Staff Paper

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Staff Paper 2000-12

June 2000

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by

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19 Pages

Abstract. The high costs of rehabilitating and/or expanding government-managed irrigated schemes in Mali (*Office du Niger*) has prompted policy-makers and researchers to explore the potential for the underdeveloped farmer-managed *bas-fond* to contribute to ensure an adequate rice supply and increase rural households' incomes. Because little is known about *bas-fond* rice production in Mali, this paper analyzes its financial profitability based on data collected from a random sample of 221 farmers. Data analysis revealed that there are numerous rice production systems in the *bas-fond*. Budget analysis showed that the four most common *bas-fond* production systems yield higher returns than the opportunity cost of labor and they are more profitable than the main upland crops competing with rice for farmers labor (cotton, sorghum/millet, and maize). Within a given *bas-fond* system, however, profitability varies considerably across farms.

Keywords: Rice production, financial profitability, *bas-fond*, *Office du Niger*, Africa, Mali.

1. Introduction

Mali's agricultural sector, which accounts for the major share of GDP (42%), foreign exchange (75%), and employment (83%), is dominated by cereals (sorghum, millet, maize, and rice). With per capita food production falling behind a rapidly expanding demand for food from the 1970s until recently, largely because of recurrent droughts (since 1974), rural-urban migration, and low agricultural productivity, reducing poverty and improving the country's food security has remained the major challenge for the Mali government. The various governments in Mali have always given priority to increasing domestic rice production because it is the only cereal that can be grown under irrigation in a drought-prone country, it offers the greatest potential for significant yield increase, and it is an important staple for the politically powerful urban consumers.

The most important goals of Mali's rice policy have been to (1) reduce imports, (2) stabilize urban prices and supply, (3) increase and stabilize rice farmers' incomes, and (4) ensure nationwide food security. The primary mean to achieving these goals have been to expand the area under intensive rice production. The *Office du Niger*, the semi-autonomous public agency responsible for managing the country's intensive rice production schemes, has always been the centerpiece of the supply side of rice policy in Mali. While it currently supplies about 50 percent of the country's domestically produced rice, the high costs of rehabilitating and/or expanding the existing government-managed irrigated schemes[2] has prompted policy-makers and researchers to explore the potential for including the largely underdeveloped farmer-managed inland valley swamps (also known as *bas-fonds*) as part of the national strategy to ensure an adequate rice supply and increase rural households' incomes. Unfortunately, very little is known about *bas-fond* rice production in Mali. Other recent publications aimed at filling this information gap have addressed various research issues including factors determining farmers's adoption of improved varieties and fertilizer (Dimithè *et al.*, 1998_a), the determinants of rice yield (Dimithè *et al.*, 1998_c), and the profitability of *bas-fond* rice production from the point of view of the country as a whole (Dimithè *et al.*, 1998_b). This paper focuses on the question: Is *bas-fond* rice production profitable to farmers?

To answer this question, this paper recognizes that these *bas-fonds* are cultivated by small-scale farmers who also cultivate upland crops. For farmers, interactions between rice and those other crops are important because they compete for scare resources, especially labor. Thus, the profitability of *bas-fond* rice production should automatically take into account the opportunity cost of not producing upland crops by using an appropriate estimate of family labor opportunity cost. But, given that it is difficult to accurately estimate the opportunity cost of family labor, this paper analyzes *bas-fond* financial profitability relative to three alternatives: (a) different systems for producing *bas-fond* rice, (b) employment as a wage laborer, and (c) returns to family labor in producing upland crops. The analysis starts with a comparison of the returns to a day of family labor from alternative *bas-fond* rice production systems. While this analysis examines the systems' net returns to family labor relative to each other, it does not necessarily imply that they are profitable. To examine this issue, a second round of analysis compares these returns with the opportunity cost of labor, based on the assumption that the next best alternative for family labor is to seek a wage employment. However, the synthesis recognizes that rural wage labor may not represent an alternative to rice farming for all farmers because such opportunities in these villages are seasonal and limited. Thus, a third round of analysis examines *bas-fond* rice production profitability by comparing its net returns per day of family labor with the corresponding values from cotton, sorghum/millet and maize enterprises, which are the main upland crops competing with rice for farmers' labor.

2. Analytical Framework

To determine financial profitability, enterprise budgets are estimated to determine the costs and returns per hectare to *bas-fond* rice production and competing farming enterprises. The main components of an enterprise budget are the value of production (returns), costs, and net returns. While net returns can be computed either as net returns over cash costs or net returns over all costs. This paper uses net returns over all costs (excluding family labor) to determine the net return per day of family labor which is compared to its opportunity cost to assess the profitability of the enterprise.

It is important to caution that budget analysis implicitly assumes that each farmer desires to increase expected income and makes the "best" possible use of the resources available to her or him. However, rice farmers' objectives are typically more complex, particularly for women farmers for whom the rice enterprise has an important social dimension that is not captured by monetary indicators, especially when measured in financial terms (Dimithè, 1997). For example, while men decide on how crop production from the uplands is to be used, women who crop rice have a discretionary power over the use of their rice harvest. Although this harvest is often used as a complement to the upland harvests in securing the family food consumption needs, it symbolizes a gender-based social freedom for women by increasing their ability to satisfy their needs and social obligations (*e.g.*, welcoming visitors).

3. Data Sources

For estimating rice budgets, the paper uses data collected from a random sample of 221 rice farmers selected from a purposive sample of 12 *bas-fond* villages in Mali-Sud during the 1995-96 cropping season. Enumerators stationed in the villages monitored resources applied to each rice plot throughout the cropping season. In addition, each farmer was interviewed to collect data on his or her agricultural production objectives and priorities, institutional backstopping, cropping calendar, time spent on farm operations by labor category, input use level, expenditures on hired labor and purchased non-labor inputs, production constraints, and crop yields. To assess the profitability of the upland crops, the paper uses budget estimates reported by Giraudy and Niang (1994) and labor data collected in 1988 and 1989 by the Farming Systems Research unit (ESPGRN) based in Sikasso.

