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Staff Paper

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Contribute to Improving Food Security in the Sahelian
African Countries: An Evidence from the Bas-Fond
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Can Agricultural Production in the Marginal Lands Contribute to Improving Food Security in the Sahelian African Countries: An Evidence from the *Bas-Fond* Rice Production in Mali¹

by

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Abstract - - To improve national food security, successive Mali governments have always focused on expanding and intensifying production in the government-managed irrigation schemes (*Office du Niger*), which account for about 50% of domestic rice production. Because the cost of expanding and rehabilitating those schemes is high, the government is looking for complementary cost-effective ways to achieve this goal. The government could increase domestic rice supply by investing in improving the farmer-managed inland valley swamps. Although the government has paid little attention to those marginal lands, farmers have been growing rice in these areas using traditional technologies. This paper used data from a survey of 334 *bas-fond* farmers and secondary data to examine the potential contribution that these undeveloped *bas-fonds* could make to improve food security and rice exports in Mali. The study found that, if fully developed, the *bas-fonds* and flooded plains could produce more rice than is currently being supplied by the *Office du Niger*, or imported through commercial imports or food aid. As expected, rice yields in the *bas-fonds* are lower than in the *Office du Niger*. However, *bas-fonds* rice production is both financially profitable and provides a higher return per day of family labor than the competing upland crops (maize, sorghum/millet and cotton). In addition, the estimated domestic resources cost ratios show that, compared to the *Office du Niger*, *bas-fond* rice production represents a better use of domestic resources, both for producing rice for home consumption and for the market.

Keywords: Rice production, food security, profitability, competitiveness, *bas-fond*, flooded plains, *Office du Niger*, Mali.

Introduction

The growing land scarcity in the Sahel, which is brought about in part by the rapid 2-3% annual population growth, a slow agricultural productivity (about 0.6% per year) in the main food crops (millet and sorghum), and an expansion of cotton production, has resulted in increasing food shortages (Reardon et al., 1997). While researchers attempt to identify and understand desirable patterns of intensification in the

good lands, the marginal ones have often been overlooked or classified as unsuitable to agriculture either because of associated diseases such as schistosomiasis or river blindness, or their poor productivity. Yet, in many Sahelian countries, farmers have been cropping such lands for many years using traditional practices and technologies. A typical example in Mali are the inland valley swamps (known as *bas-fonds*).

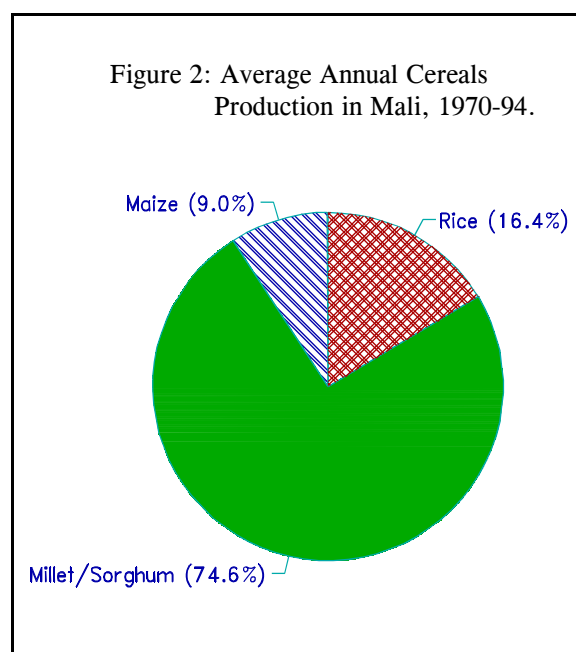
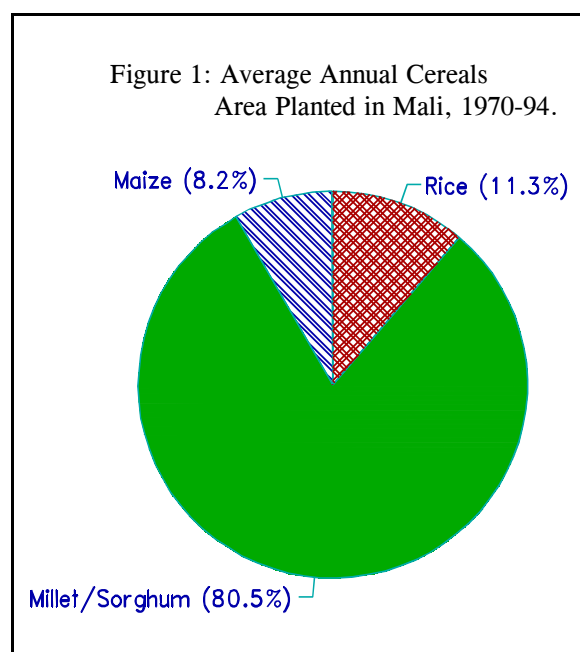
Until the early 1970s, Mali was self-sufficient in cereals. However, after the 1974 drought, per capita food production failed to keep pace with the rapidly expanding demand for food. As the gap between national food production and demand widened in the late 1980s--largely because of recurrent droughts, rural-urban migration, and low agricultural productivity--Mali became increasingly dependant on commercial imports and food aid. Although agricultural productivity has improved since early 1990s and Mali has significantly reduced cereal import, especially with respect to rice, the government is seriously considering further investments to intensify rice farming in order to boost domestic production and improve food security. The government could continue to expand the input-intensive government-managed schemes which have been the focus of rice policy in Mali, but the cost of expanding and rehabilitating those irrigation systems is high (e.g., the rehabilitation cost of the water control system of canals and diversion dam is estimated to be around 2,600,000 CFA.F/ha or \$4,906/ha).

