MAN-EQUIVALENTS 13.4
LONGITUDE	[illegible] 15	FILE OH	FARMLAND AREA OWNED 12.6[illegible] RENTED OUT 0.00, RENTED 0.00, MANAGED 12.63
LATITUDE	[illegible]		CROPP.PATTERN CROP(S) AREA CROP(S) AREA CROP(S) AREA
ALTITUDE,M	[illegible]		1[illegible] 12.6[illegible]
		AUTHOR	
SOIL TYPE		M[illegible]LUMBA KAMUANGA	
	BROWN CLAY LOAM	YEAR OF OBSERV. 1979	
CLIMAT. TYPE	SUBTROP.-SAV.		TRACTORS 0.0 DRAFT ANIMALS [illegible].1 CATTLE 14.1 GOATS/SHEEP 3.5

CLIMATE		TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM		[illegible]	0	0	[illegible]	[illegible]	20	94	202	25[illegible]	1[illegible]7	27	[illegible]	0
TEMPERATURE	MEAN		2[illegible].4	2[illegible].6	2[illegible].7	32.1	32.7	30.3	27.5	26.4	27.0	2[illegible].5	27.5	24.4
	HIGH													
	LOW													
HUMIDITY	PERC													
LABOUR INPUTS (MD)														
CROP:LAND PREP.		367	2		10	5	76	96	90	68	16	3		1
PLANTING		9						6	2	1				
CULTIVATION		302	2	4	2	5	4	3	19	31	90	100	48	2
HARVESTING		573	118	45	49	44	22	21	23	14	26	18	67	127
OTHERS		202	19	18	23	1	4	10	4	8	11	8	74	22
TOTAL		1454	141	67	84	55	106	136	138	122	143	128	181	152
LIVESTOCK ACTIVIT.		78		2	2	22	5	13	19	9	2	1	2	1
GEN.FARM ACTIVITIES		749	126	76	140	27	48	30	54	19	43	56	72	52
TOTAL FARM		2261	266	144	226	105	157	187	211	151	188	185	255	286
OF WHICH:	FARMER	966	25	25	16	14	20	24	20	27	29	24	25	17
	FAMILY	1832	216	113	176	57	119	154	187	115	157	156	219	162
	P.LABOUR	12					3			6		3		
	C.LABOUR	164	25	6	34	34	12	6	5	2	2	3	10	27
	OTHERS	7					2	4					1	1
OFF-FARM ACTIVITIES		403	15	24	32	16	68	45	48	31	29	29	57	9
POWER INPUT (HOURS)														
ANIMALS		2253	34	20	28	15	458	687	524	457	21	8		2
TRACTORS														
IRRIGATION WATER														

FARM ECONOMICS	CASH	KIND	TOTAL
FARM PRODUCTION			
CROPS	11720	[illegible]	11872.01
LIVESTOCK	[illegible]47	375	722.41
TOTAL	12067	[illegible]	12594.42
VARIABLE COSTS	5[illegible]70	1438	6764.01
GROSS MARGIN	[illegible]97	-[illegible]94	5830.41
VALUE SPAREEQ.			
GROSS MARGIN(ADJ)	[illegible]97	-[illegible]	5830.41
OVERHEAD COSTS			
RENT	[illegible]		2[illegible].0[illegible]
TAXES	[illegible]955		295[illegible].00
PERM.LABOUR	134		134.3[illegible]
INTEREST PAID			.03
REPAIR/MAINT.			
OTHERS	616		616.04
TOTAL	[illegible]735		37[illegible]4.5[illegible]
NET FARM EARNING	[illegible]163	-[illegible]94	205[illegible].[illegible]
OFF/FARM EARNINGS	[illegible]90	1[illegible]	2525.21
FAMILY EARNINGS	5[illegible]	-[illegible]05	4621.1[illegible]
VALUE HOMECONSUMP.		628	627.97
HOUSEHOLD EXPENS.	4430		4430.16
BALANCE	[illegible]62	-1433	-4[illegible]7.04

NET WORTH STATUS	FARM LAND	S.C. STOCK	FERTI-LIZERS	TOOLS/MACHINERY	DRAFT ANIMAL	PROD. ANIMAL	TOTAL OUTPUT	TOTAL FEED	NET WORTH VALUE	PERC.
OPENING VALUES			250	1421	3956	10580	11157	74	16082	99.5
PURCHASES				147		273	419			
SALES					147		147	74		
DEPRECIAT.				182	640		822			
CLOSING VALUES			[illegible]	1386	3170	10802	15608		15608	100.0

PRODUCTIVITIES	
GROSS MARGIN/UNIT AREA (CROPS)	524.07
LABOUR (MD)/UNIT AREA (CROPS)	115.1[illegible]
GROSS MARGIN/MD CATTLE	-54.2[illegible]
GROSS MARGIN/MD (CROPS)	4.55
GROSS MARGIN/MD (CATTLE)	-6.1[illegible]
GROSS MARGIN/ME (FARM)	435.8[illegible]

A4. Aggregate Farm Table for Small Sized Farms in Kolongo (Values in 100 MF, area in ha)

FARM ANALYSIS PROJECT 222 SURVEY (10 OBSERV)