4. Results and Discussions

Farm-level data collected for this study were used to group farms into homogeneous production systems, which are defined based on input combinations farmers used. The data indicated that there exists numerous rice production systems in the *bas-fonds* surveyed. The four most common systems are:

(1) *Traditional* production system: farmers had no water control, planted "traditional" rice varieties, but applied no chemical fertilizer or herbicide;

(2) *Macro semi-intensive* production system: farmers had water control, used "traditional" rice varieties, but applied no chemical fertilizer or herbicide;

(3) *Micro semi-intensive* production system: farmers had no water control, used "traditional" rice varieties, applied no fertilizer, but applied some herbicide;

(4) *Intensive* production system: farmers had water control, used "improved" rice varieties, and applied both chemical fertilizer and herbicide.

Interestingly, each of these systems is found in more than one village and is followed by both male and female farmers-- although all systems are predominantly cultivated by women (88%). For each production system, enterprise budgets are estimated based on mean or median values of the technical production coefficients, depending on the skewness of the data. Farmers' input application rates are standardized by dividing plot-level data by the corresponding plot size, and averaging them across all farmers in the system to obtain per hectare values.

Production costs are grouped into operating and fixed costs. Operating costs are defined as costs associated with the use of variable purchased inputs (*i.e.*, seeds, fertilizer, herbicide, hired labor, and in-kind "payments") plus the interest cost of working capital. In estimating the cost of seeds, "traditional" and "improved" seed varieties are valued differently. Although farmers seldom buy or sell seeds of "traditional" rice varieties, these seeds are valued at their opportunity costs (*i.e.*, consumer price of 85 CFA.F/kg). In contrast, prices set by the government agency responsible for promoting cotton and rice production (CMDT) in the villages surveyed are used to value seeds of "improved" varieties because CMDT is their main source (*i.e.*, 150 CFA.F/kg). Because farmers following the *intensive* production system did not apply the same combination of fertilizer[1], the cost of this input (*i.e.*, 43,344 CFA.F/ha) was estimated by averaging total fertilizer expenditures made by each farmer across all farmers in this production system.

The cost of hired labor was estimated based on three assumptions. First, because farmers hired different amounts of labor for each operation, its cost is included in the budget only for farming operations for which at least 30% of the farmers hired labor (*i.e.*, plowing, hand weeding, harvest, and threshing). Second, given that hired female labor is rare in the area surveyed, no gender differential was used in valuing hired labor. In addition, although differences in age affect individuals' work ability, for simplicity, no adjustment was made to account for these differences because the number of hours of farm labor and the actual work effort each laborer provides depend on several factors in addition to gender and age, such as the farm operations involved, and farmer's attitude towards leisure. Third, hired labor costs are estimated separately for each *bas-fond* production systems because they are system-specific.

Because hired labor is paid by task, the corresponding costs were estimated in three steps. First, for each farmer in the four production systems, his/her total expenditures on hired labor (including both cash and non-cash payments) were computed for each of the four farming operations (*i.e.*, plowing, hand weeding, harvest, and threshing). Non-cash payments, which represent in-kind payments or amenities such as food and drinks provided by the farmer to non-family labor, were valued by the farmers themselves at the corresponding market value. Cash labor expenditures include the actual acquisition price of labor hired as individuals, plus the cost of labor hired as a group, both converted to a per hectare basis. Second, in each system, an average cost of hired labor for each farming operation was estimated by dividing the operation total expenditures made by all farmers for labor hired by the size of the sub-sample. Finally, for each system, the total cost of hired labor was derived by summing the corresponding costs for all farm operations considered. Typically, fixed costs in rice farming include the cost of land, the annual equivalent cost of farm equipment and land development, as well as water utilization fees. For this study, no cost is included for depreciation costs associated with the use of farm implements (*i.e.*, harrows, carts, and draft animals) because they are mainly used in the uplands. Depreciation costs for farm equipment such as hoes and knives are excluded because they are considered negligible--these tools cost about 500 CFA.F (*i.e.*, about $0.94) each and are used over an extremely long period of time. Finally, the cost of land development and water utilization fees are also excluded in the financial analysis because they are borne by the government cotton development agency (CMDT). Table 1 reports the estimated financial budgets for the four *bas-fond* rice production systems described earlier.

Table 1: Financial Budgets for *Bas-fond* Rice Production Systems, Mali, Rainy Season 1995-96.

Budget Items	Production Systems			
	Purely Traditional	Macro-Semi-Intensive	Micro-Semi-Intensive	Intensive
1. INPUT USE RATES				
Seeds (kg/ha): "traditional" (@ 85 CFA.F/kg)	207	116	94	0
"improved" (@ 150 CFA.F/kg)	0	0	0	218
Herbicide (l/ha @ 6,580 CFA.F/l)	0	0	2.5	2.5
Fertilizer	0	0	0	(a)
Family labor (hours/ha):	256	224	249	341
2. OUTPUT				
Average yield (kg of paddy/ha)	1,021	1,232	1,423	2,366
Market price of paddy (CFA.F/kg of paddy)	115	115	115	115
Gross revenue (CFA.F/ha)	117,415	141,680	163,645	272,090
3. COSTS				
Operating Costs (CFA.F/ha):				
Seeds	17,595	9,860	7,990	32,700
Herbicide	0	0	16,450	16,450
Fertilizer	0	0	0	43,344
Hired labor	39,000	56,795	14,000	49,164
Interest on working capital (12%)	2,220	2,837	1,898	5,749
Total operating costs (CFA.F/ha)	58,815	69,492	40,338	147,407
Fixed Costs (CFA.F/ha):	0	0	0	0
Total non-family labor costs (CFA.F/ha)	58,815	69,492	40,338	147,407
4. PERFORMANCE MEASURES				
Gross margin (CFA.F/ha)	58,600	72,188	123,308	124,683
Net returns to family labor (CFA.F/ha)	58,600	72,188	123,308	124,683
Net returns per day of family labor (CFA.F)	1,374	1,934	2,971	2,194
Opportunity cost of family labor (CFA.F/ha)	21,333	18,667	20,750	28,417
Total production cost (CFA.F/ha)[b]	80,148	88,158	61,088	175,824
Enterprise profit (CFA.F/ha)	37,267	53,522	102,558	96,266
Prod. cost per kg of paddy produced (CFA.F)[b]	78	72	43	74
Break even yield change (%)	-32	-38	-63	-35

Exchange rate: $1=530 CFA.F

[a] Farmers applied combinations of urea, NPK (15-15-15), and DAP. These fertilizers are applied at the rates 100-0-0 kg/ha respectively, or 105-82-0 or 150-0-122. Urea is valued at 175.0 CFA.F/kg, NPK at 196.0 CFA.F/kg, and DAP at 243.7 CFA.F/kg.