Alternatively, as a complement to rice production from the irrigated systems, the government could increase rice production by investing in improving the less intensive systems, especially the untapped potential of the inland valley swamps for which there has been a growing interest among agricultural policy-makers and researchers. Unfortunately, very little is known about *bas-fond* rice production. To guide their decisions, scientists and government officials need answers to numerous questions. This paper focuses on four of these questions: (1) What is the current level of rice production in the *bas-fonds*? (2) What is the potential for expanding *bas-fond* production? (3) Would this additional production significantly improve household and national food security? (4) Would *bas-fond* farmers be willing to produce more rice?

The paper is structured in three parts. The first part highlights the importance of rice in Mali, and the country's irrigation potential. The second part examines the potential of *bas-fond* rice production to increase the national food supply, thereby increasing availability. The third part of the paper focuses on the potential of the *bas-fonds* to generate rural household incomes, thereby increasing household access to food. Both food availability and access to food constitute the two components of a country's food security. This paper is based on secondary data and survey-generated data collected from a random sample of 334 farmers selected from a purposive sample of 12 *bas-fond* villages in Mali-Sud, during the cropping season 1995-96².

Rice is an Important Staple in Mali

Mali's agricultural sector is characterized by a low level of diversity and a high degree of production variability that often leads to food deficits. The dominant crops are cotton, cereals (sorghum, millet, rice and maize), and groundnuts. Cotton, the main cash crop, is grown mostly in the southern part of the country by smallholders, with strong extension advice from *Compagnie Malienne de Développement des Textiles* (CMDT) management. Cotton provides greater financial security to the farmers than do food crops, as inputs (seed, fertilizer, pesticide, in-kind loans for animal traction) are guaranteed by the parastatal CMDT, which also provides active and effective technical support. Millet, sorghum, and maize are the major rainfed staples. Rice, the only cereal grown under irrigation in this drought-prone country, offers the greatest potential for significant yield increases. Sorghum and millet account for about 81 percent of total area planted (Figure 1), and 75 percent of total grain production (Figure 2).



Cereals, the main source of energy in the Malian diet, provide approximately 79 percent (1,770 kcal/year/individual) of the total human energy supply (Semega, 1991). While millet, sorghum, and maize account for about 85 percent of these cereal calories, rice provides the remaining 15 percent (Staatz *et al.*, 1989) and accounts for about 6.4 percent of the total expenses of Malian households (DNSI, 1994).

According to Mali's most recent (1988-89) nationwide consumption expenditure survey (DNSI, 1994), national rice consumption per capita averages about 34 kg per annum, and is higher in urban areas (58.0

² This survey was conducted by the MSU Food Security II project, in collaboration with the Malian national research institute's (IER) subsector economic research program (ECOFIL), and its Farming Systems and *Bas-Fond* Rice Research programs.

kg/year) than in rural areas (24.3 kg/year). While currently only third among cereals, in terms of per capita consumption, Mali's strategic development plan (Ministère de l'Agriculture, de l'Élevage, et de l'Environnement, 1992) projected that per capita rice consumption will increase at an annual rate of 2.1 percent in urban areas and 0.4 percent in rural areas. Because the demand for rice is growing rapidly and it is largely consumed by politically powerful urban consumers, who represent about 27.5 percent of Mali's population, government places a high priority on increasing rice production.

Irrigation Potential and Rice Production Systems

While one of the largest countries in West Africa (477,000 s. miles), Mali's agricultural potential is limited by irregular and low rainfall, ranging from 200 mm in the north to 1,400 mm in the south. Because northern Mali is a semi-desert, the bulk of the country's 8.7 million inhabitants are concentrated in the Niger Valley and in the south-eastern region of the country. According to the World Bank (1992), Mali has the largest irrigable land potential (i.e., land that could be developed for irrigated crop production) of any Sahelian country, estimated at from 500,000 to 2,000,000 hectares. However, to date, only about 200,000 hectares have been developed, 75 percent of which is currently cultivated (World Bank, 1992). To develop its vast irrigable land potential and thereby lessen the unfavorable effects of the irregular rainfall pattern, Mali has established several government-managed irrigation schemes in large and small perimeters along the Niger and Senegal Rivers and other small rivers in the south of the country, but has provided only limited encouragements to communities to farmer-managed schemes in *bas-fonds* and flooded plains. As a result of these investments, Mali currently has approximately 263,880 hectares in rice production (Haïdara *et al.*, 1998).

