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PRODUCTION IMPACT REPORT

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With Collaboration of the Unite de Politique Agricole/Ministry of Agriculture and SAED/DPDR

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1 INTRODUCTION

1.1 Report Objectives and Approach

Rice sector reforms represent one of the central pillars of changes which the Senegalese government has undertaken in agriculture in the past decade in an effort to reinvigorate its economy The objective of the research activities which this report summarizes has been to assess the impact of these reforms on rice producers Four issues have framed the research into this impact First ***how have reforms affected the performance of the rice producing sector?*** This question seeks to establish the direct effect of reforms on production and productivity in the sector The second and third questions attempts to examine reasons behind changes in performance The second question examines ***how reforms have affected the environment of rice production?*** This question seeks to understand changes in the markets for rice paddy as well as of commercial inputs and services, and domestic resources that farmers use in rice production Understanding these changes then allow a response to the third question which is ***how reforms have changed incentives to produce rice and the resultant behavior of rice producers*** This question focuses on changes in level and variability of net financial returns to rice production It then examines changes in production behavior that has been brought about by these new incentives Lastly, the analysis then poses the larger question of ***what are the long-term consequences of reforms for rice production*** This question seeks to assess changes in the longer-run viability of the rice production economy as a result of reforms It does this by investigating the underlying economic value of rice production and consequences for producer welfare

1 2 Review of Policy Reforms and Expected Impacts on the Rice Sector

A review of rice sector policy actions which occurred in Senegal over the decade between 1987 and the present demonstrate the dramatic changes which has taken place in the economic environment of rice production Table 1 1 summarizes these changes, and presents hypotheses of the expected impact of each reform on (a) farmer incentives to produce rice, (b) the rice farmers' overall welfare, and (c) the economic efficiency of rice production The reforms and the hypotheses attached to them are explained below These hypotheses underlie the analyses of questions posed above, which are evaluated in the remainder of the report

1 3 Factor and Input Market Reforms

Initial reforms in the rice sector dealt with the withdrawal of SAED from factor and input markets Factor market reforms included the ceding managing control of "pioneer" lands (which included most new areas suitable for irrigation development) to community organizations A second reform in this area was the withdrawal of SAED from extending input credit for agriculture Its role was replaced by the CNCA, which established an office in St Louis to provide seasonal and equipment credit to farmers in the Senegal River Valley These two reforms

occurred together and were coordinated such that new investors in land or rice processing received preferential consideration for credit

Concurrent with these reforms, SAED also phased out its role in the distribution of inputs to agriculture This role had included supply of imported inputs, production of improved seed, and in some cases, subsidization of these inputs for irrigated crops These activities were ceded to the private sector, with SAED only serving as an advisor to producers in the choice and use of inputs

Each of these reforms was expected to improve access to, and facilitate efficient allocation of capital, land and agricultural inputs to rice and other agricultural activities They were therefore expected to improve production efficiency Effects on rice production and producer incomes where also expected to be positive because the reforms were expected to attract more land and capital to agricultural invests in the valley, and particularly in rice production, and raise production through more effective use of inputs

1 4 Rice Market Reforms

Reforms in the rice market began later and resulted first in a withdrawal of SAED from marketing domestic production, and subsequently in a withdrawal of the government from the role of direct importer of rice Simultaneous with the withdrawal of SAED from role of production wholesaler and processor, the apparatus for determining the domestic price was liberalized In the first phase, the domestic price was allowed to reach an internal price equilibrium subject to managed imports and administered border prices With the liberalization of international trade, the price was allowed to seek its own level with respect to the international market as well, subject only to the effects of border tariffs

Expectations of the results of these reforms are, first, that marketing efficiency would rise with the transfer of responsibility for collection and processing at the producer end, and the transfer of importing and wholesaling to private actors Regarding price levels, the expectation is less obvious, because even as the reforms were implemented, wrangling continued about the levels of protection which would be maintained for the domestic market The tariff regimes adopted by the government ostensibly maintained protection levels at near their historical levels However, as the analyses which follow will demonstrate, these reforms were only partially implemented, and so reduced rice protection and therefore incentives to producers Lastly, the reduction in protection is expected to raise efficiency in rice producing and provide a net positive contribution to overall economic welfare

Table 1 1 Policy Reforms Affecting Rice Producers

Date	Reform[a]	Impact on rice production incentives[b]	Impact on farmer welfare[b]	Impact on production efficiency[b]
	Factor and Input Market Reforms	+	+	+
1987	Transfer of "pioneer" lands from SAED management to *Communaute Rural* management			
1987/ 1988	CNCA takes over input and equipment credit operations from SAED			
1989	Liquidation of last SAED input stocks			
1989	Privatization of agricultural equipment services			
1990	Privatization of irrigation infrastructure construction and maintenance services			
1990	Transfer of seed farms and sorting center to producer organizations			
	Rice Market Reforms	-	+/-	+
1994	Privatization of SAED rice mills			
1994	Abandonment of administered paddy price			
1994	Liberalization of local rice sales by the CPSP			
1995	Liberalization of rice import trade			
1995	Revision of border protection to include Variable Levy			
1996	Reform of operational procedures for variable levy			
	Macroeconomic Reforms			
1994	Devaluation of the currency	+	+/-	+

Note [a] Derived from Jean François BELIERES *Difficultes de mise en place d une alternative liberale a un modele de developpement de type revolution verte administree et moderne Le cas de la riziculture irriguee dans le Delta du fleuve Senegal* (CIRAD SAR Montpellier le 6 septembre 1995)

[b] + = positive impact – = negative impact +/– = substantial positive and negative impacts ? = unknown impact

1 5 Macroeconomic Reforms

It is important to mention other broader structural reforms to the Senegalese economy which occurred concurrently with these reforms because they have also contributed to the impacts which have occurred on producers Most notably the currency devaluation in 1994 occurred roughly simultaneously with the liberalization of the rice market The devaluation resulted in a substantial improvement in the profitability of rice production given the full tradable nature of the product, in comparison to a substantial contribution of nontradables in production costs To a large extent, this improvement offset the loss of protection resulting from market reforms, and thereby cushioned the immediate impact of these reforms On the other hand, to the extent that the effects of the devaluation are being gradually eroded by domestic inflation, this effect may be transitory

Other macroeconomic reforms, including revisions of investment, banking and trade policies to stimulate private investment and growth may be expected to contribute to the agricultural sector, including rice producers Again however, the anemic response of investment to reforms in general suggests that either these reforms remain to be implemented or that they have not been sufficient to induce these responses

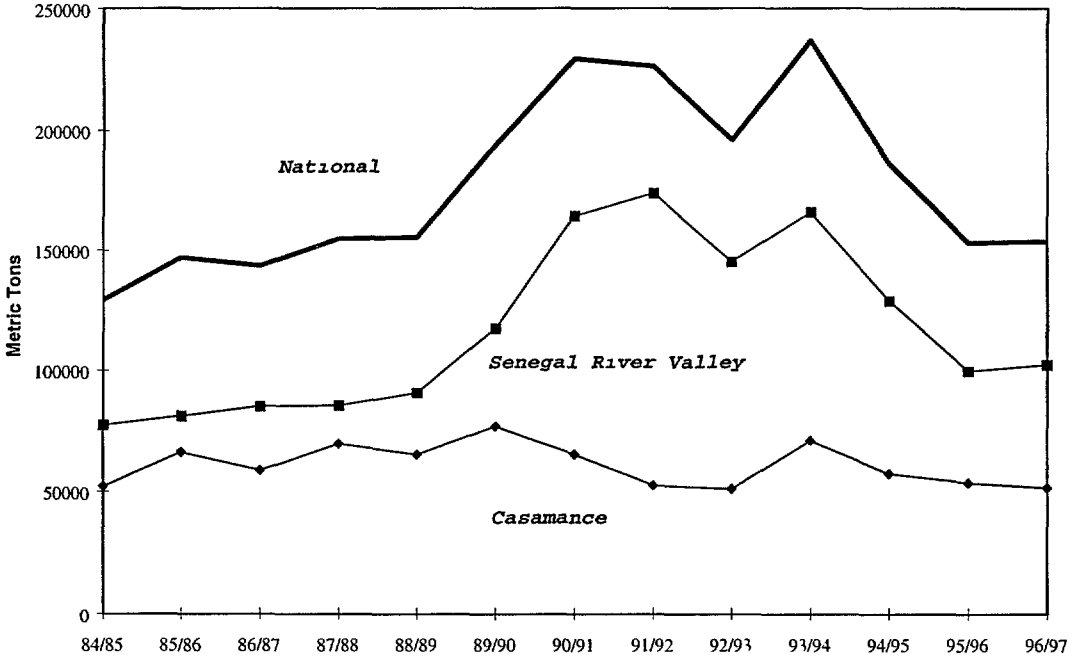
2 HOW HAVE REFORMS AFFECTED PERFORMANCE OF THE RICE PRODUCING SECTOR IN SENEGAL

2 1 Trends Over the Period of Policy Reform

Since the beginning of rice sector reforms, rice production in Senegal has shown, first a rapid growth in production, and then a decline These trends are plotted in Figure 2 1 Both the growth and the subsequent decline have been due primarily to changes in production in the Senegal River Valley, as suggested by the relative stability of production in the other principal producing area of the country, the Casamance As the Figure illustrates, total national production in 1997/1998 returned to levels roughly equivalent to levels achieved ten years ago, although the share contributed by the Senegal River Valley (SRV) has increased marginally in comparison to the Casamance