COUNTRY	REP OF MALI	DATA SOURCE	RESOURCE BASE
PROVINCE/REGION	SEGOU 4TH REGIO	FARM-LEVEL AGRO-ECON	FARMER AGE 55.2, SCHOOLYEARS .6
VILLAGE/SUBREG.	N O.N. CONCESSIO	OMIC SURVEY OF RICE PRODUCTION AT THE OF FICE DU	FAMILY ADULTS 4.1 PERM.LABOUR 0.0 YOUTH/OLD 1.1 CHILDREN 1.8
			MAN-EQUIVALENTS 4.7
LONGITUDE	N 13		FARMLAND AREA OWNED 3.51 RENTED OUT 0.00, RENTED 0.00, MANAGED 3.51
LATITUDE	W 7		CROPP.PATTERN CROP(S) 16 AREA 3.51 CROP(S) AREA CROP(S) AREA
ALTITUDE, M	0	AUTHOR MULUMBA KAMUANGA	
SOIL TYPE	BROWN CLAY LOAM	YEAR OF OBSERV. 1973	

CLIMATE TYPE SUBTROP-SAHE — TRACTORS 0.0 DRAFT ANIMALS 1.9 CATTLE 1.5 GOATS/SHEEP 1.2

CLIMATE	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM	724	0	0	3	3	28	34	202	239	127	27	3	0
TEMPERATURE MEAN		2.4	26.6	29.7	32.1	32.7	30.3	27.5	26.4	27.0	28.5	27.3	24.4
HIGH													
LOW													
HUMIDITY PERC													
LABOUR INPUTS (MD)													
CROPS: LAND.PREP.	92			1	4	21	30	24	9	3			
PLANTING	16						13	2					
CULTIVATION	45				2	1	1	5	15	11	7	2	
HARVESTING	190	35	13	13	12	11	21	15	10	9	6	14	29
OTHERS	31	11	3	1			2	3			2	5	2
TOTAL	374	46	16	15	18	33	59	50	35	23	17	21	32
LIVESTOCK ACTIVIT.	15				5	5	1	2			1	1	1
GEN.FARM ACTIVITIES	55	6	3	2	9	6	2	4	4	4	4	3	8
TOTAL FARM	445	52	19	17	31	44	71	56	39	28	22	25	40
(OF WHICH: FARMER	125	17	3	1	12	15	10	12	11	10	3	5	12
FAMILY	317	35	16	16	19	29	53	43	28	18	14	18	29
P.LABOUR													
S.LABOUR	3		1					2					
OTHERS)													
OFF-FARM ACTIVITIES	121	5	10	7	13	5	14	12	13	14	17	3	3
POWER INPUT (HOURS)													
-----------ANIMALS	781	297	2	4	23	113	159	134	52				6
TRACTORS													
IRRIGATION WATER													

FARM ECONOMICS	CASH	KIND	TOTAL
FARM PRODUCTION			
CROPS	1434	78	1518.96
LIVESTOCK	156	29	187.78
TOTAL	1591	99	1706.75
VARIABLE COSTS	624	248	871.96
GROSS MARGIN	966	-148	834.78
VALUE SHARECR.			
GROSS MARGIN(AD)	966	-148	834.78
OVERHEAD COSTS			
RENT			.07
TAXES	780		779.60
PERM.LABOUR	19		18.67
INTEREST PAID			01
REPAIRS/MAINT.			
OTHERS	96		95.51
TOTAL	894		893.85
NET FARM EARNING	72	-148	-59.07
OFF/FARM EARNINGS	544	54	612.63
FAMILY EARNINGS	517	-94	553.56
VALUE HOMECONSU		51	50.67
HOUSEHOLD EXPEND	679		669.94
BALANCE	-53	-144	-167.95

NET WORTH STATMT	FARM LAND	PERM. CROPS	BUILDINGS	TOOLS/MACHINE	DRAFT ANIMA.	PROD. ANIMAL	TOTAL OWNED	TOTAL OWED	NET WORTH VALUE	PERC.
OPENING VALUES			167	622	919	700	2407	35	2372	98.5
INCOMING						18	18			
OUTGOING				7	40		47	35		
DEPRECIAT.				47	125		172			
ENDING VALUES			167	569	754	717	2206		2206	100.0

PRODUCTIVITIES	
GROSS MARGIN/UNIT AREA (CROPS)	211.37
LABOUR (MD) /UNIT AREA (CROPS)	106.74
GROSS MARGIN/MD CATTLE	68.71
GROSS MARGIN/MD (CROPS)	1.98
GROSS MARGIN/MD (CATTLE)	6.94
GROSS MARGIN/MD (FARM)	177.47

A5. Aggregate Farm Table for Medium Sized Farms in Kolongo (Values in 100 MF, area in ha)

FAFM ANALYSIS — [illegible]

COUNTRY	REP OF MALI	DATA SOURCE	RESOURCE BASE
PROVINCE/REGION	SEGOU 4TH REGIO	FARM-LEVEL AGRO-ECON	FARMER AGE 54.0, SCHOOLYEARS 1.4
VILLAGE/SUBREG.	N O.N. CONCESSIO	OMIC SURVEY OF RICE PRODUCTION AT THE OF FICE DU	FAMILY: ADULTS 5.4 PERM.LABOUR 0.0 YOUTH/OLD 1.5 CHILDREN 2.9
			MAN-EQUIVALENTS 5.1
LONGITUDE	W 13		FARMLAND AREA OWNED 7.05 RENTED OUT 0.00, RENTED 0.00, MANAGED 7.05
LATITUDE	N 7		CROPP.PATTERN CROP(S) 15 AREA 7.05 CROP(S) AREA CROP(S) AREA
ALTITUDE,M	0	AUTHOR MULUMBA KAMUANGA	
SOIL TYPE	BROWN CLAY LOAM	YEAR OF OBSERV. 1979	