Based on water source and the level of water flow control, the country's rice production systems may be classified into three sub-systems: (1) the fully controlled irrigation sub-systems, which are either in large (*Office du Niger*, Baguinéda, Manantali, and Selingué) or small perimeters along the Niger (1,700 km) and Senegal Rivers, (2) the partially controlled irrigation sub-systems which are found in smaller irrigated perimeters (*Opération Riz Ségou*, *Opération Riz Mopti*, *Opération Riz Sikasso*) and smaller rivers in the south, and (3) the largely undeveloped traditional flooded plains and *bas-fond* sub-systems, which are found mostly in southern Mali. Currently, the largest share (48%) of the rice area (126,078 ha) is found in the flooded plains, followed by the fully irrigated sub-system (25%; 65,953 ha), the traditional *bas-fond* (14%; 37,263 ha) and the partially irrigated (13%; 34,588 ha) the sub-systems (Haïdara *et al.*, 1998).

Past government efforts to increase rice production have focused on both expanding and rehabilitating the intensive irrigated areas (fully and partly controlled irrigation sub-systems) and increasing yields in these schemes. Yet, the cost of rehabilitating and expanding those irrigation systems is high. 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). As a result, in recent years the government has sought to exploit the untapped potential of the *bas-fond* and flooded plains rice production systems, which are now seen as complementary to the large government-managed schemes.

Southern Mali's (Mali-Sud) *bas-fonds* are narrow inland valley swamps that used to be permanent rivers, but have dried up with declining rainfall. During the rainy season, the water table in these swamps rises due to overflow from small rivers, seepage, and slope surface runoff from adjacent upland, generally supplying water throughout the growing season. The standing water level in these *bas-fonds* ranges from a shallow/medium depth (25-50 cm for 2-5 months) to deep water (50-100 cm). They may extend over 25 km in length and vary from around 10 m wide in the upper levels to about 100 m in their lower stretches. These *bas-fond* are largely undeveloped (i.e., little or no water control infrastructure) and are primarily cultivated by women (88%), who attach a utility value to rice self-sufficiency that exceeds its monetary value. In contrast, while the flooded plains are also largely undeveloped and are irrigated by overflows from small rivers and seepage, they are much wider than the *bas-fonds*. As is the case with the *bas-fonds*, plains are completely dry during the off-season.

Potential Contribution of Traditional Rice Production to Increase the Food Supply

The potential contribution of *bas-fond* rice production can be assessed in terms of the per capita amount of paddy rice produced from the *bas-fond* in each village surveyed and what this production level represents in the total domestic rice supply, and in comparison with commercial imports and food aid. Table 1 presents the yields observed in the *bas-fond* villages surveyed and the corresponding per capita milled rice production. This table shows that in seven of the ten villages, per capita milled rice production is higher than or equal to national average rice consumption (34 kg/person/year). In other words, there is a real potential for *bas-fond* villages with surplus production of paddy to sell rice to deficit areas.

Table 1. Contribution of *Bas-fond* Rice Production, Mali, Cropping Season 1995-96.

Location	<i>Bas-Fond</i> Area Cultivated (ha)	Village Population	Yield (kg paddy/ha)	Total Paddy Production (t)	Per Capita Milled Rice Production ^(a) (kg)
Kado	108	3,542	1,099	119	22
Diassola	3	221	2,989	9	26
Kafuziéla	69	1,625	886	61	26
Solo	32	1,400	1,940	62	29
Niéna	128	3,457	1,433	183	34
Banko	35	806	1,465	51	41
Faradié	34	398	1,046	36	58
Sola	300	1,900	591	177	61
Péniasso	125	840	1,011	126	98
Longorola	330	540	1,826	603	725
Mali-Sud	48,657 ^(b)	-	1,216 ^(c)	59,167 ^(d)	-

^(a) Computed using a 65 percent milling recovery rate.

^(b) Total potentially cultivatable *bas-fond* area in Mali-Sud, based on a *bas-fond* inventory conducted by the CMDT in 1992.

^(c) Assuming rice yields in the *bas-fond* area are equal to the average yield in the 12 surveyed villages.

^(d) Estimated by multiplying the total potentially cultivatable *bas-fond* area by the assumed yield.

Source: Dimithè (1997).

At the national level, the importance of this contribution is reflected by comparing the “potential” level of *bas-fond* rice production with the rice supply from the *Office du Niger*, as well as with commercial imports and food aid to Mali (Table 2). Currently, only part of Mali-Sud’s *bas-fond* area is planted to rice. However, if all of Mali-Sud *bas-fonds* (48,657 ha) were brought into production and assuming the average yield observed in this study, 59,167 mt of paddy could be produced. This represents about 31 % of the total paddy produced by the *Office du Niger* annually over the last five years, 26 % of commercial rice imports, and 160 % of food aid (rice) to Mali in 1991.

Similarly, only part of Mali-Sud’s flooded plains are currently planted to rice. However, if all of Mali-Sud’s flooded plains (*i.e.*, 173,000 ha) were brought into production and assuming the average yield observed in the *bas-fonds*, 189,091 mt of paddy could be produced. This represents about 111 % of the total paddy produced by the *Office du Niger* annually over the last five years, 93 % of commercial rice imports, and 569 % of food aid (rice).