FIGURE 2 1

Senegalese Rice Production

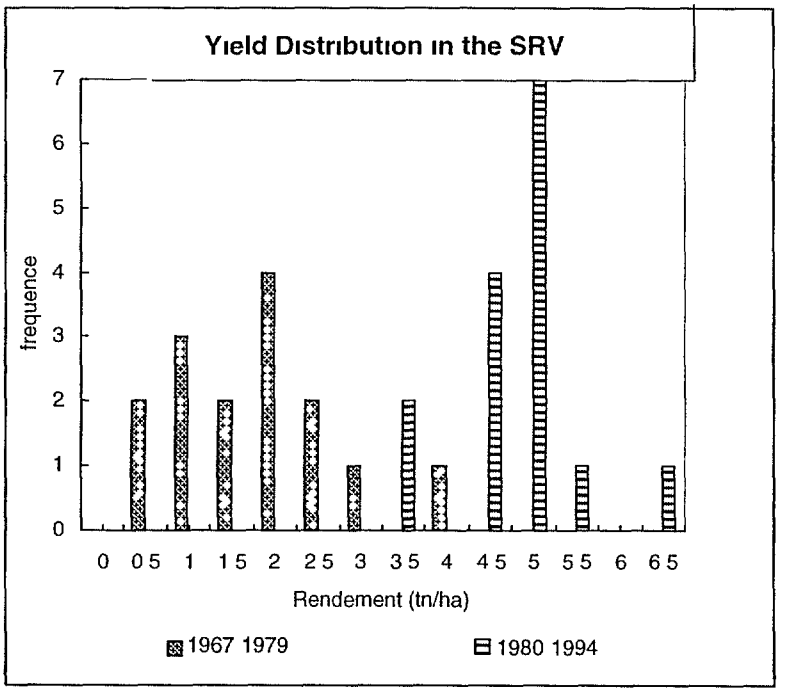


Within both regions, Figure 2 2 and Figure 2 3 (on the following page) illustrate the contribution of area and yield changes to these trends over the same time period From these figures it is clear that the principal source of production expansion and then contraction in the Senegal River Valley has been changes in cropped area which has followed the same expansion and contraction trend that is shown by production (These trends are roughly the same for both rainy and dry season areas, although rainy season area is consistently an order of ten times more than dry season area) Yield trends in the SRV show almost no change over the period, despite a very strong yield peak in 1994

In the Casamance, agricultural ministry data suggest that cropped area actually contracted during the early 1990s, in the same interval that it was growing in the SRV As in the SRV, yields show very little trend in the Casamance

The observed divergence in performance of the two regions over the last twelve years suggests a distinctly different reaction to the policy environment for rice reforms over the period of the past 15 years This report will argue that the substantial growth and then stagnation over the period in the Senegal River Valley has been in response to changes in production incentives, while relatively unchanged rice production in the Casamance reflects the economic isolation of it's rice economy

FIGURE 2 4



The relative stagnation of yields over the past decade ignores a more important trend that occurred in the previous decade when irrigated rice production in the Senegal River Valley was first installed Irrigation created the opportunity to produce rice under controlled conditions, which allowed technical intensification using high yielding varieties and fertilizers This "intensive" rice technology resulted in the dramatic improvement in rice yields, which is illustrated in Figure 2 4 This change in rice yield explains the divergence of rice yields that is evident in Figure 2 3 between the SRV and the Casamance

FIGURE 2 2

Trends in Area Planted to Rice

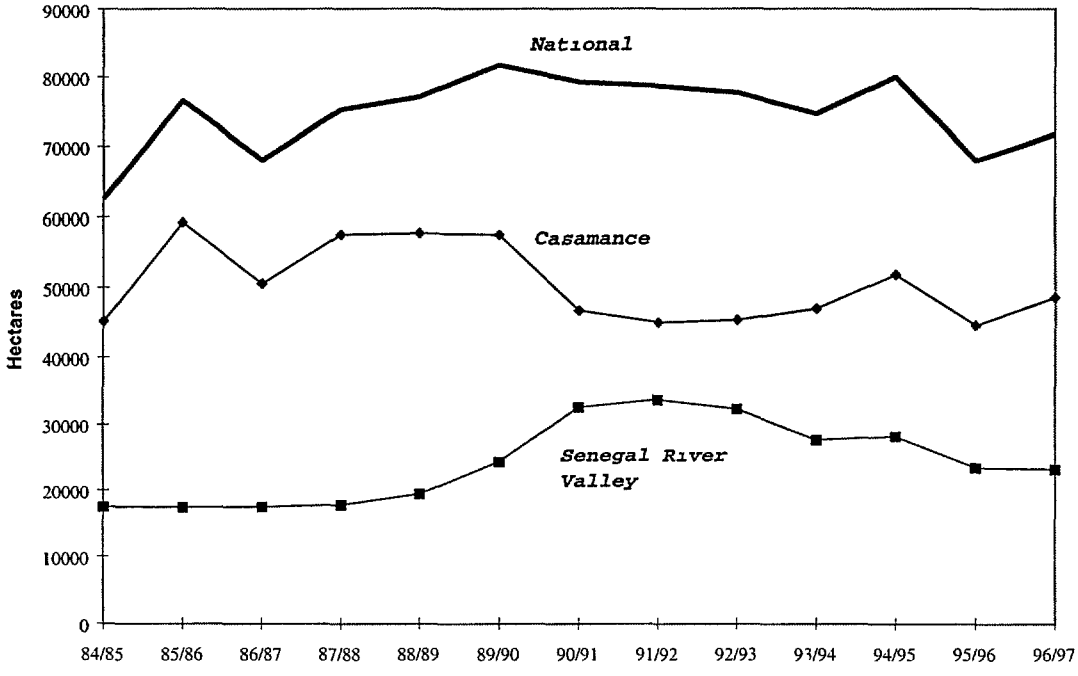
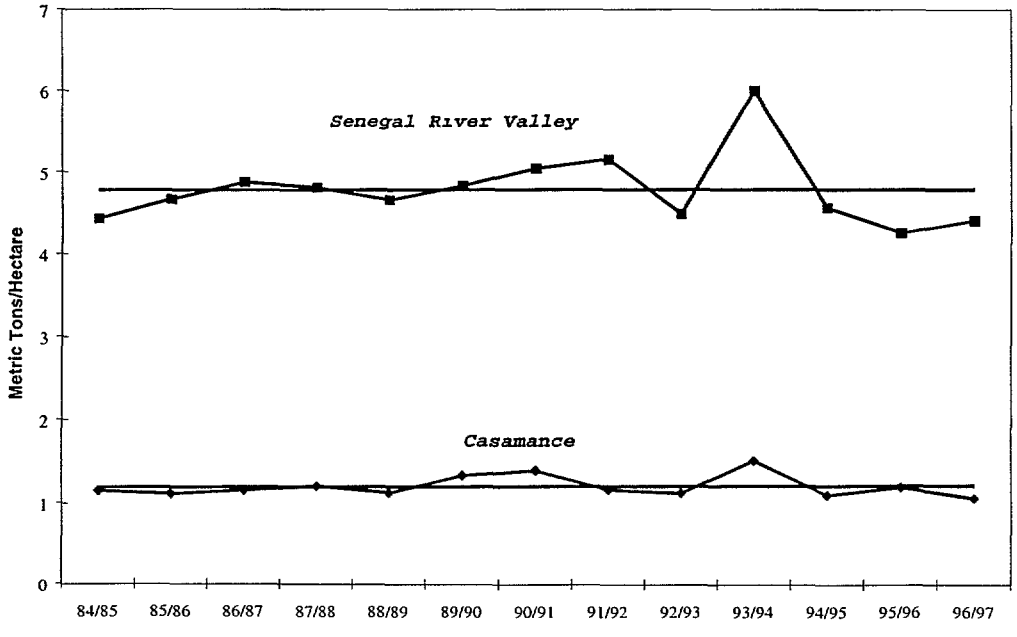