CLIMATE TYPE SUBTROP-SAHE — TRACTORS 0.0 DRAFT ANIMALS 2.4 CATTLE 1.3 GOATS/SHEEP 0.9

CLIMATE	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM	724	0	0	3	9	20	34	282	233	127	27	3	0
TEMPERATURE MEAN		2.4	26.6	29.7	32.1	32.7	30.3	27.5	26.4	27.0	28.5	27.3	24.4
HIGH													
LOW													
HUMIDITY PERC													
LABOUR INPUTS (MD)													
CROPS:LAND.PREP.	102			2	5	24	35	26	7	3			
PLANTING	9						5	3	1				
CULTIVATION	67				1	3	1	5	19	25	12		
HARVESTING	258	35	18	15	11	10	14	14	13	16	11	34	66
OTHERS	27	6	1			1	1	2	1		2	8	4
TOTAL	461	40	19	17	18	38	56	58	41	45	25	42	70
LIVESTOCK ACTIVIT.	5				1	2	1	1					
GEN.FARM ACTIVITIES	55	2	4	3	13	3	2	6	4	3	3	1	5
TOTAL FARM	522	42	24	20	32	48	59	56	45	48	23	44	76
(OF WHICH) FARMER	91	4	2	1	7	12	9	10	9	12	5	7	13
FAMILY	429	34	22	13	24	36	50	47	36	36	22	36	62
P.LABOUR													
S.LABOUR	2				1							1	1
OTHERS)													
OFF-FARM ACTIVITIES	132	7	13	3	15	10	12	13	21	16	9	3	4
POWER INPUT (HOURS)													
ANIMALS	647	13	2	7	20	137	224	190	42	2			10
TRACTORS													
IRRIGATION WATER													

FARM ECONOMICS	CASH	KIND	TOTAL
FARM PRODUCTION			
CROPS	2425	584	3008.44
LIVESTOCK	61	55	115.33
TOTAL	2485	638	3123.78
VARIABLE COSTS	1084	589	1733.02
GROSS MARGIN	1402	49	1390.76
VALUE SHARECR.			
GROSS MARGIN(AD)	1402	49	1390.76
OVERHEAD COSTS			
RENT			
TAXES	1648		1648.29
PERM.LABOUR	31		30.71
INTEREST PAID			.21
REPAIR/MAINT.			
OTHERS	107		107.01
TOTAL	1786		1786.22
NET FARM EARNING	-384	49	-395.46
OFF/FARM EARNINGS	370	71	450.00
FAMILY EARNINGS	-14	120	54.54
VALUE HOMECONSU		118	118.11
HOUSEHOLD EXPEND	1029		1028.65
BALANCE	-1043	2	-1092.22

NET WORTH STATMT	FARM LAND	PERM. CROPS	BUIL-DINGS	TOOLS/MACHINE	DRAFT ANIMA.	PROD. ANIMAL	TOTAL OWNED	TOTAL OWED	NET WORTH VALUE	PERC.
OPENING VALUES			157	844	1214	512	2727	33	52690	99.9
INCOMING				90		103	183			
OUTGOING				43	86		129	30		
DEPRECIAT.				113	230		343			
ENDING VALUES			157	768	899	614	2438		32438	100.0

PRODUCTIVITIES	
GROSS MARGIN/UNIT AREA (CROPS)	206.14
LABOUR (MD) /UNIT AREA (CROPS)	65.46
GROSS MARGIN/NO CATTLE	-45.96
GROSS MARGIN/MD (CROPS)	3.15
GROSS MARGIN/MD (CATTLE)	-10.87
GROSS MARGIN/ME (FARM)	226.77

A6. Aggregate Farm Table for Large Sized Farms in Kolongo (Values in 100 MF, area in ha)

FARM ANALYSIS SURVEY (OBSERV)

COUNTRY	REP OF MALI	DATA SOURCE	RESOURCE BASE
PROVINCE/REGION	SEGOU 4TH REGIO	FARM-LEVEL AGRO-ECON	FARMER AGE 53.3, SCHOOLYEARS 1.0
VILLAGE/SUBREG.	N O.N. CONCESSIO	OMIC SURVEY OF RICE	FAMILY: ADULTS 9.3 PERM.LABOUR 0.0 YOUTH/OLD 3.3 CHILDREN 6.3
		PRODUCTION AT THE OF	MAN-EQUIVALENTS10.0
LONGITUDE	N 13	FICE DU	FARMLAND AREA OWNED 11.83 RENTED OUT 0.00, RENTED 0.00, MANAGED 11.83
LATITUDE	W 7		CROPP.PATTERN CROP(S) AREA CROP(S) AREA CROP(S) AREA
ALTITUDE,M	0		15 11.83
		AUTHOR	
SOIL TYPE		MULUMBA KAMUANGA	
	BROWN CLAY LOAM	YEAR OF OBSERV. 1979	