Finally, if all of both Mali-Sud’s *bas-fonds* and flooded plains were brought into production, a total of 269,535 mt of paddy could be produced. This represents about 43 percent more paddy than was produced annually by the *Office du Niger* over the last five years, 119 percent of commercial imports, and 711 percent of food aid to Mali. Furthermore, given that total rice imports (commercial imports plus food aid) have

averaged 263,000 mt in recent years, exploiting the combined potential of these traditional rice production systems would enable Mali to improve its self-sufficiency and exports in rice.

Table 2. Potential *Bas-Fond* and Flooded Plains Rice Production, as a Percentage^(a) of the Rice Supply from *Office du Niger*, Commercial Imports, and Food Aid.

Rice Supply Source	<i>Bas-Fond</i> ^(b)	<i>Bas-Fond</i> & Plains ^(c)
<i>Office du Niger</i> ^(d)	31	143
Commercial Imports ^(e)	26	119
Food aid ^(f)	160	128
Commercial Imports & Food aid ^(g)	22	102

^(a) *Bas-fond* (flooded plains) production potential divided by the respective rice supply sources.

^(b) Estimated *bas-fond* production potential, 210,368 mt.

^(c) Estimated flooded plains production potential, 189,091 mt.

^(d) Average amount of rice supplied by the *Office du Niger* over the period 1991-95, 226,000 mt.

^(e) Commercial imports (rice) in 1991, 226,000 mt.

^(f) Food aid (rice) in 1991, 37,000 mt.

^(g) Total commercial imports plus food aid, 263,000 mt.

Clearly, developing the untapped potential of Mali-Sud's *bas-fond* and flooded plains would significantly contribute to the government's effort to boost domestic rice production and thereby ensure an adequate food supply for all. This contribution could be even more significant, if greater attention is given to addressing constraints that limit intensification of these systems. These constraints are reported in the concluding section of the paper. However, before advising the government to invest in developing and intensifying these traditional rice production, it is first necessary to establish its profitability to farmers and to the country as a whole. As noted earlier, the research reported in this paper was designed to assess the profitability of the *bas-fond* rice production. While the authors believe that the general findings reported in this study may also apply to the flooded plains rice production system, a separate study focusing on this sub-system is required to confirm this proposition.

Potential Contribution of *Bas-fond* Rice Production to Increase Rural Households Income

The first part of this paper documented the current level of rice production in the *bas-fonds*, and estimated its potential contribution to the national rice food supply. This section focuses on assessing whether *bas-fond* farmers would be willing to produce more rice by analyzing the profitability of the *bas-fond* rice enterprises. 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 scarce 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, because it was difficult to accurately estimate the opportunity cost of family labor, the 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.

Furthermore, to analyze the profitability of *bas-fond* rice production, rice farmers are grouped into four production systems that are defined by their unique combination of inputs (water control, variety, fertilizer and herbicide application), as shown in Table 3. Inputs are valued at the market prices farmers paid for, non-purchased resources are valued at their opportunity costs, and outputs are valued at the average farm-gate price received by farmers at harvest.

Table 3. Predominant Types of Bas-fond Production Systems, Mali-Sud.

Production Systems	Water control	Varieties	Fertilizer	Herbicide
Purely Traditional	none	traditional	none	none
Macro-Semi-Intensive	yes	traditional	none	none
Micro-Semi-Intensive	none	traditional	none	some
Intensive	yes	improved	some	some

Relative Profitability of Alternative Bas-Fond Rice Production Systems

Table 4 summarizes the profitability of the *bas-fond* production systems identified in this study, based on the technical input/output coefficients reported by Dimithè (1997). 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, estimated to be 500 CFA.F/day. Similarly, 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. Among the four systems studied, the most profitable is the *micro-semi-intensive* system, which also has the lowest production costs. This system is so profitable primarily because of significant herbicide substitution for hired labor to control weeds.

Table 4. Comparative Financial Budgets for the Bas-Fond Rice Enterprises, Mali, Rainy Season 1995-96.

Production Systems	(CFA.F/ha)				(CFA.F/kg)	(CFA.F/day)
	Gross Revenues ^(a)	Total Variable Costs ^(b)	Total Fixed Costs	Total Production Costs ^(b)	Paddy Production Cost ^(c)	Net Return/Day of Family Labor
Purely Traditional	117,415	58,815	0.00	58,815	78	1,374
Macro-Semi-Intensive	141,680	69,492	0	69,492	72	1,934
Micro-Semi-Intensive	163,645	40,338	0	40,338	43	2,971
Intensive	272,090	147,407	0	147,407	74	2,194

^(a) Paddy is valued at 115 CFA.F/kg. The currency exchange rate in 1996 was US \$1 = 560 CFA.F.

^(b) Excluding family labor.

^(c) Excluding family labor valued at 500 CFA.F/day of farm work.

Source: Dimithè (1997).