FIGURE 2 3

Trends in Rice Yields by Region



Since the mid-eighties, however, trend growth in yields has not occurred However, the dramatic spike in yields in 1993/1994 does suggest potential yields in the region with existing technologies is substantially higher than current performance The reversal of this yield spike occurred simultaneous with the currency devaluation in 1994 One hypothesis examined in this report is that this yield reduction occurred because tradable inputs used in rice production doubled in price following the devaluation, and resulted in a reduction in input dose levels and hence a return to lower yields

2 2 Current Production Performance

In the last year, the performance of the rice sector in Senegal has continued to stagnate, reflecting two principal problems in the production economy (i) A continuing weakness in financial incentives to produce in the Senegal River Valley, and (ii) A severe credit constraint Given the current policy environment it is not likely that this situation will change dramatically next year In the Casamance, security disturbances may adversely affect rice productive in that region, although there is little evidence of this to date Each of these issues is explored in sections below

2 2 1 Senegal River Valley

Rainy season trends

Planted area for the 1997 rainy season *(hivernage)* exceeded the 1996 rainy season planted area as of the end of September but by only a small amount (2%) The 1996 *hivernage harvested* area represented 90 6% of planted area This exceeded the previous year's harvested area by slightly more than 100 hectares despite the fact that nearly 300 hectares less area were planted Thus the cropping efficiency of harvested area to cropped area rose substantially last year

SAED expectations are that yields will again achieve the 4 5 ton/ha[1] that were attained last year (However, new data from SAED based upon a different measure of production give a more detailed picture of yield performance in the river valley These suggest that last year's yield assessments may have overstated production in general)

If the higher harvesting percentage attained last year can also be sustained this year, and if yields also hold at last year's levels, production will grow very slightly this year In light of lower public seasonal credit disbursements this year, this result is especially welcome in suggesting that the rice sector has not continued the drop in production that was experienced in 1995/1996

[1] 1997 data are based upon estimates made in SAED's *Suivi Hebdomadaire de la Campagne Agricole 1997 1998 Situation 30/9/97*

Dry season trends

Although exact data are not yet available, SAED estimates based upon area planted show an increase of nearly 30% in rice production in the last dry season These data contradict expectations of a variety of knowledgeable observers who predicted that the dry season harvest had fallen off in 1997 from 1996 This was expected first as a continuation of the trend in which the *contre saison* (dry season) crop has declining since 1991 In 1996, *contre saison* production fell to levels lower than any since 1987 Expectations of continued decline in 1997 were also due to the lack of CNCA credit for the *contre saison* rice crop (This issue is discussed below under constraints)

Yield variability

Yield variability remains high in the Senegal River Valley and thus there are both very high and very low performers in all zones in the Senegal River Valley Table 2 1 presents yields by perimeter type and season between 1993 and 1996 for the Delta only based on SAED parcel data Perimeter types used here correspond to distinctions made by SAED These are

- Rehabilitated SAED perimeters,
- Extensions of SAED perimeters,
- Village perimeters, and
- Private perimeters

The first two categories distinguish respectively SAED perimeters, which have been rehabilitated and turned over to farmer group management although typically with substantial SAED support, and those, which are privately, constructed extensions of SAED perimeters undertaken by farmers with land in SAED perimeters Village perimeters represent collective efforts by farmer groups typically with less direct intervention by SAED, although SAED has often provided some technical advice and support to these groups Private perimeters are constructed by individuals typically with no formal assistance of SAED

Tests of significance show that differences both by perimeter type and season are highly significant but if seasonal averages are aggregated to yearly averages no significant difference in time is found These results confirm the validity of using season and perimeter type as category distinctions in analyses, which follow

Table 2 1 Average Yields in the Senegal River Valley Delta by Perimeter Type and Season

	SAED Rehabilitated		SAED Extension		Small Communal Perimeter		Small Private Perimeter	
	Mean	Coeff Var	Mean	Coeff Var	Mean	Coeff Var	Mean	Coeff Var
CSC93	5346	0 27			4863	0 65	3763	0 56
HIV93_94	4562	0 96	4652	0 37	3430	0 33	3291	0 59
CSC94	4369	0 36	5549	0 33	4163	0 16	7234	
HIV94_95	3745	0 46	4062	0 39	2916	0 53	3311	0 43
CSC95					3617	0 35	2387	
HIV95_96	4733	0 28	3339	0 58	3512	0 42	2908	0 38
Average	4551	0 47	4401	0 42	3750	0 41	3816	0 49

Source SAED Farm Survey 1993 1996
Note Using the French acronyms throughout PIV = small communal (village) irrigated perimeter, PIP = small private perimeter

Results in the table illustrate that SAED rehabilitations and extensions have had substantially higher average yields than either village or private perimeters in the Delta The pairwise yield distinction between the two SAED classifications are not significant in the sample, but are highly significant for all other pairs Also noteworthy is the fact that coefficients of variation are generally high in all cases, and especially so for private perimeters This reflects the perception of professionals that the expertise of managers of private perimeters varies greatly Surprisingly, however, yield variation in SAED rehabilitated perimeters is also high in comparison to extensions or village perimeters The explanation for this is unclear, but appears to reflect the very low performance in one season (Hivernage 1994/1995) No time trend can be discerned in the data based upon a regression of yield over time with dummies for perimeter type

SAED data also shows that yields also vary considerably by region of the SRV Delegation differences range between 1 3 ton/ha in Bakel to 4 3 ton/ha in Podor However, the extremely low yield levels in Bakel are misleading because they include rainfed *basfond* (flooded lowland) rice yields Other reasons for low yields are that farmers in Bakel also use lower seed quality, perhaps due to isolation, and practice more direct seeding and less transplanting than in the Matam Department Lower labor use in rice production, despite the proximity of the two regions is likely due to much higher male labor out-migration patterns around Bakel

2 2 2 The Casamance

Despite political insecurity in the Casamance during the past few years, rice production appears to have sustained past levels This lack of impact is a testament to the fact that rice production is largely for on-farm consumption and rarely enters the larger market Moreover it does not depend on the market for inputs since commercial inputs are rarely used

Table 2 2 Rice Area and Yield in the Casamance 1995/1996 and 1996/1997

Region	Departments	1995/1996		1996/1997	
		Area (ha)	Yield (paddy, kg/ha)	Area (ha)	Yield (paddy, kg/ha)
Ziguinchor	Bignona	14076	838	9951	1547
	Oussouye	4970	1251	5250	748
	Ziguinchor	3765	759	3543	871
	Tot / Moy region	*22811*	*949 3*	*18744*	*1055 3*
Kolda	Kolda	2943	902	4872	824
	Sedhiou	19192	1087	18057	941
	Velingara	2424	1087	2131	955
	Tot Moy region	*24559*	*1025 3*	*25060*	*906 6*
	Projet SODAGRI	610	3300	1127	4000

Source DISA/DA, provided by PROGES Project

Data from the PROGES project perimeters also confirms the apparent lack of impact of security issues on rice production While area fell by 9% in project valleys in the Sédhiou department, it rose by 8% in the Bignona department Moreover, in Sedhiou, yields more than compensated for area loss, with a 77% increase It is unclear what contributed to this large increase Project interventions including better water control structures, and improved seed may have contributed in part, but favorable weather may also have played a part Yields were relatively unchanged in the Bignona valleys

Overall, the current situation in both the Senegal River Valley and in the Casamance suggests that rice production has sustained levels of the recent past in both regions Despite great political turbulence in the region, the Casamance rice sector appears to be stable, largely due to the isolation of rice from the larger markets In the SRV, on the other hand, where market actors have taken over the product and input markets, recent stability reflects increasing maturity of these markets for producers, although the policy environment in which these markets operate remains in flux