[b] Includes family labor valued at 500 CFA.F for a six-hour day of farm work.

Source: Dimithè (1997).

Family labor requirements were estimated from recall data provided by farmers. The median amounts of family labor used for cleaning, plowing, and planting were estimated by pooling together the estimates provided by all farmers for each operation in the four production systems, because for these generic operations

family labor requirements are assumed to be independent of the systems. In contrast, the amount of family labor used for weeding, fertilizing, harvesting and threshing was estimated separately for each of the four production systems because these operations are clearly system specific. For each production system, total family labor requirements are estimated by summing median family labor used in each operation. The estimated total labor used (*i.e.*, combining family and hired labor) is 724, 906, 417, and 931 hrs/ha (*i.e.*, 121, 151, 70, and 155 persondays[2]) in the *traditional*, the *macro-semi-intensive*, the *micro-semi-intensive*, and the *intensive* systems, respectively.

Previous studies report varying labor requirements for *bas-fond* rice production, ranging from 93 persondays (Ahmadi in Lavigne Delville, 1994), to 100-120 persondays (Séné Conseil in Lavigne Delville, 1994), 131-197 persondays (Coulibaly, 1995), and 303 persondays (Matlon and Fafchamps, 1988). This variability highlights the difficulty in comparing labor data reported in different studies. In part, the differences between these estimates depend on the data collection method used (*i.e.*, recall or record keeping), the technology farmers used (*e.g.*, manual or mechanical), individual characteristics of farmers, and the type of statistic reported (*i.e.*, mean or median). When the measurement method is recall interview, as is the case in this study, the accuracy depends in part on when the interview is conducted, relative to when the operation was performed. The variability across farmers can be attributed to factors such as farm size, weed type and density, attitude towards leisure.

Production Costs

The costs of production associated with the four most common *bas-fond* production systems are estimated with and without including an opportunity cost of family labor (Table 1). When family labor is excluded, the mean total cost of production is 40,338 CFA.F/ha for the *micro-semi-intensive* system, 58,815 CFA.F/ha for the *traditional* system, 69,492 CFA.F/ha for the *macro-semi-intensive* system, and 147,407 CFA.F/ha for the *intensive* system. These estimates are within the range (63,900-126,410 CFA.F/ha) reported by Coulibaly (1995) on Mali-Sud's *bas-fonds*, except for the *intensive* system, which has a higher production cost than estimated by Coulibaly (1995). These costs correspond to a mean average production cost of 28 CFA.F/kg of paddy produced in the *micro-semi-intensive* system, 58 CFA.F/kg of paddy for the *traditional* system, 66 CFA.F/kg of paddy for the *macro-semi-intensive* system, and 62 CFA.F/kg of paddy for the *intensive* system.

When family labor is included as a cost component and valued at 500 CFA.F/day, the mean total cost of production under each system increases by 19-51 percent, ranging from 61,088 CFA.F/ha for the *micro-semi-intensive* system, to 80,148 CFA.F/ha for the *traditional* system, 88,158 CFA.F/ha for the *macro-semi-intensive* system, and 175,824 CFA.F/ha for the *intensive* system. Similarly, these cost correspond to a mean average production cost of 43 CFA.F/kg of paddy produced in the *micro-semi-intensive* system, 78 CFA.F/kg of paddy for the *traditional* system, 72 CFA.F/kg of paddy for the *macro-semi-intensive* system, and 74 CFA.F/kg of paddy for the *intensive* system.

While the estimated production costs (with and without family labor) show that the total production cost in the *intensive* system is more than twice the cost in any of the other three systems, the average costs mean difference between the *traditional* system, the *macro-semi-intensive* system, and the *intensive* system is 2-6 CFA.F. The relative importance of the structural components of the *bas-fond* rice production costs differ from one system to another. However, hired and family labor represent the main cost component, accounting for 75 percent of total costs in the *traditional* system, 86 percent in the *macro-semi-intensive* system, 86 percent in the *micro-semi-intensive* system, and 44 percent in the *intensive* system.

Bas-Fond Rice Production Is Profitable to Farmers

Table 1 shows that for all systems, the returns per day of family labor (ranging from 1,374 to 2,971 CFA.F/day) is higher than its opportunity cost (500 CFA.F/day). Thus, under the assumptions made earlier, all four *bas-fond* rice production systems are financially profitable. The same observation can be made using the associated costs of producing a kilogram of paddy (ranging from 43 to 78 CFA.F/kg), which are lower than the farm-gate producer price of paddy (115 CFA.F/kg).

Economic studies on rice production in the major rice-producing countries in West Africa (*i.e.*, Côte d'Ivoire, Liberia, Sierra Léone, Sénégal, and Mali) have focused on commercialized production with good water control and under a subsidized policy environment. In Mali, the only exception is a study by Coulibaly (1995). The positive results obtained in this study are consistent with those obtained by Coulibaly (1995), who found positive financial returns of 64,170 CFA.F/ha to *bas-fond* rice production in Sikasso, 10,990 CFA.F/ha in Kadiolo, and 9,435 CFA.F/ha in Bougouni, assuming zero opportunity cost for family labor (Appendix 1). However, when family labor is valued at 500 CFA.F/day, this study's results are consistent with Coulibaly's findings for farmers in Sikasso, but contradict his negative results for farmers in Kadiolo and Bougouni. One possible explanation for this discrepancy is the fact that this study uses average input and output prices throughout the *bas-fond* area, while Coulibaly used site-specific prices.