It is important to note that the results reported in Table 4 are based on a single-year data set. In addition, they do not take into account the production risks associated with the prevailing erratic rainfall and poor water control in these *bas-fonds*. However, sensitivity analysis shows that, under the *traditional* production system, a 32% yield decrease would be necessary for farmers' net returns to fall to zero (break even), *ceteris paribus*. The same estimate is 38% for the *macro-semi-intensive* system, 63% for the *micro-semi-intensive* system, and 35% for the *intensive* system (Dimithè, 1997). A detailed discussion of the financial profitability of these systems and how variable are the returns per day of family labor in *bas-fond* rice farming is reported by Dimithè (1997). For this paper, an equally interesting question is the profitability of *bas-fond* rice production compared to cotton and the main cereals competing with rice for farmers' labor.

Profitability of Bas-Fond Rice Production Relative to Upland Crops Production

Bas-fonds are complex heterogeneous production environments. In all *bas-fonds*, water availability, soil texture, and related physical and chemical properties vary along the toposequence (Carsky and Masajo, 1992). Furthermore, because *bas-fond* fields are cultivated by small-scale farmers who also cultivate upland fields, the interrelationships which link upland and *bas-fond* activities are a particularly important dimension of the *bas-fond* agroecosystems. In this context, the successful promotion of *bas-fond* rice production will depend in part on its profitability, relative to the main competing upland crops--cotton, maize, and sorghum/millet.

The financial enterprise budgets for the cotton, maize, and sorghum/millet enterprises are summarized in Table 5. The data used to develop these budgets are adapted from a study conducted within the cotton development agency (CMDT) by Giraudy and Niang (1994) and labor data collected by IER's Farming Systems Research Program in 1988 and 1989.

Comparing Tables 4 and 5 reveals that all four *bas-fond* rice production systems (Table 4) yield higher returns to a day of family labor than any of the three upland crop enterprises (Table 5). Among upland crops, maize and then sorghum/millet are the most profitable, followed by cotton which yields the lowest return to a day of family labor. Furthermore, the returns to a day of family labor from the rice, maize and sorghum/millet enterprises are higher than labor's opportunity cost (*i.e.*, 500 CFA.F/day), regardless of their level of mechanization. The return per day of family labor from the cotton enterprise is only higher than its opportunity cost when the farmer uses one implement.

Table 5. Comparative Financial Budgets for Maize, Sorghum, and Cotton Enterprises in the *Bas-fond* Villages, by Level of Mechanization, Mali, Rainy Season 1995-96.

	Gross Revenues ^(a)	Total Variable Costs	Total Fixed Costs	Total Production Costs	Net Return to Family Labor	Net Return/Day of Family Labor
<i>Manual</i>						
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
<i>One implement</i>						
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
<i>More than one implement</i>						
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) Maize is valued at 75 CFA.F/kg, sorghum/millet at 90 CFA.F/kg, and cotton at 115 CFA.F/kg.

Source: Adapted from Giraudy and Niang (1994) in Dimithè (1997).

These results show that, compared to the upland crops, *bas-fond* rice production is a meaningful complementary source of income to farmers. While several constraints would have to be relaxed to extend and intensify *bas-fond* rice production, the associated relative financial profitability and utility value suggest that if given greater attention, the *bas-fonds* could make a major contribution to raising rural household incomes and thereby increase household access to food and reduce food insecurity.

However, it is important to recognize that these results are based on a single-year data set. Furthermore, although *bas-fond* rice production yields a higher return to family labor than the competing upland crops, the area available for cultivation in the *bas-fond* is limited. As a result, farmers' individual plot sizes are small

(0.3 ha) compared to the upland (1.3 ha). For a farmer, what matters is not just the profitability per ha, but also the total revenue he can obtain given the set of constraints he/she faces. In addition, one key reason why the cotton enterprise appears so unprofitable is because almost all fixed costs of the upland crops are attributed to cotton production. This allocation pattern is based on the consideration that the cotton enterprise drives the household farm enterprises. 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.

For example, cotton ensures farmers access to inputs (some of which go to food crops) via the cotton development agency's (CMDT) credit system, and capitalizes the farming system as a whole. Because of guaranteed revenue from selling their cotton, these farmers have greater flexibility in deciding when to market their food crops. Finally, the profitability of the rice enterprise is estimated assuming no fixed cost associated with water control investment because this cost is borne by CMDT. Thus, if farmers bear the cost of water control, the profitability of the corresponding systems will decline.

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. The linkages with the livestock sub-sector relate to the fact that cotton seeds are used to feed livestock. The linkages with the processing sub-sector relate 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. Thus, 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 farmers to abandon or reduce cotton cultivation, and thereby decrease its production?