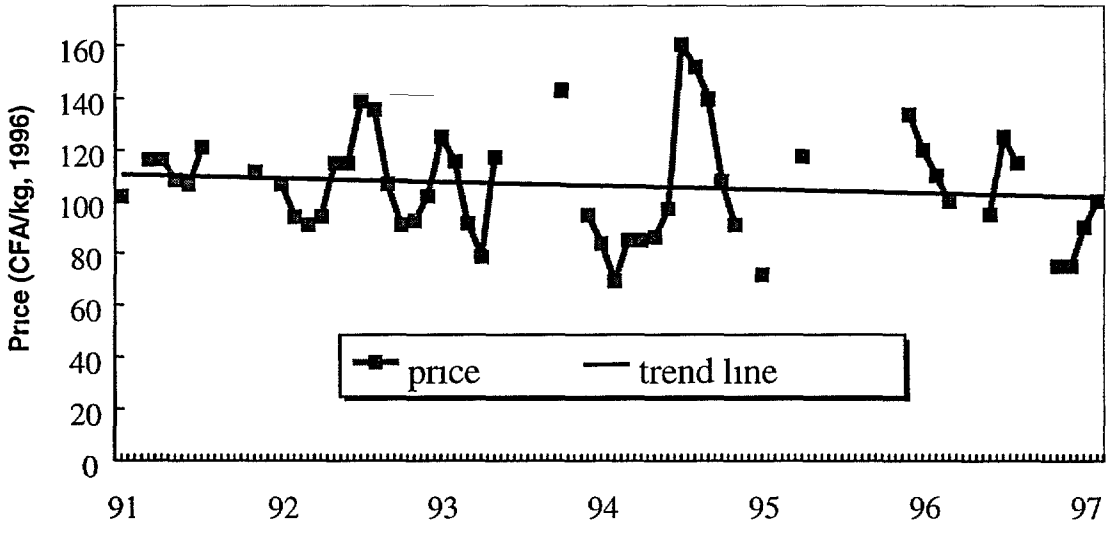
3 HOW HAVE REFORMS CHANGED THE RICE FARMING ENVIRONMENT

3 1 Product Markets

Paddy prices paid to producers rose in nominal terms between 1993 and the present, but in real terms they have remained stagnant and even declined slightly, as is illustrated by Figure 3 1 The nominal increase has been fueled by the 1994 devaluation, but despite the fact that rice is a traded commodity in Senegal, the nominal rise did not match the level of the devaluation (or even domestic inflation) The devaluation did not translate into a corresponding price increase because coincident with the devaluation, the government liberalized rice trade and reduced border protection for imported rice

FIGURE 3 1

Trends in Real Paddy Rice Price in the Senegal River Valley, Senegal



Presents a comparison of prices received by producers by perimeter type in the Senegal Delta between 1993 dry season harvest and the harvest of 1995/96 rainy season Both SAED perimeter types received the same price This is to be expected since farmers in both perimeters are in fact the same farmers Village perimeters appeared to receive higher average prices but this higher price is due entirely to higher prices that village perimeters received in the 1995 dry season, when SAED perimeters did not cultivate rice Private farmers, on the other hand received lower prices than others overall, perhaps reflecting their weaker bargaining power with

respect to buyers and mills, than other farmers who are typically obtain bargaining power through village or perimeter associations

Table 3 1 Average Paddy Price by Season and Perimeter Type (CFA/kg, SRV Delta)

	SAED Rehabilitated	SAED Extension	PIV	PIP	Group Total
CSC93	77 52		82 00	87 32	80 60
HIV93_94	88 48	91 57	93 19	79 95	88 64
CSC94	103 92	105 18	97 99	105 88	103 94
HIV94_95	102 47	99 45	94 24	91 77	100 36
CSC95			125 03	101 82	121 71
HIV95_96	120 02	119 40	117 76	117 32	119 40
Group Total	101 57	102 08	105 35	93 19	101 31

Source SAED Farm Survey 1993 1996

The market for paddy in the valley has undergone a transformation in the past decade from one largely controlled by a few mills to one in which most paddy is now hulled by small village level dehullers These small *"decortiques"* have gained popularity because operating costs per kilogram of product are lower, they are more accessible to farmers, and allow the farmer to micromanage sales of production

In competition with these small dehullers are a large number of rice mills Two of the rice mills are large privatized mills from SAED, while the rest are private mills, mostly "mini-rizerie" which were established in the early 1990s when the domestic market was privatized At that time the CNCA made a large credit envelope available for investments in rice marketing Due to low interest rates, and rapid production growth in the period, there was a rush to construct mills More than 30 were constructed Of these, however, only 15 ever opened, and today only 6 remain in operation The disastrous performance of this sectors may be attributed in part to very lax analysis of milling needs by credit agents for the sector, and in part to the reversal of fortunes of the rice sector in the valley in the mid 1990s

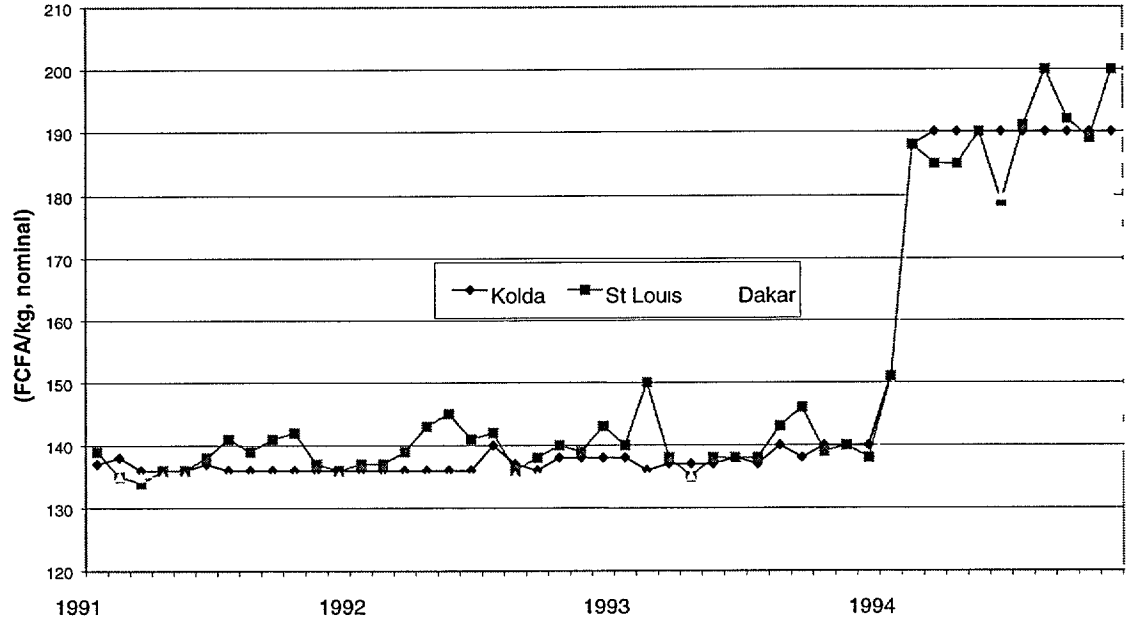
Less is known of price trends in the Casamance Wholesale markets exist in the urban centers of Ziguinchor and Kolda for rice, but virtually all rice in these markets is imported Until recently, local rice was virtually unavailable through markets This phenomenon is explained both by strong cultural aversions to selling rice and by economic conditions Cultural aversions are associated with the fact that rice has been traditionally produced by women for the household's consumption It was considered ungenerous to sell it to others Moreover, since less than 5% of households are thought to be net surplus producers of rice, the volume of rice available for market has been nearly nonexistent

Recently, however, an effort has been made by village and inter-village water user groups (Comité Villageois et Inter-villageois de Gestion de l'Eau) to promote local sales of paddy in periodic village markets In these markets, paddy has sold for an average of around 100 FCFA in 1997

A comparison of retail prices of imported rice in Senegal presented in Figure 3 2 suggest that for the Casamance region, the price of rice is closely linked to the price in Dakar and that the price is only slightly above the Dakar price, and usually less that the price in St Louis Another observation, which further supports the price link to external markets is the fact that The variability of the Kolda prices also closely reflects Dakar prices, further illustrating the close association of wholesale markets to world prices As an importable to the village level, the village price can be assumed to fallow these prices closely and even if local paddy is not commonly sold, these prices may also be assumed to reflect the opportunity cost of local paddy