The least profitable of the four production systems is the *traditional* system, which has an average production costs of 78 CFA.F/kg of paddy, and a return to a day of family labor of 1,374 CFA.F/day (*i.e.*, about three times higher than the opportunity cost of labor). The most profitable of the four systems is the *micro-semi-intensive* system, which has the lowest average production costs per kg of paddy produced (*i.e.*, 43 CFA.F/kg), and the highest return to a day of family labor (*i.e.*, 2,971 CFA.F/day), which is about six times higher than the opportunity cost of labor. One reason why this system is so profitable is that it is also the system that used the least labor per ha, primarily because these farmers substitute herbicide for hired labor to control weeds. The fact that this system is more profitable than the more intensive technological package (*i.e.*, *intensive* system) highlights the important contribution of herbicide as a labor-reducing technology and thereby the impact of labor cost on profitability. Furthermore, compared to *micro-semi-intensive* system, the lower financial profitability of the *macro-semi-intensive* system suggests that the existing quality of water control infrastructure (*i.e.*, dams across streams with no internal control of the water level) is ineffective. However, complementary investment in plot-level water control (*e.g.*, internal bonding) could significantly improve the effectiveness of these infrastructure (Dimithè, 1997).

Variability of Bas-Fond Rice Production Profitability

The results reported in Table 1 indicate that as in other places in West Africa[3], *bas-fond* rice production more than covers the opportunity cost of family labor. However, these results are based on mean or median values of the budget items. Typically, farmers grow *bas-fond* rice as a substitute for grain purchases later in the post-season during the hungry period, when prices are high. This observation is supported by the producer survey research conducted by the MSU Food Security project in 1985/86 in four producing regions of Mali, which revealed that many farmers make cash purchases of food (Dioné, 1989). Similarly, the 1988/89 nationwide budget-consumption survey indicated that 41.4 percent of the rice that households consumed in rural areas was purchased in the market.

Traditionally, sensitivity analysis is used in budget analysis to evaluate the impact of possible measurement and estimation errors and the variability of budget items estimates on profitability by varying some assumptions and/or technical coefficients used in the base-run scenario. Table 1 indicates that, given the costs and output price used, under the *traditional* production system, a 32% "poor year" yield decrease would be necessary to drive farmers' returns down to the break even point, *ceteris paribus*. For *macro-semi-intensive* system the corresponding figure is 38%, for *micro-semi-intensive* system 63%, and for the *intensive* system 35%.

In addition, given the small sample size of farmers following each of the rice production systems, this paper uses the actual profit level of individual rice farmers as indication of the variability of the performance of the different systems. While the choice of the central tendencies used to estimate the enterprise budgets (Table 1) is theoretically justified, examining the distribution of the net returns per day of family labor among the farmers in each of the four *bas-fond* rice production systems is useful because of production risk associated with the erratic rainfall, poor water control, and the inherent farmer to farmer variations. To conduct this analysis, financial budgets were estimated separately for each sampled farmer. In this process, revenues were determined by valuing each farmer's specific observed yield by the market price (115 CFA.F/kg). In addition, the average costs reported in Table 1 were maintained. In contrast, for each farmer, the family labor requirement for harvesting and threshing were adjusted in direct proportion to the corresponding yield difference (*i.e.*, relative to the average yield in Table 1). Figures 1-4 show the resulting distribution of net returns per day of family labor among the sampled farmers in each of the four production systems.

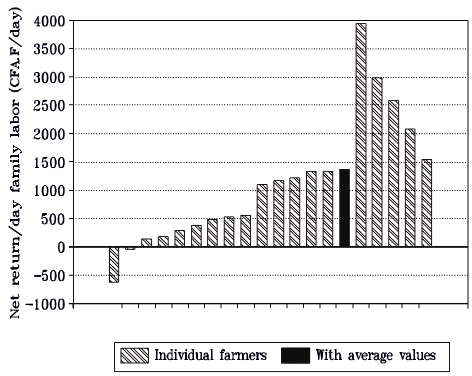

Figure 1: Net Returns/Day of Family Labor Among Farmers (N=19) Following the *Traditional* System.

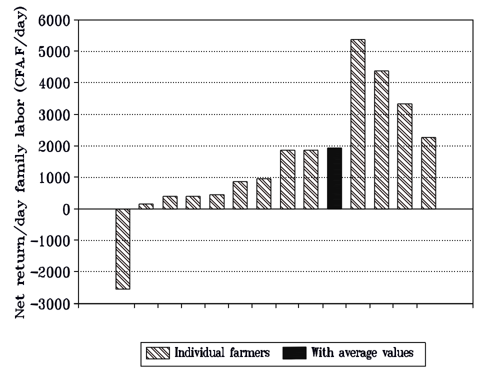

Figure 2: Net Returns/Day of Family Labor Among Farmers (N=13) Following the *Macro-Semi-Intensive* System.

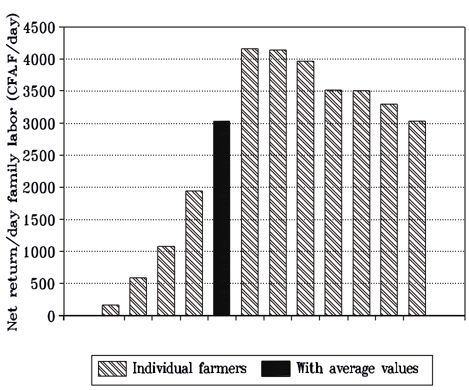

Figure 3: Net Returns/Day of Family Labor Among Farmers (N=11) Following the *Micro-Semi-Intensive* System.

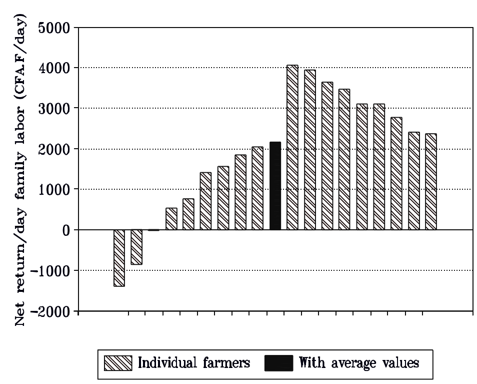

Figure 4: Net Returns/Day of Family Labor Among Farmers (N=18) Following the *Intensive* System.