Competitiveness

In the previous section, we have examined the profitability of each of the identified rice production systems from the point of view of individual farmers. However, the ranking of farmers' profitabilities can sharply diverge from the social ranking due to policy-induced distortions and/or market failures. As mentioned earlier, before advising the government to devote more effort to promote *bas-fond* rice production, it is also necessary to determine whether or not the contribution of these rice production systems to the Mali's overall economy is great enough to justify using scarce government resources that are required to further develop them. In other words, are these systems competitive? Indeed, recent developments indicate that agricultural policy makers pay increased attention to competitiveness. Since the 1980s, many countries, including Mali, have implemented policy reforms designed to reduce direct state participation in agriculture, increase productivity, ensure the cost-effectiveness of agricultural research expenditures, liberalize commodity trade, and free market prices to play a greater role in directing economic activities along efficiency lines. Knowledge of the competitive position of alternative production systems is important because the associated potential welfare gains can be used to foster economic growth and improve food security. Over the long-run, additional welfare gains can be assured if research resources are used to strengthen competitive production systems.

In this paper, competitiveness is defined as the ability of a given system to produce rice of a specific quality, at a given point in time, in a specific market, at a lower unit cost than another rice production system. This definition recognizes that competitiveness is a relative term. For example, a given rice production system can be more competitive than another rice production system in the regional market at a specific time in the year, for a given rice quality. At the same time, it might be less competitive than the same production system in a local market, given consumer preferences and transportation costs. The immediate implication of this definition is that evaluating the competitiveness of different rice production systems requires that these systems be compared at different market levels, for the same rice quality, and during the same time period. In this paper, Sikasso, Bougouni, and Bamako are used as output markets. *Bas-fond* rice quality is categorized as 45 percent broken rice, which is comparable in quality to *Thai A1 super*.

To assess the competitiveness of alternative production systems, simply comparing production costs is often inconclusive because these costs are frequently distorted by government policies or market failures. As a

result, a crop can be profitable for farmers (*e.g.*, because of price subsidies), even though its production may not represent an efficient use of resources from the point of view of the country. Conversely, a crop can be unprofitable for farmers, even though its production represents an efficient use of the country's resources.

The DRC framework offers what Michael Morris (1990) describes as a way to "see through market distortions" in order to empirically measure competitiveness by generating quantitative indicators of the efficiency of using domestic resources to produce a given crop. In this framework, the measure of efficiency is social profit, defined as each production system's net contribution per hectare of cultivated land to the national income.

The DRC framework generates two measures of the relative efficiency of alternative production systems: net social profit (NSP) and the domestic resource cost (DRC) ratio. The NSP indicates the contribution of each rice production system to national income, measured in terms of social net returns to family labor and management. In contrast, the DRC ratio, which is a restatement of the NSR expressed as a unitless ratio, indicates the efficiency of each alternative system in using domestic resources to earn or save one unit of foreign exchange. However, both indicators lead to the same conclusions. This paper uses the DRC ratio.

First, DRC ratios are estimated for subsistence and commercial *bas-fond* farms³. To determine these DRC ratios, fertilizer and paddy market prices were adjusted to reflect their social value, and the cost items are grouped into their tradable and nontradable components. In this process, the costs of CMDT investments to control water, which were excluded in the financial analysis because they are borne by CMDT, are included. In addition, secondary data are used to estimate similar budgets and DRC ratios for two commercial rice production systems managed by the *Office du Niger*--a rehabilitated perimeter in Niono and a non-rehabilitated perimeter in Macina. All these DRC ratios are estimated by varying the distance between each of the three central output markets under consideration and the village where the rice was produced. A detailed discussion of these estimations is reported by Dimithè (1997). The results obtained are represented in Figures 3 to 6 for the *bas-fond* systems and Table 6 for the *Office du Niger* systems.

Figure 3 depicts how these DRC ratios for subsistence *bas-fond* rice production systems vary over space, as the distance between the production/consumption point and Bamako increases. Figure 3 shows that the four systems have DRC ratios which are less than 0.7, regardless of the distance between the production/consumption point and Bamako. In other words, producing rice for home consumption in any of the Mali-Sud *bas-fond* systems is a better use of domestic resources than shipping rice from outside the region into Mali-Sud to feed these farm households. However, it is important to recognize that this result does not take into account the production risks associated with erratic rainfall and poor water control in these *bas-fonds*.

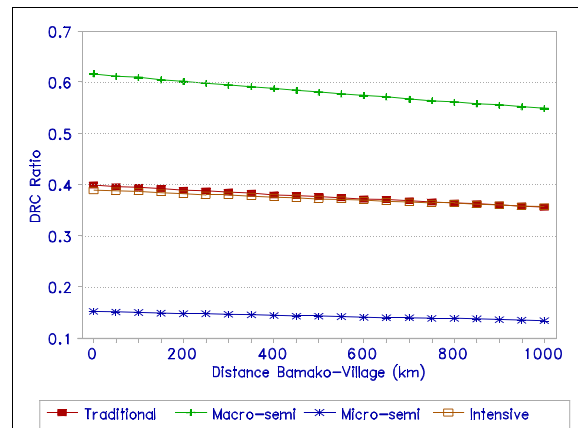


Figure 3: DRC Ratios for Subsistence *Bas-Fond* Rice Production Systems over Space, Mali, 1997.

³ Bas-fond farms that consume all of the rice they produce are defined as subsistence farms, whereas *bas-fond* farms that sell all of their production are considered to be commercial farms.