CLIMATE TYPE SUBTROP-SAHE — TRACTORS 0.0 DRAFT ANIMALS 5.3 CATTLE 1.3 GOATS/SHEEP 1.7

CLIMATE	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM	724	0	0	3	9	20	94	202	239	127	27	3	0
TEMPERATURE MEAN		2.4	26.(	29.7	32.1	32.7	30.3	27.5	26.4	27.0	28.5	27.3	24.4
HIGH													
LOW													
HUMIDITY PERC													
LABOUR INPUTS (MD)													
CROPS:LAND.PREP.	200			6	17	50	71	33	18	4			
PLANTING	10						9	1					
CULTIVATION	113				2	2	1	4	17	42	42	3	
HARVESTING	455	37	32	32	9	17	16	12	13	22	18	50	145
OTHERS	43	6	12		1		1	3	2	1	2	14	1
TOTAL	821	33	44	39	29	69	98	54	50	69	63	67	146
LIVESTOCK ACTIVIT.	4					2						2	1
GEN.FARM ACTIVITIES	90	8	(	12	10	14	15	6	3	9	2	4	3
TOTAL FARM	915	101	50	50	39	85	114	59	52	78	63	73	150
(OF WHICH: FARMER	120	9	2	5	9	16	21	7	4	12	10	13	13
FAMILY	792	31	47	45	30	68	92	53	48	67	53	60	137
P.LABOUR													
S.LABOUR	2			1									
OTHERS)	1								1				
OFF-FARM ACTIVITIES	142	4	10	11	23	13	21	3	12	10	11	5	3
POWER INPUT (HOURS)													
ANIMALS	1062	23	17	22	33	213	454	205	87			2	
TRACTORS													
IRRIGATION WATER													

FARM ECONOMICS	CASH	KIND	TOTAL
FARM PRODUCTION			
CROPS	3582	3	3585.00
LIVESTOCK	300	75	375.47
TOTAL	3882	78	3960.47
VARIABLE COSTS	2570	747	3316.28
GROSS MARGIN	1313	-668	644.19
VALUE SHARECR.			
GROSS MARGIN(AD)	1313	-668	644.13
OVERHEAD COSTS			
RENT			
TAXES	2840		2840.00
PERM.LABOUR	53		53.33
INTEREST PAID			.06
REPAIR/MAINT.			
OTHERS	95		94.58
TOTAL	2988		2987.98
NET FARM EARNING	-1675	-668	-2343.79
OFF/FARM EARNINGS	393	69	495.38
FAMILY EARNINGS	-1275	-600	-1848.41
VALUE HOMECONSU		59	59.05
HOUSEHOLD EXPEND	1558		1558.42
BALANCE	-2834	-659	-3465.88

NET WORTH STATMT	FARM LAND	PERM. CROPS	BUILDINGS	TOOLS/MACHINE	DRAFT ANIMA.	PROD. ANIMAL	TOTAL OWNED	TOTAL OWED	NET WORTH VALUE	PERC.
OPENING VALUES			200	930	2550	770	4450	160	4290	96.4
INCOMING						44	44			
OUTGOING								160		
DEPRECIAT.				132	687		820			
ENDING VALUES			200	798	1863	814	3674		3674	100.0

PRODUCTIVITIES	
GROSS MARGIN/UNIT AREA (CROPS)	44.62
LABOUR (MD) /UNIT AREA (CROPS)	69.38
GROSS MARGIN/MD CATTLE	87.10
GROSS MARGIN/MD (CROPS)	.64
GROSS MARGIN/MD (CATTLE)	26.29
GROSS MARGIN/ME (FARM)	64.53

APPENDIX B

FARM MANAGMENT DATA COLLECTION AND ANALYSIS SYSTEM

EXAMPLES OF CROP AND LIVESTOCK TABLES

B1. Examples of Crop Table: Aggregation of 27 Rice Field Observations (Values in 100 MF, area: 1 ha)

CROP ANALYSIS 16 CYCLE [illegible] SURVEY 27 OBSERV.

COUNTRY	REP. OF MALI	DATA SOURCE	
PROVINCE/REGION	SEGOU 4TH REGIO	FARM-LEVEL AGRO-ECON	
VILLAGE/SUBREG.	N.O.N. CONCESSIO	EPIC SURVEY OF RICE	
		PRODUCTION AT THE OF	TYPE OF TENURE 0
LONGITUDE	[illegible] 15	RICE DU	FARMERS SHARE,PERC 0
LATITUDE	[illegible] 7		CULT.SIZE 2.8[illegible]
ALTITUDE,M	[illegible]		CULT.PRACT. 0
DRAINAGE	[illegible]	AUTHOR	PLANT.METH. 0
IRRIGAT. SOURCE	[illegible] METHOD 0	KLEEMBA KAMPANCA	ROT.1YEAR AGO 0
SOIL TYPE	[illegible] 0 0	YEAR OF OBSERV.1979	2YEAR AGO 0
	BROWN CLAY LOAM		3YEAR AGO 0
CLIMATE TYPE	SUBTROP-SAME		

CLIMATE	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM	7[illegible]4	0	0	3	9	20	94	202	23[illegible]	127	27	3	0
TEMPERATURE MEAN		[illegible].4	26.6	2[illegible].7	32.1	3[illegible].7	30.3	27.5	26.4	27.0	28.5	27.3	24.4
HIGH													
LOW													
HUMIDITY PERC													