FIGURE 3 2

Comparison of Rice Prices



3.2 Input Markets

3 2 1 The policy environment for inputs

Current policy in Senegal is to create an environment conducive to input use in agriculture In accordance with this policy, some importable agricultural inputs, particularly fertilizer, benefit from reduced or zero tarriffication A second policy, which has encouraged input use for the first half of the past decade, has been the general overvaluation of the exchange rate To offset this implicit tax on local production of inputs, a third policy has been the

protection of domestic investments in agricultural inputs This policy has applied to phosphate fertilizers, several phyto-sanitary products and some farm equipment, which are produced locally This protection has been applied, however, not in the form of tariff protection, but rather through licensing of production and trade in commodities produced in Senegal to those who produce them

Liberalization of input markets in the Senegal River Valley occurred in 1988 when SAED withdrew from fertilizer and crop protection chemical delivery With the liberalization of the input market, a period of rapid proliferation of input suppliers occurred in the valley These suppliers rapidly filled the vacuum created by the withdrawal of SAED services, particularly in the Delta where there was a concentration of users These suppliers rely however on very few sources of supply The largest supplier is SenChim, which is the distribution affiliate of Industrie Chimie du Senegal (ICS), the only phosphate producer in Senegal SenChim is jointly owned by ICS and a European agrochemical firm This position gives it sole rights to sell ICS production in Senegal Its European partners also insure its ability to provide other inputs to the Senegalese market at attractive prices The second largest player in the input market is SPIA, a private industry based in Louga which both imports and fabricates plant protection chemicals

Table 3 2 Analysis of Nominal Protection for Fertilizer Inputs to Rice Production (CFA/tn)

DAP	Level	Mill	Port	Wholesale	Retail	Retail
	Location	Dakar	Dakar	Dakar	Ross Bethio	Ziguinchor
Price Structure						
Market price (sales)	a	120000	120000	142000	154000	232500
Cost price	b	110456	132772	128250	151487	170247
Reference price	c	98039	126032	134282	143740	160492
Cost of Tradables						
Market price (sales)	d	101141	109274	136800	131409	198674
Cost price	e	91597	122045	123050	128896	136421
Reference price	f	86240	118181	119066	124151	130564
Nominal Subsidies						
Official	(b/c)	1 13	1 05	0 96	1 05	1 06
Market	(a/c)	1 22	0 95	1 06	1 07	1 45
Nominal Protection Coefficient						
Official	(e/f)	1 06	1 03	1 03	1 04	1 04
Market	(d/f)	1 17	0 92	1 15	1 06	1 52

UREA	Level	Mill	Wholesale	Retail	Retail
	Location	Dakar	Dakar	Ziguinchor	Ross Bethio
Price Structure					
Market price (sales)	a	140000	140000	240000	160000
Cost price	b	125433	134758	170761	157018
Reference price	c	119684	129009	150600	140274
Cost of Tradables					
Market price (sales)	d	130507	122295	199237	117084
Cost price	e	115941	117053	129998	114102
Reference price	f	112812	113795	125005	112060
Nominal Subsidies					
Official	(b/c)	1 05	1 04	1 13	1 12
Market	(a/c)	1 17	1 09	1 59	1 14
Nominal Protection Coefficient					
Official	(e/f)	1 03	1 03	1 04	1 02
Market	(d/f)	1 16	1 07	1 59	1 04

Source SENAGROSOL 1997

In interviews with producer groups, several raised the problem of price gouging by wholesale suppliers These claims were corroborated by a small input supplier which claimed that one large supplier undermined its efforts to import and sell urea in 1994 by offering to buy its stocks of imports at cost, and when it refused, by slashing their own price of urea to force it out of business

To test the efficiency of the internal market in providing these products to farmers in the Senegal Valley, SENAGROSOL carried out a rapid study to assess costs and marketing margins in importation or local production of the most important inputs to rice production DAP and urea, the principal fertilizers, and Propanil, Weedon and Furadan (the principal crop protection chemicals) Of these only DAP and Propanil are produced in Senegal, while the others are imported

Results of their analysis presented in Table 3 2 show that in the Senegal River Valley market prices for these products closely reflect costs of production or importing plus transaction margins in moving these productions to points of sale Differentials between cost prices and market prices are less than 10% in all cases in the Senegal River Valley Comparisons between market prices and import-based prices suggest only slight margins that are not explained by official taxation in the Senegal River Valley Market price based nominal protection coefficients report the ratio of market prices to economic costs of delivery to points of sale In the Senegal River Valley these are typically less than 5% for fertilizers and less than 15% for crop protection chemicals The tax margins reflect indirect taxation of transactions cost in the case of fertilizers, since no direct border tax applied on fertilizers The higher tax on crop protection chemicals is due to the TVA applied on these products

On the other hand, in the Casamance, differentials between actual market prices and estimated costs of importing are over 50% Prices in 1997 confirmed the continuation of these high prices, with retail prices reaching 260 CFA/kg for Urea, 240 CFA/kg for DAP and 5000 CFA/kg for Propanil These high prices suggest that markets are operating imperfectly in the south This poor performance is not surprising given the presence of only one distributor of fertilizers in Ziguinchor The lack of competitors is explained by the very low volume of commercial inputs used in the region

These results suggest that despite stories of irregular behavior by input suppliers, there is little evidence that this is an important problem in the Senegal River Valley This is not to say that individual suppliers do not resort to unscrupulous means, nor that prices don't vary substantially Prices for inputs as with rice now reflect variation in world market conditions These variations are important and are liable to continue to illicit complaint from farmers On the other hand, in Casamance, there appear to be very large rents in the market, due primarily to the small size of the market

3 2 2 Seed

Since, responsibility for rice seed production in the SRV has been transferred to a seed producers association Despite several subsequent supply shortages, this transfer of

responsibility appears to have been successfully accomplished and to have resulted in an improvement in the availability and quality of certified seed in the SRV Evidence of improved seed quality is provided by tests conducted by the regional agricultural office, which found higher germination rates, and lower levels of heterogeneity, and of foreign matter in seed subsequent to these changes [2]

Table 3 3 Share of Seed Purchased from Alternative Sources in SRV Delta

	CSC93	HIV93_94	CSC94	HIV94_95	CSC95	HIV95_96
Own Seed	48 5%	37 5%	56 9%	49 1%	50 0%	21 2%
Farmer Organization	3 0%	21 9%	36 2%	17 2%	30 0%	43 2%
Merchants	24 2%	17 2%	5 2%	26 7%	10 0%	15 3%
Other Organizations	24 2%	23 4%	1 7%	6 9%	10 0%	20 3%

Source SAED Farm Survey 1993 1996

Changes in the market for rice seed in the SRV are also suggested in Table 3 3, which gives evidence of a reduction in farmer reliance on their own seed It shows farmer use of own production for seed dropping from 48 % to 21% between 1993 and 1996 while sourcing from farmer organizations rose from 3% to 43% This change in thought reflects farmers buying improved seed from seed producer associations

Fluctuations in seed sourcing are also evident in the table, however These have been blamed on ruptures in availability of improved seed in the last few years, particularly in 1995/1996 From the seed producers' union's perspective these have been caused by their inability to obtain credit to produce to levels sufficient to meet demand In 1997, however, reflecting their interest in the seed market, the seed producers' union reported plans to expand production again even if it did not get the credit that it had requested of the CNCA As of June 1997, more than the total production of the previous year had already been financed out of association members' own resources This enthusiasm to produce was due to the strong sales of the previous year's seed production

Rice seed costs to farmers have risen since 1993 in response to the devaluation Differences in seed cost appear to be significant, with PIP show the highest average costs Differences in costs between perimeter types are thought to reflect differences in use rates of certified seed rather than differences in seed price

As Table 3 4 illustrates, the pace of increase has not kept up with inflation despite the fact that both the price and the share of higher cost certified seed in use has increased The remarkable weakness of the cost increase suggests that liberalization of the seed market has improved productivity among seed producers and so countered inflationary pressures

[2] Interview with Departmental Agricultural Officer in St Louis

Table 3 4 Rice Seed Price Comparisons by Season and Perimeter Type in the SRV

(CFA/kg)