Figures 1 to 4 reveal that, under the assumptions outlined earlier, although on average each of the four *bas-fond* rice production systems was profitable to farmers, this enterprise is not profitable for some farmers. Thus, from a production risk standpoint, the *micro-semi-intensive* system is the most attractive of all four systems because not only is it the only system for which all sampled earned positive net returns per day of family labor (ranging between 16 and 4,142 CFA.F/day), the distribution of these returns is skewed to the right of the average value reported in Table 1 since seven of the 11 farmers (64%) using this system earn more than that average. In addition, among the 11 farmers using this system, only one (9%) earns positive net returns per day which are less than the assumed opportunity cost of family labor.

Figure 1 shows that the net returns per day of family labor among the farmers using the *traditional* system range between a negative 631 CFA.F/day and a positive 3,936 CFA.F/day. The distribution of these returns is skewed to the left of the average value reported in Table 1, as 14 of the 19 farmers (74%) using this system earn less than that average return (1,374 CFA.F/day). In addition, two (11%) of the 19 farmers have negative returns, and five (26%) earn positive net returns per day which are less than the assumed opportunity cost of family labor (*i.e.*, 500 CFA.F/day). A comparison of the distribution of net returns per day of family labor among the sampled farmers following the *micro-semi-intensive* system (Figure 3) and those following the *macro-semi-intensive* system (Figure 2) suggests that the existing quality of water control infrastructure (*i.e.*, dams across streams with no internal control of the water level) is ineffective in reducing the production risks farmers face. However, complementary investment in plot-level water control (*e.g.*, internal bonding) could improve the effectiveness of these infrastructure.

Similarly, Figure 2 shows that among farmers using the *macro-semi-intensive* system, the net returns per day of family labor range between a negative 2,529 CFA.F/day and a positive 5,368 CFA.F/day. As with in the *traditional* system, the distribution of these returns is skewed to the left of the average value reported in Table 1, since nine of the 13 farmers (69%) using this system earn less than that average return (1,934 CFA.F/day). In addition, among the 13 farmers using this system, one (8%) has a negative return, and four (31%) earn positive net returns per day which are less than the assumed opportunity cost of family labor.

Finally, Figure 4 shows that net returns per day of family labor among farmers using the *intensive* system range between a negative 1,398 and a positive 4,051 CFA.F/day. These returns are evenly distributed around the average value reported in Table 1. Among the 18 farmers using this system, three (17%) have a negative return, and the rest (83%) earn more than the assumed family labor cost.

It is important to recognize that the distribution of net returns per day of family labor among the sampled farmers in each of the four production systems is based on small sample sizes (less than 20). Furthermore, this distribution captures not only the intra annual production risk associated with variable water condition between farmers' plots, but also the inherent farmer to farmer variability in profitability attributable to their resource endowments. There exists an important production risk due to year-to-year variability associated with the prevailing erratic rainfall condition which is not captured in this analysis. Granted this limitation, however, these results indicate that, even within a given *bas-fond* rice production system, the profitability of the rice enterprise is quite variable. Thus, a key research question is to determine the factors that account for this variability. Most of the economic studies on rice production in the major rice-producing countries in West Africa (*i.e.*, Côte d'Ivoire, Liberia, Sierra Léone, Sénégal, and Mali) have focused on intensive irrigated systems and showed that the factors explaining the differences in profitability were country specific[4] (McIntire, 1981). In other words, they examined factors that may explain variation in profitability across countries or systems but not within a given system. Explaining this variability is a challenge for future research.

Comparative Financial Analysis of the Rice and Upland Crop Enterprises

In the previous analysis, the profitability of *bas-fond* rice production was examined without regard to other crops in the farming system, implicitly assuming that the next best alternative to a farmer is to seek wage employment. However, as mentioned earlier, rural wage labor in the villages surveyed is seasonal and limited (Dimithè, 1997). Interactions with other crops are important, especially because *bas-fond* fields are cultivated by small-scale farmers who also cultivate upland fields. Therefore, the interrelationships which link upland and *bas-fond* activities are a particularly important dimension of the *bas-fond* agro-ecosystems. For farmers, one of the major questions is how profitable is the *bas-fond* rice enterprise as an income-generator, relative to other sources of revenues? To answer this question, an accurate estimate of the opportunity cost of family labor, which automatically implicitly captures the opportunity cost of not cultivating upland crops is needed. Indeed family labor opportunity cost is the net return to labor from the farmers' best alternative which is forgone by producing rice. Typically, farmers have a variety of revenues opportunities, including crop production and processing, livestock, handicrafts, hunting, and urban remittances. A study conducted in Mali-Sud by Giraudy and Niang (1994) revealed that sources of revenues most cited by farmers are cotton (62% of the production units (PUs) surveyed) and cereals (48%). Among the cereals, sorghum ranks first (22%), followed by millet (14%), maize (11%), rice (2%), and finger millet (1%). But, because it was difficult to accurately estimate the opportunity cost of family labor, the remaining part of this paper directly analyzes profitability of rice (per hectare of cultivated land) relative to the main upland crops grown in the villages surveyed (cotton, maize and sorghum/millet), by comparing their net returns to family labor.

The financial budgets for these upland crops are presented in Appendix 2. Those budgets are based on estimates reported by Giraudy and Niang (1994) and labor data collected in 1988 and 1989 by the FSR unit based in Sikasso. Giraudy and Niang (1994) estimated average budgets for the cotton, cereals and peanut enterprises for representative production units using no animal traction, one set of animal traction equipment, and two or more sets of animal traction equipment[5]. Their cereals budget is based on average values from maize and sorghum/millet enterprises. Furthermore, their budgets excluded labor costs and were not standardized to a per hectare basis. This study uses the same estimates with four adjustments.

First, outputs are valued using 1996 producer prices. Second, the budget item estimates for cereals are partitioned into their maize and sorghum/millet components based on the relative field size of each crop in the production unit. In doing so, we assumed that farmers apply fertilizer and herbicide only on maize and not on sorghum/millet. Thus, the full costs of fertilizer and herbicide are attributed to the maize enterprise. Third, the resulting budget enterprise estimates, including cotton, were then converted to their per hectare values. Fourth, we added estimates of family labor data valued at the same opportunity cost used earlier in the rice budgets (500 CFA.F/day), and the interest costs for fixed and operating capital (excluding family labor costs) based on a 12 percent rate used in private banks.