LABOUR INPUTS (MD)	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SEEDBED/NURSERY	1.[illegible]				.0	.0	.0	.0	.6	.[illegible]	.0	.0	
SOIL PREPARATION	23.6		.0	.2	.0	5.6	6.7	7.0	2.6	.5	.0	.[illegible]	
CLEARING													
DIGGING	.4							.0		.4			
PLOUGHING	14.7			.[illegible]	.0	3.[illegible]	4.2	4.7	1.5	.1			
SOWING/PLANTING	.4		.0				.[illegible]	.1	.1				
APPLY FERTILIZER	1.[illegible]	.2	.[illegible]	.9	.2	.0	.0	.0	.0	.2	.1		.1
APPLY PESTICIDES													
IRRIGATING	1.1	.[illegible]	.4	.1	.1	.1	.1	.2	.0	.0	.0	.[illegible]	
CARE/CULTIVATION	18.[illegible]			.1	.1	.1	.2	.2	.[illegible]	8.4	8.7	.[illegible]	
WEEDING	16.7						.0	.0	.[illegible]	7.4	8.6	.1	
FENCING	.0									.0			
THINNING	.[illegible]				.0					.6			
HARVESTING/PROC.	25.7	5.6	3.1	[illegible]	4.[illegible]	1.6	1.6	1.3	.[illegible]	1.0	.8	5.[illegible]	7.7
CUTTING	10.2	4.2	1.4	1.[illegible]	.[illegible]						.1	3.2	7.2
THRESHING	4.2	.5	.6	.4	.2	.0	.2	.1	.0	.3	.3	.[illegible]	.[illegible]
SORT/PACK.	5.0	.5	.5	.[illegible]	3.4	.[illegible]							
OTHERS	16.3	1.1	2.5	3.0	.0	.4	1.1	.3	.1	1.1	.8	6.9	1.8
TOTAL	102.[illegible]	7.1	6.1	7.5	4.8	7.[illegible]	1[illegible].0	9.9	4.4	11.[illegible]	10.5	12.[illegible]	[illegible].7

POWER INPUT (HOURS)	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ANIMAL SOIL PREP.	1[illegible]8.0	.8		2.2	.5	26.6	36.4	28.6	22.6	.3			
CULTIVAT.	.2				.2								
HARVESTING													
OTHERS	3.3	.8	7	.5			.4	.3	.1		.8		.0
TRACTOR SOIL PREP.													
CULTIVAT.													
HARVESTING													
OTHERS													
IRRIGATION WATER													

	NO.TREES	AGE
1ST CROP	0	0
2ND CROP	0	0
3RD CROP	0	0

YIELD AND OUTPUT		AMOUNT	PRICE	VALUE
1ST CROP	MAIN PROD.	1463	.60	879.[illegible]
	BY-PRODUCT			
2ND CROP	MAIN PROD.			
	BY-PRODUCT			
3RD CROP	MAIN PROD.			
	BY-PRODUCT			
TOTAL				[illegible]79.22

VARIABLE COSTS		AMOUNT	PRICE	COSTS
1ST CROP:SEED/PLANTS		[illegible]	.68	[illegible]6.85
2ND CROP:SEED/PLANTS				
3RD CROP:SEED/PLANTS				
FERTILIZERS	ORGANIC			
	MINERAL	53	1.[illegible]0	[illegible].38
	[illegible]205			
	[illegible]			
	CA[illegible]			
PESTICIDES	INSECT.			
	FUNGIC.			
	RODENT.			
	HERBIC.			
	TOTAL			
PACKING MATERIAL				
TRANSP/MARKET CHARGE				[illegible].[illegible]4
SEAS.HIRED LABOUR		7	6.6[illegible]	4[illegible].[illegible]
ANIMAL POWER,HIRED			.2[illegible]	.[illegible]
	OWN	13[illegible]	.17	23.01
TRACTOR POWER,HIRED				
	OWN			
OTHERS				[illegible]4.[illegible]
TOTAL				[illegible]4.4[illegible]

OVERHEAD COSTS	COSTS
RENT,VALUE SHARECRO.	244.[illegible]
DEPRECIATION	49.76
INTERESTS	
OTHERS	
TOTAL	254.34

ECONOMICS	VALUE
VALUE OF PRODUCTION	879.22
GROSS MARGIN	[illegible]3.79
NET EARNINGS	[illegible].45
PRODUCTION COSTS/100	[illegible].35

FARM MANAGEMENT AND PRODUCTION ECONOMICS,FAO

B2. Example of Livestock Analysis (Values in 100 MF)

TYP: CATTLE — FARM 50 — SURVEY (1 OBSERV.)

COUNTRY	REP. OF MALI	DATA SOURCE		BREED	P
PROVINCE/REGION	SEGOU 4TH REGIO	FARM-LEVEL AGRO-ECON		MANAG.PRACTICE	0
VILLAGE/SUBREG.	N.D.N. SUBPREFSTG	OSIC SURVEY OF RICE PRODUCTION AT THE OF RICE OU		PURPOSE KEEPING	5
LONGITUDE	N 13				
LATITUDE	W 7				
ALTITUDE, M	?	AUTHOR	COLUMBA KAMUANGA		
CLIMATE TYPE	SUBTROP-SAHE	YEAR OF OBSERV.	1979		

INVENTORY	LESS 1 Y. NO	LESS 1 Y. VALUE	1-3 YEARS NO	1-3 YEARS VALUE	MORE 3 Y. NO	MORE 3 Y. VALUE
MALES						
FEMALES						
UNDETERM.						
TOTAL						

CLIMATE		TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINFALL MM		724			3	9	20	94	212	239	127	27	3	
TEMPERATURE	MEAN		[illegible]	25.6	29.7	32.1	31.7	30.3	27.5	26.4	27.0	29.5	27.3	24.4
	HIGH													
	LOW													
HUMIDITY	PERC													

LABOUR INPUTS (MD)	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
WATERING													
STALLFEEDING	11.8				3.5	2.3	4.5	1.0					
CUTT.GRASS													
HERDING	10.8		1.0		.3			5.5	4.0				
MILKING/COLLECT.													
PROCESS/MARKET.													
SANITATION													
CLEANING SHED													
OTHERS	2.6		1.1				1.3	.3					
TOTAL	24.1		2.1		3.8	2.3	5.8	6.8	4.0				