	SAED Rehabilitated	SAED Extension	PIV	PIP	Group Total
CSC93	123		204	187	147
HIV93_94	156	130	152	172	154
CSC94	112	114	147	90	114
HIV94_95	158	144	109	181	154
CSC95			133	100	130
HIV95_96	197	167	178	182	190
Group Total	158	139	153	176	157

Source SAED Farm Survey 1993 1996, Dagana Department data only

In the Casamance, efforts by the Winrock /ISARA project and by PROGES to promote improved seed varieties have also begun to show results A 1996 PROGES survey found between 20% and 30% of households with irrigated land now use improved rice seed A continuing problem, however, is the slow rate at which farmers renew their seed stock A principal constraint in this regard is the lack of a sufficient improved seed multiplication structure

3 2 3 Other inputs

Unlike rice seed, other input prices have risen much more rapidly, reflecting their tradable characteristics For other inputs, prices have risen by between 60 and 90 percent The two that rose the least, DAP and Propanyl are the two which are produced domestically, while, Weedon and Urea, which rose 90% and 75% respectively, are both imported Moreover, as illustrates, nearly the entire increase in each case occurred in the first season after the devaluation for each of these commodities, unlike seed These characteristics reflect the increasing tradable nature of these commodities

Table 3 5 Evolution of Input Price Indices

(CSC 1993 = 100)

Season	Inflation	Rice Seed	Urea	DAP	Weedon	Propanyl
CSC93	1 00	1 00	1 00	1 00	1 00	1 00
HIV93_94	1 02*	1 05	0 92	0 99	1 05	0 92
CSC94	1 32	0 78	1 71	1 69	1 87	1 70
HIV94_95	1 52*	1 05	1 75	1 61	1 93	1 56
CSC95	1 61	0 88	1 70	1 80	2 20	1 76
HIV95_96	1 68*	1 29	1 75	1 62	1 90	1 58

Note * indicates interpolated estimate by author

3 2 4 Machine services

Unit cost increases per hectare for machine services are presented in Table 3 6 Changes in unit costs reflect both changes in unit price and use levels The numbers show highly variable increases in costs per hectare, with plowing and canal repair showing the highest increases (58% and 66% respectively) Offset plowing, the most popular type of mechanical soil preparation has only increased by 24%, while mechanical threshing costs have only increased by 4% Explanations for the very low increase in threshing costs are not clear, however, Table 3 7 shows significant differences in machine service unit costs between perimeter types, which are disguised in the time series Most obvious are plowing and canal repair/resurfacing which show high costs respectively for SAED rehabilitation's and extensions These suggest that occasional costs may explain some of the variations in average unit costs over time

Table 3 6 Evolution of Unit Costs of Machine Services in the Senegal River Valley

(CFA/kg)

Season	Plowing	Offset Plowing	Canal/dike resurfacing	Threshing
CSC93	14250	14974	11751	20333
HIV93_94	21155	15436	11860	18980
CSC94		17612	28861	15753
HIV94_95	10068	16860	24986	11240
CSC95	10000	18000	10179	20033
HIV95_96	33434	18542	19539	21215
% increase '93 to '96	58%	24%	66%	4%

Table 3 7 Comparison of Machine Service Costs Per Hectare by Perimeter Type in the SRV Delta

(CFA/ha)

Perimeter Type	Plowing	Disking	Canal Repair	Threshing
SAED Rehabilitated	33541	16758	11124	15002
SAED Extension		16614	44670	17148
PIV	10588	16725	11146	20271
PIP	15464	18286	15807	26400
Total	25543	16877	16665	17491

Source SAED Farm Survey 1993-1996 Dagana Delegation data only

Overall, prices for machine services in the Senegal River Valley have increased at the pace of inflation but do not yet reflect the full increase price that would be expected as a result of the devaluation of 1994 This is so because the capital cost of the current machine stock was

incurred before the devaluation This fact implies that machine costs should continue to rise as machinery is replaced, and that these increases will outstrip general price increases in the economy Until this relative cost increase is complete, the process of labor substitution for machine services that is noted in Section 4 below is likely to continue

3 3 Factor Markets

3 3 1 Labor

Information on labor markets suggests that these have been only weakly impacted by the reforms of the past decade Opportunity costs of labor quoted by farmers obtained by evaluating SAED survey data appear unreliable because of the wide variation and very low absolute levels of these estimates This appears to be because units for measuring quantities of labor are not consistent, nor is the quality (male or female, adult or child) Rapid reconnaissance data collected during the period suggests however, that labor wages remained relatively stable between 1993 and 1995 with adult males paid about 700 CFA in non- harvest periods of the rainy season during this period Only in the last year (1997/98) did wages appear to rise substantially to around 1000 CFA/day for the same period This rise appears to reflect the impact of general inflationary pressure resulting from the devaluation three years earlier

Over all, it is estimated that wages in the valley have risen about 30% since the devaluation This suggests that in comparison to machine services manual labor has become less expensive and therefore use of manual labor in production should have increased Data on labor use patterns presented in the next section of this report corroborates this expectation, showing greater use of labor overall in rice production, of which a greater share is family labor

In the Casamance, the labor market is much less developed, with most labor provided by family or shared labor within the community Only for transplanting and harvesting is external labor used, although its use has been noted to be rising Current rates for rural wages are estimated to be around 800 CFA per day in areas where the market is more developed These areas seem to be correlated with zones where animal traction is more developed, implying that labor is a severe constraint in these areas

3 3 2 Credit

The wider context for rural credit in Senegal has not changed substantially over the period of reforms of the rice sector because over the period private banks have remained outside the market, and public institutions have continued to be the sole formal source of credit However, there has been substantial variation in the nominal cost of credit through these formal institutions in step with inflationary pressures over the period In the Senegal River Valley, there also has been major changes in the institutional apparatus for distribution and collection of credit which has perturbed farmer access

This perturbation occurred with the transfer of administration of farmer credit from SAED to the CNCAS, and the subsequent delinking of farmer and paddy marketing credit Under

the SAED system seasonal credit was extended to farmers under agreements which allowed the collecting agency to deduct reimbursements from mill payments to farmers at the end of the harvest However, the liberalization of the paddy market in the valley broke the implicit guarantee that the banking agency had of collecting on seasonal credit loans via its claim on rice mill payments Because liberalization meant farmers could sell to any miller at any price the banking agencies lost control of reimbursements The immediate effect was a sharp decline in reimbursement rates in 1994 of 1993 credits

Responding to this loss of control, the CNCA applied much stricter performance criteria for new lending which resulted in a severe reduction in credit availability This reduction is illustrated in the decline in credit per hectare of over two thirds between 1991 and 1997 (Table 3 8) These trends are roughly consistent with trends collected from farmer surveys presented in Table 3 9, although the latter table illustrates other observations concerning the market First, SAED farmers consistently obtain greater loans per hectare than either private or village perimeters This finding is not surprising to the extent that these farmers are better monitored and likely to be better connected with the credit institutions Moreover, at least for village perimeters, lower credit availability levels is understandable given much higher levels of outstanding debt

Table 3 8 Credit Availability in the SRV

	Dagana	Rest of valley	Total Credit	Credit per hectare	Repayment Rate
	(Current value (10^6 CFA)			*(1996 CFA)*	
1987/1988	149	0	149	12928	100%
1988/1989	742	61	802	64857	98%
1989/1990	1765	292	2057	132417	96%
1990/1991	4744	847	5591	267419	86%
1991/1992	4061	907	4967	233765	80%
1992/1993	3063	613	3676	180626	63%
1993/1994	2237	708	2945	170025	76%
1994/1995	2045	551	2596	111138	67%
1995/1996	1222	400	1623	72869	60%
1996/1997	1257	571	1828	78890	70%

Source CNCAS

Table 3 9 Credit Use Patterns in Rice Production in the SRV Delta

(CFA/ha)