The labor data obtained from the FSR program were collected on farms using animal traction. To determine the labor requirement for the non-mechanized farms, a conversion factor was estimated based on a study conducted in Bénin by Gouthon *et al.* (1996) by dividing average labor requirement from non-mechanized farms by that from mechanized farms. This conversion factor (1.25) indicates that non-mechanized farms use about 25 percent more labor than the mechanized farms. Thus, labor requirements for the non-mechanized farms were estimated by multiplying the FSR data by the estimated conversion factor. Furthermore, because animal traction is used primarily in the uplands, the study assumed the same labor requirement per hectare for all rice farmers who use animal traction equipment. Table 2 summarizes the key budget components estimated for rice and the upland crops.

Table 2 shows that, overall, the three upland crops and the rice enterprise have positive net returns to family labor. In other words, when the opportunity cost of family labor is assumed to be equal to zero, these four crops are profitable to farmers, regardless of their level of mechanization. However, the estimated returns to a day of family labor show that all four *bas-fond* rice production systems yield higher returns per day of family labor than the three upland crop enterprises, regardless of their level of mechanization. Maize is the most profitable of the three upland crops, followed by sorghum/millet.

Table 2: Comparative Financial Budgets for the *Bas-Fond* Rice, and Representative Maize, Sorghum, Cotton Enterprises in the *Bas-fond* Villages, Mali, Rainy Season 1995-96.

Production Systems	Budget Items (CFA.F/ha)					
	Gross Revenues[a]	Total variable Costs	Total fixed costs	Total costs	Net return to family labor	Net returns/ day of family labor
Rice Production Systems:						
Purely traditional	117,415	58,815	0	58,815	58,600	1,374
Macro-semi-Intensive	141,680	69,492	0	69,492	72,188	1,934
Micro-semi-Intensive	163,645	40,338	0	40,338	123,308	2,971
Intensive	272,090	147,407	0	147,407	124,683	2,194
Upland Crops:						
Manual						
Maize	87,150	1,272	0	1,272	85,878	1,128
Sorghum/millet	62,550	1,272	0	1,272	61,278	823
Cotton	160,580	62,222	0	62,222	98,358	485
One set of implements						
Maize	106,275	34,717	1,123	35,840	70,435	1,157
Sorghum/millet	73,350	3,136	6,359	9,495	63,855	1,072
Cotton	184,140	64,086	24,093	88,179	95,961	591
More than 1 set of implements						
Maize	119,100	34,848	3,962	38,810	80,290	1,318
Sorghum/millet	86,310	4,663	24,343	29,006	57,304	962
Cotton	234,670	65,613	113,705	179,318	55,352	341

[a] Rice is valued at 115 CFA.F/kg, maize at 75 CFA.F/kg, sorghum/millet at 90 CFA.F/kg, and cotton at 115 CFA.F/kg.

Source: Adapted from Table 4 and Appendix 2.

When the opportunity cost of family labor is assumed to be 500 CFA.F/day, the return per day of family labor from the rice, maize and sorghum/millet enterprises are still higher than its opportunity cost, regardless of their level of mechanization. In contrast, the return per day of family labor from the cotton enterprise is only higher than its opportunity cost for farmer owning one set of animal traction implements.

The cotton enterprise looks unprofitable in part because almost all fixed costs of the upland crops are attributed to cotton production, based on the consideration that those inputs (*i.e.*, animal traction) are primarily used in the cotton fields. As a result, because the other household crops free-ride on cotton for farm fixed investments, they tend to be very profitable, compared to cotton. However, it is likely that farmers look at the profitability of the entire grain-cotton system, which includes the spillover benefits from cotton in terms of access to inputs (some of which go to food crops) via the cotton development agency's (CMDT) credit system. Furthermore, the guaranteed cotton cash flows permit better timing of farmers sales of food crops.

In addition, for the country as a whole, cotton production offers important growth linkages with the livestock and processing sub-sectors, as well as demand and fiscal linkages. Cotton seeds, which were not valued in the earlier budgets, are used to feed livestock (an important subsector of the Mali's economy). The linkages with the processing sector relates to the employment generated in the ginning process. Fiscal linkages refer to the cotton subsector's important contribution to fiscal revenues, which are reinvested in the economy. Given the importance of cotton in the Mali's economy, a critical question for future research is to determine how greater intensification of the *bas-fond* rice production would affect the cotton enterprise. For example, would greater intensification of *bas-fond* rice production induce a significant number of farmer to abandon or reduce cotton cultivation, and thereby decrease its production?

5. Conclusion

This study analyzed the financial returns associated with four *bas-fond* rice production systems, and compared the financial profitability of the *bas-fond* rice enterprise to major alternative upland crops (*i.e.*, cotton, maize and sorghum) competing with rice for the production units' labor and capital. Using standard budgeting techniques, the study found that for all systems, the returns per day of family labor in the rice field (ranging from 1,374 to 2,971 CFA.F/day) is higher than its opportunity cost (500 CFA.F/day). In addition, for all systems the cost of producing a kilogram of paddy (ranging from 43 to 78 CFA.F/kg) is lower than the output farm-gate producer price (115 CFA.F). These results indicate that, under the set of assumptions made in this study, these systems are financially profitable. Within a given *bas-fond* rice production system, however, profitability varies considerably from farm to farm. Among the four systems studied, the *micro-semi-intensive* system is the most attractive both from an average profitability standpoint and risk standpoint. Its financial superiority over the more intensive technological package (*i.e.*, *intensive* system) highlights the important contribution of herbicide as a labor-reducing technology and thereby the impact of labor cost on profitability. Similarly, its superiority over the *macro-semi-intensive* system suggests that the existing quality of water control infrastructure (*i.e.*, dams across streams with no internal control of the water level) is ineffective. However, complementary investment in plot-level water control (*e.g.*, internal bonding) could significantly improve the effectiveness of these infrastructure.

With regards to cotton, maize, and sorghum, the study found that, when the opportunity cost of family labor is assumed to be equal to 500 CFA.F/day, all four *bas-fond* rice production systems yield higher returns per day of family labor than the three upland crop enterprises. Maize is the most profitable of the upland crops, followed by sorghum/millet.