POWER INPUTS (HOURS)	
TRACTOR	
OTHERS	

INVENTORY CHANGES	BIRTH NUMBER	BIRTH VALUE	DEATH NUMBER	DEATH VALUE	SALE/CONSUMPT. NUMBER	SALE/CONSUMPT. VALUE	PURCHASE NUMBER	PURCHASE VALUE	CHANGE IN INVENTORY
TYPES									

ECONOMICS	AMOUNT	PRICE	VALUE
VALUE OF PRODUCTION			
MAIN PRODUCT	222	8.00	1776.50
BY-PRODUCT			
INV.CHANGES			
TOTAL			1776.50
VARIABLE COSTS			
FEED, FORAGE			
CONCENTR.	900	.06	54.00
MINERALS			
VETERIN.COSTS			
ANIMAL REPL.	502	.38	189.00
MARKET/TRANSP			
HIRED LABOUR			
MACHINERY			
OTHERS	.3		865.00
TOTAL			1108.00
GROSS MARGIN			668.50
OVERHEAD COSTS			
RENT			
PERM.LABOUR			
DEPRECIATION			
OTHERS			
TOTAL			
NET EARNINGS			668.50

FARM MANAGEMENT AND PRODUCTION ECONOMICS, FAO

APPENDIX C

LABOR USE ON RICE FIELDS (CASIER AND HORS-CASIER) AT THE O.N.

(IN MAN-DAYS PER HECTARE)

Labor Use on Rice Fields (casier and Hors-casier) at the O.N.
(in man-days per hectare)

Kolodogou				Sahel				Kolongo			
Farm Code	Casier Fields	H. C. Fields	Total Farm	Farm Code	Casier Fields	H. C. Fields	Total Farm	Farm Code	Casier Fields	H. C. Fields	Total Farm
1	125.3	175.3	143	20	121.8	30.5	163.6	30	28	-	28
2	116.0	123.2	141	21	87.8	-	83.4	31	77.8		77.8
3	94.8	-	95.3	22	204.4	-	204.3	32	67.5		67.5
4	99.4	-	100.7	23	129.3	-	129.3	33	100.5		100.5
5	128.2	63.8	121.8	24	155.8	-	155.8	34	130.7		130.7
6	108.6	-	89.4	70	219.8	-	203.5	35	55.7		55.7
7	50.8	19.5	43.0	71	156.6	-	156.5	36	171.0		171.0
8	-		-	72	190.1	96.8	179.0	37	89.1		89.1
9	153.3	96.1	130.8	73	196.5	-	196.4	38	162.5		162.5
10	75.3		75.4	74	73.2	-	73.2	39	271.0		271.0
11	99.4		120.3	75	106.4	-	95.9	40	80.8		80.8
12	170.9		251.3	76	197.4	44.8	162.6	41	118.8		118.8
13	131.6		132.5	77	75.3	-	76.5	42	168.3		168.3
14	155.7		160.0	78	-	50.1	50.2	43	79.3		79.3
50	91.8	60.0	104.8	110	154.1	-	154.1	45	62.2		62.2
51	106.3		106.3	111	157.8	64.8	143.3	80	43.5		43.5
52	80.3		83.6	112	120.0	34.4	34.3	81	36.9		36.9
53	116.3		116.3	114	148	-	148.4	82	65.2		65.2
54	81.9		81.9	160	111.7	-	112.8	83	71.6		71.6
55	175.3	35.9	88.0	161	46.8	-	47.6	84	53.4		53.4
56	109.7	122.6	113.5					85	39.4		39.4
57	125.8	52.8	96.1					86	151.3		151.3
58	105.0	145.8	107.0					87	86.7		86.7
59	209.3	113.9	191.6					88	79.7		99.7
60	141.9	-	135.0					89	62.0		62.0
61	38.4	26.9	34.4					90	74.0		74.0
100	143.8	79.3	89.2					91	34.0		34.0
101	149.6	72.5	146.4					92	102.0		102.0
102	135.6	-	136.4					93	85.0		85.0
103	54.0	-	56.8					94	53.4		53.4
104	118	67.9	72.8					95	53.3		53.3
140	80.2	44.0	69.9					120	72.4		72.4
141	148	-	149.9					121	102.5		102.5
								122	33.2		33.2
								180	55.8		55.8
								181	68.0		68.0
	Average	Aver.	Aver.		Aver.	Aver.	Aver.		Aver.		Aver.
	116.7	81.2	111.9		139.6	53.6	128.5		86.3		86.3
	SD=37.9	SD=37.4	SD=42.9		SD=49.1	SD=24.4	SD=53.5		SD=49.4		SD=49.3

Pairwise Comparison of Means of Labor Inputs (man-days per hectare)

Kolodogou	Sahel	Kolongo
$n = 32$	$n = 20$	$n = 36$
$\Sigma X^2 = 458,449$	$\Sigma X^2 = 384,834.7$	$\Sigma X^2 = 353,599.1$
$(\Sigma X)^2 = 401,385.6$	$(\Sigma X)^2/n = 330,450.6$	$(\Sigma X)^2/n = 263,254.5$
$\Sigma x^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{n} = 57,063.5$	$\Sigma x^2 = 54,384.1$	$\Sigma x^2 = 90,344.6$
d.f. = 31	d.f. = 19	d.f. = 35

Difference between Kolodogou and Sahel

$$\text{pooled } s^2 = \frac{57,063.5 + 54,384.1}{50} = 2,228.95 \qquad \text{d.f.} = 50$$

$$S_{\bar{X}1 - \bar{X}2} = \sqrt{s^2\left(\frac{n_1 + n_2}{n_1 \quad n_2}\right)} = \sqrt{2,228.95\left(\frac{52}{540}\right)} = 13.46$$

$$t = \frac{52}{13.46} = 3.86 > 1.96$$ significant at 1 and 5 percent levels.