Perimeter Type	Season	Debt in Arrears	Current Debt	Total Outstanding Debt
SAED Rehabilitated	CSC94	37,934	163,147	201,081
	HIV94_95	49,904	94,219	144,123
	HIV95_96	38,078	146,925	185,003
	Total	42,684	129,834	172,518
SAED Extension	CSC94	13,845	159,573	173,418
	HIV94_95	3,290	145,753	149,044
	HIV95_96	64,484	156,669	221,153
	Total	25,237	152,738	177,974
PIV	CSC94	0	0	0
	HIV94_95	17,400	64,899	82,299
	CSC95	0	0	0
	HIV95_96	890,585	38,658	929,243
	Total	416,954	33,744	450,698
PIP	CSC94	0	0	0
	HIV94_95	68,232	108,389	176,621
	CSC95	0	0	0
	HIV95_96	0	39,264	39,264
	Total	34,116	70,257	104,373
Total	CSC94	31,580	151,341	182,921
	HIV94_95	42 813	99,699	142,512
	CSC95	0	0	0
	HIV95_96	174,904	122,189	297,093
	Total	90,849	115,103	205,953

Source SAED Farm Survey Date 1993 1996

Table 3 9 also illustrates that in 1995/1996 credit was only available in the rainy season for all perimeters The breakdown in credit disbursement in the dry season apparently resulted from very low reimbursement rates in the rainy season of that year This was due to the substantial fall in the paddy price and subsequent delays in farm sales The system was reestablished the following rainy season, but again in the 1996/1997 and in 1997/1998 dry seasons similar disruptions occurred

In 1997 the government bailed out producer groups and rice mills that had been holding stocks since 1995/1996 These stocks had gone unsold because purchases were made by these entities with the intent of selling at a higher price The government ultimately contributed a subsidy of 25 FCFA/kg to cover the losses that these entities would have incurred This gesture allowed these entities to survive but has only underlined the fundamentally political nature of the credit system Not surprisingly, recovery rates are still low in the SRV for seasonal production credit (estimates of around 80 % in 1996/1997)

These trends illustrate a fundamental problem in the credit allocation system, particularly for the dry season Each year the pace of rainy season paddy marketing, and consequently the pace of rainy season loan reimbursements is slow This results in most farmers falling into

arrears at the point when the CNCA assesses farmer requests for dry season loans As a result, the CNCA has allocated very little production credit for dry season crops To counter this problem, SAED has suggested that the CNCA move to an annual financing of seasonal credit to farmers

3 3 3 Land

Land markets are not formally established in the SRV However, certain transactions have increases since the government granted responsibilities to local level councils for land use allocation In the early 1990s these councils allocated a large share of land to entrepreneurs, particularly in the delta region However, a series of factors slowed down this process First local communes became concerned that too much land was being given to outsiders, secondly a concern that the distribution of land between persons within the community was inequitable, and finally because of poor performance of many of these investors, credit for land investments dried up As a result, large areas of land that were allocated have never been developed and much of what was developed has been abandoned

Despite the excesses that accompanied the initial land grab of this period, however, there continues to be interest by some investors in acquiring and developing land in the SRV In addition, within perimeters there are also informal short term exchanges of land on a rental or sharecropping basis although these arrangements are typically within extended families or among friends, and therefore not accessible to outside investors

4 HOW HAVE FARMERS' INCENTIVES TO PRODUCE AND PRODUCTION BEHAVIOR CHANGED AS A RESULT OF REFORMS?

The previous section has identified a number of changes in markets for paddy as well as for inputs and factors in production of rice which have transformed the environment of rice production in Senegal This chapter examines how these changes have affected farmer incentives to produce rice and how their production methods have changed in response to these incentives

4 1 Measuring the Basis of Changes in Farmer Behavior

4 1 1 Financial incentives

An analysis of financial returns to rice farmers based upon SAED farmer data is presented in Table 4 1 by perimeter type The table illustrates first that, both in absolute terms and as a share of costs, labor costs were highest for SAED rehabilitated perimeters Labor costs were lowest in absolute terms for village perimeters, but as a share of costs they were lower for private perimeters Input and service costs where higher for SAED extension than for rehabilitations and highest of all for privately owned perimeters, suggesting a substitution of services for labor in these perimeters Total financial costs (not presented) are equivalent to labor costs plus input and service costs Former SAED perimeters and private perimeters have total costs of between 225 and 228 thousand CFA/ha, while village perimeter costs are moderately lower at 210 thousand CFA/ha Gross revenues are highest for both SAED perimeter types, primarily because of better yields While private perimeters receive the lowest gross revenues due both to low yields and low prices Nominal profits are highest for farmers in former SAED perimeters, but village perimeter farmers also show similar rates of profit (above 80%) Due to costs nearly as high as the SAED perimeters, but the lowest gross return, private perimeter farmers' profits are the lowest, representing less than 50% of costs

A second analysis presenting the evolution in financial returns to rice production in the SRV is presented in Table 4 2 It illustrates that net financial returns per hectare increased in nominal terms between 1993/1994 and 1995/1996 by 54%, after an initial decline of 22% in 1994/95 As the table illustrates, this net increase in financial benefits occurred because revenues rose by about 36% while labor costs only rose by 15% and input costs rose by only 26% The results also demonstrate that the profit rose on financial costs also fell and then increased over the time period While these numbers suggest that financial incentives to farmers rose by 1996 over 1993 levels they are not reassuring in three respects First, the high variability in margins suggests that no clear conclusion can be drawn from this brief series (The issue of income variability is examined in the next subsection) Secondly, cost increases for some costs such as machine services had probably not been fully passed through by 1996 Lastly, these costs reflect only financial costs to farmers, but not changes in factor opportunity costs Thus, while cost increases in factors are thought not to have been great, they necessarily diminished overall implicit profit levels, and perhaps reduced relative increases as well

Table 4 1 Comparison of Financial Returns to Paddy by Perimeter Type, SRV

Perimeter Type	Labor Costs/ha		Input and Service Costs/ha		Average Paddy Price	Gross Revenue/ha		Net Revenue/ha	Profit Margin	
	CFA/ha	% Total Cost	CFA/ha	% Total Cost	CFA/kg	CFA/ha	% Total Cost	CFA/ha	% Total Cost	
SAED Extension	61155	27%	166581	73%	102 1	425923	187%	203063	89%	89%
SAED Rehabilitated	74602	33%	151360	67%	101 6	425894	188%	200821	89%	89%
PIV	55838	27%	153188	73%	105 3	371022	178%	174522	83%	83%
PIP	58307	26%	168881	74%	93 2	330711	146%	108447	48%	48%
Average	62475	28%	160002	72%	101	388387	175%	171713	77%	77%

Table 4 2 Evolution of Financial Returns to Paddy in the SRV

Cropping Year	Labor Costs/ha		Input and Service Costs/ha		Average Paddy Price		Gross Revenue/ha		Net Revenue/ha	Profit Margin	
	CFA/ha	% of 1993/94	CFA/ha	% of 1993/94	CFA/kg		CFA/ha	% of 1993/94	CFA/ha	% of 1993/94	
1993/94	62646	100%	135992	100%	87 0	100%	367505	100%	172324	100%	87%
1994/95	73312	117%	160295	118%	101 5	117%	386899	105%	153472	89%	66%
1995/96	72198	115%	171914	126%	119 5	137%	501444	136%	266153	154%	109%
Average	69365		154852		101 3		411194		190204		85%

4 1 2 Income variability for rice producers

Variability of rice producer incomes is thought to have increased in recent years with liberalization of the sector Clearly price shocks induced by the currency devaluation of 1994 temporarily increased income variability as unadministered prices of all tradables rose commensurately, and eventually inflation raised other prices as well

A more fundamental structural cause of increased price risk, however, has been the liberalization of rice production and marketing, most notably the removal of administered prices for paddy, the liberalization of rice import trade and the withdrawal of the CPSP from setting consumer prices These three steps have resulted in a direct linkage of paddy prices to world rice prices

Recognizing, this eventuality, the protection policy for rice was designed to substantially buffers the internal market from world price movements within a relatively wide range (120-160 CFA/kg CAF) However, in 1996 and 1997, the variable levy did not serve this buffering function because of problems in it's implementation Thus between September 1995 and December 1997, paddy prices varied from above 125 to below 100 CFA/kg, while consumer prices varied from over 260 CFA to as low as 190 CFA/kg

In addition to product price risk, producer incomes are also subject to price variations for inputs, and production risks due to yield variability Tradable input prices are subject to the same sources of variability as paddy (world prices and exchange rates) Rice yield variability may also be a function of policy to the extent that management practices, input doses or the level of effort on the part of farmers are influenced by the prices of products, inputs, or factor costs However, other factors, which are largely exogenous to policy may also affect yields, including most notably weather, and pest attacks