Clearly, these results show that, compared to the upland crops, *bas-fond* rice production is a financially attractive enterprise and can constitute a potential of source of income to farmers. Other results obtained from the data set used in this paper and which are published in a different paper (Dimithè *et al.*, 1998_b) show that *bas-fond* rice production is also economically profitable. However, this paper's result does not imply that *bas-fond* rice production represents a more efficient way for Mali to use domestic resources than to produce upland crops. Addressing this question would require estimation of these crop enterprises' economic budgets, which is beyond the scope of this paper. Furthermore, given the superior profitability of *bas-fond* rice production, relative to cotton, and the role and influence of the cotton development agency in the same area in which rice is produced, one critical question for future research is to determine the implications of greater intensification of *bas-fond* rice production on the cotton enterprise. For example, would greater intensification of *bas-fond* rice production induce a significant number of farmers to abandon or reduce cotton cultivation, and thereby decrease its production? Finally, the *bas-fond* rice production currently accounts for less than 10 percent of Mali domestic rice supply, compared to about 50 percent for the *Office du Niger*. A key question from the point of view of the economy as a whole is how large a contribution could further expansion and intensification of the *bas-fond* system make to supplying Mali growing demand for rice. This question is addressed in a different paper (Dimithè *et al.*, 1998).

In order for *bas-fond* rice production to constitute a reliable source of income for rural farmers, it is necessary to address constraints *bas-fond* farmers face. These constraints are discussed in details by Dimithè (1997). First, the large share of family and hired labor cost (relative to other cost items) in each of the four most common *bas-fond* systems (44-86%) suggests that one potential way to increase their profitability is to reduce the labor content of the technologies farmers used without increasing total costs. A distinctive characteristic of the most profitable of the four production systems (the *micro-semi-intensive* system) is that farmers used herbicide as their only modern input. Indeed, group discussions with farmers revealed that they face labor constraints at weeding, a very tedious operation done manually. While survey data indicated that weeding accounted for 10 percent of total labor used, plowing (22-27%), harvesting (24%), and threshing (21-39%) have the highest labor shares. Thus, if scientists succeed in identifying relatively low-cost labor-saving technologies, the financial profitability of these systems could be significantly higher. Efforts to reduce labor costs should assess the potential of reducing labor input through the substitution of adapted and economically justifiable labor-saving technologies such as herbicide, mechanical threshing, sickle harvesting, and better water control systems to reduce weed pressure (Dimithè, 1997).

In addition, complementary research is needed to increase yields by focusing on improving the timeliness and quality of land preparation, and better plot-level water control, as well as increasing the rice adaptability of "improved" varieties to the *bas-fond* poor water control (Dimithè, 1997). An analysis of the time lag between tillage and planting revealed that about 82 percent of the farmers planted less than two weeks after plowing started. This practice (i) exposes the seedlings to the effect of high concentration of harmful substances generated during the decomposition of the organic material incorporated in the wet soil, and (ii) limits the plant likelihood to utilize the ammonium released by decayed organic matter (Dimithè, 1997).

Relative to developing hybrids, short-term rapid yield increases can be achieved through traditional plant breeding strategies that rely on selecting appropriate genetic material from the world collection, producing crosses, and screening the most promising selections under farmers' agro-environments. However, for this effort to succeed, scientists must adopt a participatory approach in order to combine the experimental knowledge of farmers and their formal scientific knowledge. Still, the yield potential of "improved" varieties will not be realized in farmers' fields unless scientists also develop appropriate complementary technologies to relax fertility, pest, and disease constraints, and to stabilize the production environment which is highly erratic due to poor plot-level water control. Indeed, it is important to recognize that currently, the most pressing constraint to achieving higher rice yields is not the physiological potential of the varieties farmers plant. Rather, inadequate plot-level water control, soil infertility, pests, and diseases are the key factors that prevent farmers from fully exploiting the full potential of the varieties they currently plant.

Launched in the mid-1980s by the national agricultural research institute (*Institut d'Economie Rurale* (IER)), *bas-fond* rice research in Mali is currently undertaken primarily by the Farming Systems Research Program (ESPGRN) and the *Bas-Fond* Rice projects (PRBF), both based in Sikasso, as well as the Subsector Economics Program (ECOFIL) based in Bamako. However, these programs' research activities in the *bas-fonds* have been limited in scope due to limited funding and human capital. Unless sufficient financial support is available, it will be impossible to carry out the research required to generate appropriate technologies suitable for intensifying *bas-fond* rice farming. Thus, for these efforts to succeed, the Malian agricultural research system must mobilize a political constituency in support of agricultural research. However, as is the case throughout West Africa, Malian researchers have not been strong advocates for public investment in research. As funding from the government and the donor community continues to dwindle, there is an increasing need for researchers to become proactive advocates of the value of agricultural research, especially given the limited political power of the farmers.

Finally, efforts to modernize rice farming in Mali have largely centered on promoting the adoption of modern varieties and increased use of fertilizer and herbicide, all of which require capital. Yet, despite the major role that women play in *bas-fond* rice production, existing institutional arrangements do not provide women direct access to new rice technologies and other resources such as credit. Currently, the main source of "improved" technology is the CMDT, a government agency which only provides credit to cotton farmers. Because all cotton farmers are men, many of whom are not willing to borrow for their wives, very few women farmers have direct access to modern inputs. This condition is worsened by the patriarchal nature of the rural social structure which tends not to expect women to generate household income. As a result, women have limited access to household resources for investing in rice inputs.

Notes

[2] For example, the World Bank (1992) estimated that in 1989 the cost of a typical irrigation perimeter with full water control (canals and diversion dam) was 2.6 million CFA.F/ha (US$8,161). The rehabilitation cost of the water control system of canals and diversion dam is about 2,600,000 CFA.F/ha (*i.e.*, $4,906/ha).

3. Farmers used combinations of urea (45-0-0), NPK (15-15-15), and DAP at the rates of 100-0-0 kg/ha respectively, or 105-82-0 or 150-0-122.

4. A personday is defined as equal to six hours of work.

5. For example, Levarsser's (1979) analysis of nine rice production systems in Bénin and Spencer's (1981) analysis of 13 rice production systems in Sierra Leone found that similar inland valley rice production systems were highly profitable for farmers.