Figures 4-6 depict how DRC ratios for commercial *bas-fond* rice production systems vary over space, depending on the market in which the farmers sell their rice. These figures show that the further the production site is from the sale point, the less competitive these systems become. However, the production site would have to be very far from the market for any of the *bas-fond* systems to lose their competitiveness in those three output markets.

More specifically, Figure 4 shows that, if commercial *bas-fond* farmers sell their rice in Bamako, the *macro-semi-intensive* system is not competitive ($DRC > 1$), regardless of the distance between Bamako and the production site. In contrast, the *intensive* system is competitive ($DRC < 1$) in Bamako if the production site is less than 740 km away from Bamako. Rice produced in both the *traditional* and the *micro-semi-intensive* *bas-fond* production systems is competitive in the Bamako market for farms located less than 1,000 km away from Bamako, which include all Mali-Sud's *bas-fond* rice production sites.

Figure 5 shows that, while not competitive when Bamako is the output market (Figure 4), the *macro-semi-intensive* production system is competitive if *bas-fond* farmers within 288 km of Bougouni sell their rice in this town's market, which is closer to the rice production area than Bamako. Similarly, the *intensive* system is competitive in the Bougouni market if produced within 945 km of Bougouni. Finally, rice from both the *traditional* and the *micro-semi-intensive* *bas-fond* rice productions are competitive in the Bougouni market for farms located less than 1,000 km from Bougouni.

Finally, Figure 6 shows that, the *macro-semi-intensive* production system is competitive in the Sikasso market, the closest main city to the production sites, if produced on farms within 408 km of Sikasso and these *bas-fond* farmers sell their harvest in this market. Similarly, the other three systems are competitive in Sikasso as long as the production site is within 1,000 km of the city, which they all are.

Table 6 summarizes the DRC ratios associated with commercial *Office du Niger* production systems as reported by Dimithè (1997). The results obtained shows that, when family labor is valued at 500 CFA.F/day, rice harvested from these two systems is not competitive in any of the three markets. However, if the opportunity cost of family labor is assumed to be zero, rice produced in both of these two systems is only competitive in Sikasso.

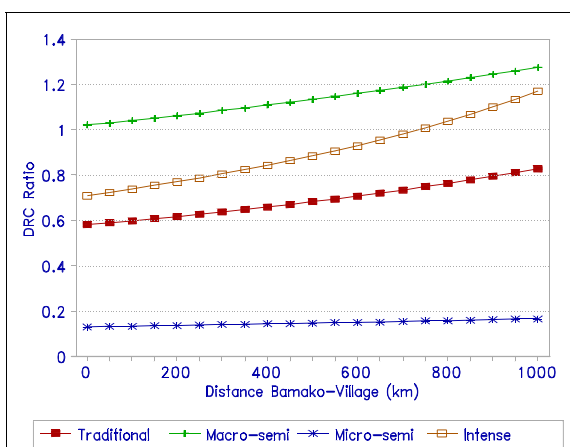


Figure 4: Bamako Output Market, DRC Ratios for Commercial *Bas-Fond* Rice Production Systems over Space, Mali, 1996.

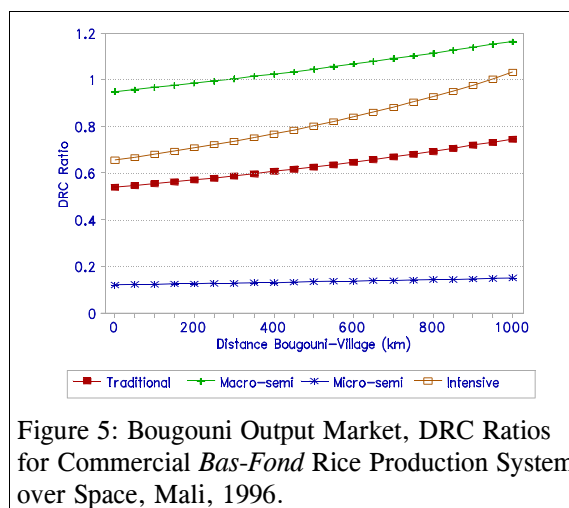


Figure 5: Bougouni Output Market, DRC Ratios for Commercial *Bas-Fond* Rice Production Systems over Space, Mali, 1996.

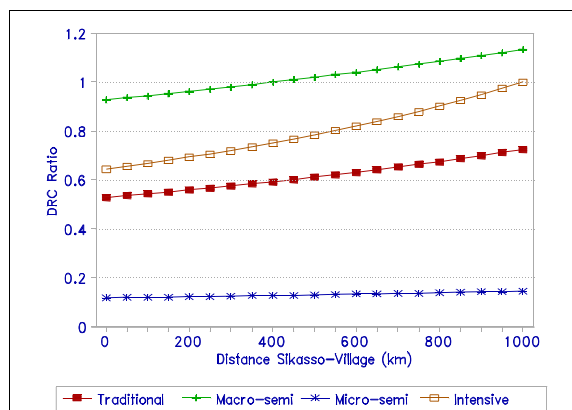


Figure 6: Sikasso Output Market, DRC Ratios for Commercial *Bas-Fond* Rice Production Systems over Space, 1996.