Difference between Kolodogou and Kolongo

$$\text{pooled } s^2 = \frac{57,063.5 + 90,344.6}{66} = 2,729.78 \qquad \text{d.f.} = 66$$

$$S_{\bar{X}1 - \bar{X}2} = \sqrt{2,729.78\left(\frac{68}{1152}\right)} = 12.69$$

$$t = \frac{68}{12.69} = 5.36 > 1.96$$ significant at 1 and 5 percent levels.

Difference between Sahel and Kolongo

$$\text{pooled } s^2 = \frac{54,384.1 + 90,344.6}{54} = 2,680.16 \qquad \text{d.f.} = 54$$

$$S_{\bar{X}1 - \bar{X}2} = \sqrt{2,680.16\left(\frac{56}{720}\right)} = 14.44$$

$$t = \frac{56}{14.44} = 3.88 > 1.96$$ significant at 1 and 5 percent levels.

Difference between Labor Inputs on Casier and Hors-casier Fields
(man-days per hectare)

Kolodogou

H. C. Fields	Casier Fields
$\bar{X}_2 = 81$	$\bar{X}_1 = 116.7$
$n_2 = 16$	$n_1 = 32$
$S_2^2 = 1{,}398.76$	$S_1^2 = 1{,}436.41$
$S_2^2/n = 84.42 = w_1$	$S_1^2/n = 44.89 = w_2$

$$t' = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{S_1^2/n_1 + S_2^2/n_2}} = \frac{35.5}{30.53} = 1.16$$

t_2 (15 d.f.) = 2.131 $\qquad$ t_1 (30 d.f.) = 2.042

significance level of $t' = (w_2t_2 + w_1t_1)/(w_1 + w_2)$

$= [(87.42 \times 2.131) + (44.89 \times 2.042)]/132.31 =$ 2.1

1.16 < 2.10, not significant at 5 percent level.

Sahel

H. C. Fields	Casier Fields
$X_2 = 53.6$	$X_1 = 139.6$
$n_2 = 6$	$n_1 = 19$
$S_2^2 = 595.36$	$S_1^2 = 2{,}410.81$
$S_2^2/n = 96.23$	$S_1^2/n = 126.88$

$$t' = \frac{86}{15.04} = 5.72$$

t_2 (5 d.f.) = 2.571 t_2 (18 d.f.) = 2.101

significance level of t′ = [(96.23 x 2.571) + 126.88 x 2.101)]/205.11 = 2.53

5.72 > 2.53, significant at 5 percent level.

APPENDIX D

YIELDS MEASUREMENT ON THE PILOT PROJECT CASIER AT FOABOUGOU (NOVEMBER 23 - DECEMBER 22, 1979)

Yields Measurement on the Pilot Project Casier at Foabougou (November 23 - December 22, 1979)

Farm Code	Number of Sampling Plots of $16m^2$	Average Grain Moisture at Harvest	Average Yield per plot (kg)	Yield Estimate at 14% Moisture kg/ha
6	3	17.2	6.94	2,529.9
12	3	17.4	6.89	2,508.4
13	3	16.2	7.92	2,917.5
23	3	17.0	5.99	2,190.1
15	4	19.4	4.51	1,669.2
22	3	19.8	5.50	1,950.7
24	2	17.0	6.52	2,381.2
14	2	18.0	7.23	2,615.1
1	3	16.3	7.91	2,909.6
2	3	18.0	7.90	2,855.4
7	4	18.1	7.07	2,552.8
11	3	19.1	7.12	2,546.9
18	4	17.2	6.15	2,241.4
25	3	17.8	4.70	1,704.5
20	2	16.9	5.78	2,111.2
17	4	18.0	6.38	2,302.2
19	2	17.2	6.86	2,501.0
5	3	16.0	8.26	3,045.8
4	3	17.6	7.78	2,822.5
3	3	17.2	7.17	2,613.7
8	3	19.0	7.58	2,710.6
10	3	16.5	6.34	2,326.7
9	3	16.5	6.93	2,542.4
21	2	16.0	4.46	1,645.6
16	4	16.1	2.64	973.0