6. These studies show that the profitability of rice production is greatly influenced by not only the availability of improved technology, but also prevailing input and output markets policies, the world market price, the quality of the road infrastructure, and the location of consumption centers. Humphreys' (1981) study of improved upland rice in Côte d'Ivoire and McIntire's study (1981) of *bas-fond* rice in Mali reported that animal traction was more profitable than manual land preparation. Humphreys' (1981), Spencer's (1981), and Monke's (1981 in Liberia) found that the use of modern inputs (fertilizer and varieties) increases profitability in the forest areas, but reduces it in the savannah. Finally, Humphreys' (1981), Spencer's (1981) and Tuluy's (1981) results indicated that complete mechanization is less profitable than partial mechanization.

7. Giraudy and Niang (1994) found that the financial performance of individual production units (PUs) depends in part on their level of mechanization (*i.e.*, animal traction). The main characteristics of the representative enterprises for these budgets are as follows. For PUs with no animal traction: 9 family members, 1 ha of cotton and 3.2 ha of maize (16%) and sorghum/millet (84%) cultivated. For PUs with one set of animal traction equipment (i.e., a plow and a pair of oxen): 14 family members, 2.2 ha of cotton and 5.8 ha of maize (15%) and sorghum/millet (85%) cultivated. For PUs with three or more sets of animal traction equipment (i.e., plow, oxen, seeder, cart, multi-purpose plow, and equipment for chemical treatment application): 14 family members, 5.6 ha of cotton and 12.5 ha of maize (16%) and sorghum/millet (84%) cultivated.

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Appendices

Appendix 1: Alternative *Bas-fond* Rice Financial Budgets, by Location, Mali, Rainy Season 1994-95.

	Location		
	Sikasso	Kadiolo	Bougouni
Inputs application rates:			
seed (kg/ha)	76	114	90
urea (kg/ha)	40	0	0
DAP (kg/ha)	39	0	0
Herbicide (l/ha)	5	0	0
Family labor (personday/ha)	160	131	197
Inputs prices:			
seed (CFA.F/kg)	100	80	50
urea (CFA.F/kg/ha)	175		
DAP (CFA.F/kg)	140		
Herbicide (CFA.F/l)	3,700		
Revenues			
Yield (kg paddy/ha)	1,971	1,230	889
Price (CFA.F/kg)	80	55	55
Gross revenues	157,680	67,650	48,895
Operating Costs (CFA.F/ha):			
Seeds	7,600	9,160	4,500
Urea	7,000	0	0
DAP	5,460	0	0
Herbicide	18,500	0	0
Hired labor	49,450	19,000	33,400
equipment rental	0	25,000	0
Total operating costs	88,010	53,160	37,900
Fixed costs (CFA.F/ha):			
Equipment depreciation	5,000	3,000	1,000
Small equipment	500	500	500
Total fixed cost	5,500	3,500	1,500
Opportunity cost of family labor (CFA.F/ha)	32,900	31,500	24,500
Total production cost (CFA.F/ha)	126,410	88,160	63,900
Net Margin including family labor (CFA.F/ha)	31,270	-20,510	-15,005
Net Margin not including family labor (CFA.F/ha)	64,170	10,990	9,495

Source: Adapted from Coulibaly (1995).

Appendix 2: Financial Budgets for Maize, Sorghum/Millet, and Cotton Enterprises in the *Bas-fond* Villages, Mali, Rainy Season 1995-96.

	Manual			1 set of implements			3 sets of implements or more		
	Cotton	Maize	Sorg./Millet	Cotton	Maize	Sorg./Millet	Cotton	Maize	Sorg./Millet
1. Revenues									
Yield (kg/ha)	1,036	1,162	695	1,188	1,417	815	1,514	1,588	959
Market price (CFA.F/kg)	155	75	90	155	75	90	155	75	90
Gross Revenues (kg/ha)	160,580	87,150	62,550	184,140	106,275	73,350	234,670	119,100	86,310
2. Costs (CFA.F/ha)									
Variable Costs	3,200	1,200	1,200	3,200	1,200	1,200	3,200	1,200	1,200
seeds	1,965	0	0	1,965	6,661	0	1,965	6,844	0
fungicide/herbicide	18,832	0	0	18,832	3,520	0	18,832	3,143	0
compound cotton fert.	0	0	0	0	9,900	0	0	6,860	0
compound cereal fert.	7,748	0	0	7,748	9,933	0	7,748	11,836	0
urea	0	0	0	1,759	1,759	1,759	3,199	3,199	3,199
maint. animal traction	27,729	0	0	27,729	0	0	27,729	0	0
insecticide treatment	2,748	72	72	2,854	1,745	178	2,940	1,767	264
interest costs	62,222	1,272	1,272	64,086	34,717	3,136	65,613	34,848	4,663
Total variables costs									
Fixed costs (CFA.F/ha):	0	0	0	22,729	1,059	5,999	107,269	3,738	22,965
depreciation	0	0	0	1,364	64	360	6,436	224	1,378
interest costs	0	0	0	24,093	1,123	6,359	113,705	3,962	24,343
Total fixed costs	62,222	1,272	1,272	88,179	35,840	9,495	179,318	38,810	29,006
Total cost (CFA.F/ha)									
Net Returns family labor (CFA.F/ha)	98,358	85,878	61,278	95,961	70,435	63,855	55,352	80,290	57,304
Op. cost fam. lab. (500 CFA.F/day)	101,490	38,062	37,230	81,192	30,450	29,784	81,192	30,450	29,784
3. Performance Indicators									
Gross Margin (CFA.F/ha)	98,358	85,878	61,278	120,054	71,558	70,214	169,057	84,252	81,647
Total production cost (CFA.F/ha)	163,712	39,334	38,502	169,371	66,290	39,279	260,510	69,260	58,790
Profit (CFA.F/ha)	-3,132	47,816	24,048	14,769	39,985	34,071	-25,840	49,840	27,520
Net ret./hr family labor (CFA.F/ha)	485	1,128	823	591	1,157	1,072	341	1,318	962
Prod. cost/kg of output (CFA.F/ha)	158	34	55	143	47	48	172	44	617

Source: Giraudy *et al.* (1994) for variable and fixed costs as well as cotton yields, ESPGRN (1989) for labor data, and survey data for yield and market prices.