Table 6. DRC Ratios^(a) for Commercial *Office du Niger* Rice Production, by Sale Point, Mali, 1996.

Production Systems	Family labor wage rate = 500 CFA.F/day			Family labor wage rate = 0 CFA.F/day		
	Bamako	Bougouni	Sikasso	Bamako	Bougouni	Sikasso
<i>Rehab. perimeter</i> (Niono)	1.295	1.264	1.179	1.066	1.042	0.974
<i>Non-rehab. perimeter</i> (Macina)	1.275	1.243	1.147	1.080	1.053	0.971

Comparing the *bas-fond* (Figures 3-6) to the *Office du Niger* (Table 6) systems indicates that, within 1,000 km of the *bas-fond* production area, rice from the *bas-fond* systems would be more competitive than rice of the same quality harvested from any of the *Office du Niger* systems, if sold either in Bougouni (Figure 5) or Sikasso (Figure 6). The same conclusion holds if farmers sell their rice harvest in Bamako, except that in this case the competitive superiority of the *bas-fond*'s *macro-semi-intensive* systems is limited to 700 km. Clearly, this result leads to the conclusion that, from the national perspective, it is less costly to produce 45 percent broken rice quality in the *bas-fonds* than in perimeters managed by the *Office du Niger*, assuming farmers' harvest is sold either in Bamako, Bougouni or Sikasso.

Conclusions

This paper has demonstrated that, for three fundamental reasons, *bas-fond* rice production could be a major contribution to improving household food security in Mali. First, if all Mali-Sud *bas-fonds* were brought into production, their production would represent about 31 percent of the total amount of paddy produced in the *Office du Niger* annually over the last five years, and 22 percent of commercial imports and food aid to Mali. If all Mali-Sud *bas-fonds* and flooded plains were brought into production, they could supply about 43 percent more paddy than the average quantity of paddy produced in the *Office du Niger* annually over the last five years, and roughly the same amount of grains as was imported annually through commercial imports and food aid.

Second, it makes sense for *bas-fond* farmers to produce rice because this enterprise is not only financially profitable, but it also yields higher returns to a day of family labor than the three upland crop enterprises competing with rice for farmers' labor. Therefore, by increasing rural incomes, *bas-fond* production raises rural households' access to food. Finally, the *bas-fond* rice production enterprise also makes sense from the national perspective. Not only do the DRC ratios establish that the *bas-fond* rice production system's contribution to Mali's economy is sufficiently large to justify using scarce resources that are required to further develop these systems, but in addition the *bas-fond* rice production systems use domestic resources more efficiently than the two *Office du Niger* systems studied (*i.e.*, the non-rehabilitated perimeter of Macina and the rehabilitated perimeter of Niono).

In a broader context, the paper provides an empirical evidence that, if given more attention, there exists marginal lands in Mali and certainly in the Sahel region that can significantly increase the potential for these African countries to improve their food security. Given the positive financial and economic performances of *bas-fond* rice production systems, there are two complementary (farm-level) ways to bring about the needed increase in its level of production. One way is through an extensification strategy that will expand the current technology over a wider production area. The preceding analysis of the private and social profitability of *bas-fond* rice production is an analysis of this option. Currently, only part of the *bas-fonds* are utilized because poor water control condition limits the command area. In order to utilize the total potential area of Mali-Sud *bas-fonds* fully, it would be necessary to improve the water control system and address other constraints *bas-fond* rice farmers face, especially labor constraints at weeding, a very tedious operation done manually. The existing quality and effectiveness of water control infrastructure (*i.e.*, dams across streams with no internal

control of the water level) can be improved with complementary investments in plot-level water control (*e.g.*, internal bonding).

With regard to labor, its large share in the total production cost (relative to other cost items) in each of the four most common *bas-fond* systems (44-86%) suggests that, 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. The high profitability of the *micro-semi-intensive* system (involving only use of herbicide) relative to the other systems indicates that given the current degree of water control in the *bas-fond*, insufficient labor for weeding is the most serious constraint on production at the present time.

The other complementary way to increase *bas-fond* rice production is through an intensification strategy involving the use of yield-increasing modern inputs such as improved varieties, and herbicide and fertilizer applications, taking into account local resources and farmers' specific conditions. While the analysis of the rice enterprise profitability presented in this paper focuses on current technology, we have argued in other publications (Dimithè, 1997) that intensifying *bas-fond* rice production would require that a number of constraints be addressed. First, because the varieties farmers currently plant were developed for a much drier area their yields tend to be lower, compared to those observed in the *Office du Niger*. For a greater intensification of *bas-fond* rice farming, scientists must develop appropriate high-yielding varieties.

However, transferring the high experimental yields achieved on-station to the heterogeneous *bas-fond* environment represents an enormous challenge for Malian researchers because they must develop higher-yielding varieties that are appropriate for the *bas-fond* environment which is unstable due to poor water control (Dimithè, 1997). 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. 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.

Second, 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, those constraints (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.

Third, 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, although *bas-fond* rice farmers are predominantly women (88%), 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 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.

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