Average 2,360 kg per hectare

SD = 500

APPENDIX E

EXPLANATION OF ABBREVIATIONS USED IN LP MATRIX

Explanation of Abbreviations Used in LP Matrix

Activities		
Column Nº	Abbreviation Used	Complete Heading
1	CT	Produce using current technique
2	IT1	Produce using intensification technique 1
3	IT2	Produce using intensification technique 2
4	IT3	Produce using intensification technique 3
5	IT4	Produce using intensification technique 4
6	IT5	Produce using intensification technique 5
7	UREA1	Buy ureau - season 1
8	AMPHO1	Buy ammonium phosphate - season 1
9	TILPHO	Buy tilemsi phosphate
10	SULAMI	Buy sulfate of ammonia
11	SEEDS1	Buy selected seeds - season 1
12	SEEDS2	Buy selected seeds - season 2
13	SDLG	Buy seedlings
14	UREA2	Buy urea - season 2
15	AMPHO2	Buy ammonium phosphate - season 2
16	SELRD	Sell rice in December
17	SERMY	Sell rice in May
18	CONSR	Consume rice
19	FEQMY	Buy equipment service in May
20	FEQJU	Buy equipment service in June
21	FEQJL	Buy equipment service in July
22	FEQAG	Buy equipment service in August
23	FEQJA	Buy equipment service in January
24	RIBR	Buy rice bran
25	FIFL	Buy rice flour
26	COTS	Buy cotton seeds
27	HLMY	Hire labor in May
28	HLJU	Hire labor in June
29	HLJL	Hire labor in July
30	HLAUG	Hire labor in August
31	HLSEP	Hire labor in September
32	HLOCt	Hire labor in October
33	HLNOV	Hire labor in November
34	HLDEC	Hire labor in December
35	HLJAN	Hire labor in January
36	HLFEB	Hire labor in February
37	HLMCH	Hire labor in March
38	HLAP	Hire labor in April
39	TRMY	Transfer capital May to June
40	TRJU	Transfer capital June to July
41	TRJL	Transfer capital July to August
42	TRAG	Transfer capital August to September
43	TRSEP	Transfer capital September to October

Explanations of Abbreviations Used in LP Matrix - continued

Activities		
Column N°	Abbreviation Used	Complete Heading
44	TROCT	Transfer capital October to November
45	TRNOV	Transfer capital November to December
46	TRDEC	Transfer capital December to January
47	TRJAN	Transfer capital January to February
48	TRFEB	Transfer capital February to March
49	TRMC	Transfer capital March to April
50	TRAP	Transfer capital April to end period

Explanation of Abbreviations Used in LP Matrix

Resources		
Row N^o	Abbreviation Used	Complete Heading
1	LAND	Land
2	FLABMY	Family labor in May
3	FLABJU	Family labor in June
4	FLABJL	Family labor in July
f	FLABAG	Family labor in August
6	FLABSEP	Family labor in September
7	FLABOCT	Family labor in October
8	FLABNOV	Family labor in November
9	FLABDEC	Family labor in December
10	FLABJAN	Family labor in January
11	FLABFEB	Family labor in February
12	FLABMC	Family labor in March
13	FLABAP	Family labor in April
14	PRRICDE	Produce rice in December
15	PRRICMY	Produce rice in May
16	CONSRIG	Consume rice
17	SSEEDS1	Supply seeds in season 1
18	SSEEDS2	Supply seeds in season 2
19	SSDLG	Supply seedlings (in 1000 twigs)
20	SUREA1	Supply urea in season 1
21	SAMPHO1	Supply am. phosphate in season 1
22	STILPHO1	Supply tilemsi phosphate in season 1
23	SSULAM1	Supply sulfate of ammonia in season 1
24	SUREA2	Supply urea in season 2
25	SAMPHO2	Supply am. phosphate in season 2
26	SRIBR	Supply rice bran
27	SRIFL	Supply rice flour
28	SCOTS	Supply cotton seeds
29	FEQSMY	Farm equipment services in May
30	FEQSJU	Farm equipment services in June
31	FEQSJL	Farm equipment services in July
32	FEQSAG	Farm equipment services in August
33	FEQSJA	Farm equipment services in January
34	OPCMAY	Operating capital in May
35	OPCJU	Operating capital in June
36	OPCJL	Operating capital in July
37	OPCAG	Operating capital in August
38	OPCSEP	Operating capital in September
39	OPCOCT	Operating capital in October
40	OPCNOV	Operating capital in Nobember
41	OPCDEC	Operating capital in December
42	OPCJA	Operating capital in January
43	OPCFEB	Operating capital in February

Explanations of Abbreviations Used in LP Matrix - continued

Resources		
Row N°	Abbreviation Used	Complete Heading
44	OPCMC	Operating capital in March
45	OPCAP	Operating capital in April
46	OPCEND	Ending operating capital

APPENDIX F

TREND IN CULTIVATED AREA, YIELDS AND FARM EQUIPMENT AT THE O.N.

Trend in Cultivated Area, Yields and Farm Equipment at the O.N.

Year	Cultivated area (ha)	Number of families	Work oxen (head)	Plows (units)	Harrows (units)	Yields (mt/ha)
1968-69	29,898	3,235	7,206	3,655	1,185	1.54
1969-70	32,826	3,209	9,763	4,446	1,810	1.65
1970-71	39,839	3,357	8,946	4,280	1,842	1.75
1971-72	38,533	3,381	8,821	4,484	2,122	1.81
1972-73	37,626	3,392	10,234	4,807	2,546	1.97
1973-74	40,139	3,672	11,458	5,219	3,192	2.07
1974-75	40,774	4,153	11,963	5,856	3,671	2.11
1975-76	39,916	4,367	13,893	6,290	3,963	2.25
1976-77	39,567	4,542	14,259	6,552	3,860	2.39
1977-78	37,746	4,751	14,665	6,487	4,147	2.66
1978-79	36,557	4,863	15,680	6,790	4,538	2.60
1979-80	36,485	4,985	16,013	6,933	4,799	1.79

Source: O.N. Bureau of Economic Affairs.

Note: Pairwise correlations between yields and the number of pairs of oxen, yields and number of plows, yields and the number of harrows were respectively 0.69, 0.64 and 0.75. Pairs of oxen and units of plows were then aggregated into sets of equipment. The number of such sets per family showed a correlation of 0.71 with rice yields.

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