Using the PAM analysis as a basis, a combined analysis of the influence of these various factors on net returns to rice produces was estimated using a Monte Carlo simulation technique In this approach the independent probability distributions for all exogenous variables (world prices of rice and important tradable inputs, (DAP and Urea), the exchange rate and, paddy yield variations) were accessed through repetitive simulations to examine their simultaneous impact on net income to rice production The analysis was carried out under three scenarios first, assuming probability distributions prior to 1994, secondly assuming distribution in the current context, but without the variable levy protection, as was the case in the past two years, and finally assuming that this policy is correctly implemented

Table 4 3 Net Financial Returns to Paddy Production under Alternative Policy Scenarios (CFA/ton)

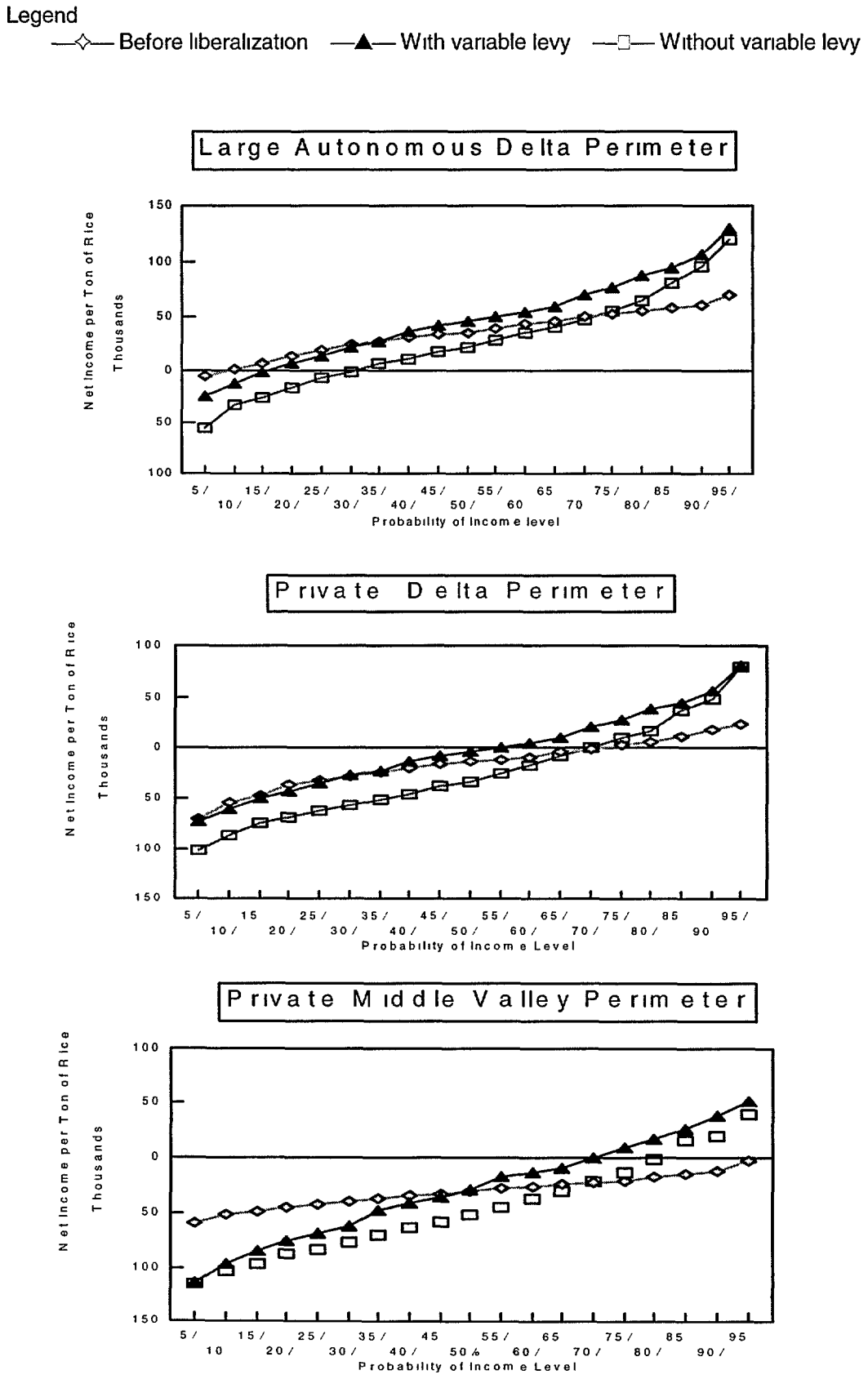
System	Traditional, mangrove, Casamance	Traditional, bas-fond, Casamance	Large Autonom Delta, SRV	Private, Delta, SRV	Large Autonom Mid-Valley, SRV	Private Mid-Valley SRV	Small Village Mid-Valley SRV
Pre liberalization							
Mean	na	na	34652	-16139	-3656	-30477	20663
STD	na	na	24133	28133	16271	16405	18559
With Variable Levy							
Mean	-41085	42657	48152	-1271	-1187	-28777	24129
STD	72752	72752	48583	48271	53869	52320	56030
Without Variable Levy							
Mean	-72464	13510	27727	-23097	-16528	-43325	5869
STD	86751	79659	52293	55519	52782	52161	61359

The summary results presented in Table 4 3 show for all production systems, that probabilities getting higher net incomes where higher prior to liberalization than is the case under liberalization but without the variable levy However, mean net incomes are higher with the variable levy than for the case prior to liberalization for all farm types Both liberalization scenarios show much higher variability in incomes, however, than was the case prior to liberalization

Graphs in Figure 4 1 give a better sense of the change in income variability with each policy regime for three types of farmers They present the cumulative probabilities of falling below each income level The zero line in each model identifies for each scenario where the producer begins to lose money in production Probabilities for falling below zero are clearly highest for private farmers in the Senegal River Valley because of the relatively low yields obtained by these production systems In all cases, administered prices prior to liberalization were better at assuring that incomes did not fall to very low (or negative) levels than under liberalization with or without the variable levy On the other hand, liberalization with or without the variable levy increases the probability of occasionally obtaining very high incomes as well Thus, incomes show a much greater range of variability than was the case prior to liberalization Comparisons of liberalization with or without the variable levy show that the levy serves to raise income probability curves at low income levels, but income probabilities converge at high income levels

FIGURE 4 1

Probability Distributions of Farm Income for Different Rice Policy Environments



In an overall context, the results of this analysis suggest that since reform, incomes to producers have probably been more variable than before reform The evidence of the previous subsection also suggests that net benefits have risen in nominal terms, although in real terms the change is less obvious to date However assuming the variable protection is part in place and is made to functioning correctly, average net profitability will be higher than was the case prior to liberalization Moreover, financial profitability should improve substantially if the quality of rice can be raised so that production is assumed to compete with, and therefore command the price of better quality rice

4 2 Changing Technologies

4 2 1 Seed quality and variety

Improvements in the quality of rice seed used by farmers is only weakly evident from farmer declarations of use of improved seed between 1993 and 1996 Farmer responses reported in Table 4 4 show that use of seed which farmers classified as improved seed fluctuated from season to season and year to year In the last year, however, improved seed use did reached 45% after dipping in 1994 These fluctuations are explained by the seed producers associations as being due to shortages in improved seed created by the transition in responsibilities that occurred at that time, and a related crisis in obtaining access to credit to finance seed production during the 1994/1995 seasons which resulted in a cut in production by seed producers

Table 4 4 Share of Certified Seed Use in the SRV, 1993-1996

	CSC93	HIV93_94	CSC94	HIV94_95	CSC95	HIV95_96
Non Certified	69 7%	67 7%	89 7%	77 6%	100 0%	54 2%
Certified	30 3%	32 3%	10 3%	22 4%		45 8%

Declarations of varieties used also illustrates little trend during the same period (Table 4 5) although the predominance throughout the period of the Jaya variety is clear The popularity of other varieties is not obvious from this data

Table 4 5 Varieties Used in Rice Production in the SRV (Share of respondents, 1993-1996)

	CSC93 Varieties	HIV93_94 Varieties	CSC94 Varieties	HIV94_95 Varieties	CSC95 Varieties	HIV95_96 Varieties
JAYA	62 5%	68 3%	10 3%	65 5%	90 0%	58 5%
IKP		7 1%	22 4%	13 8%	10 0%	7 6%
AIWU	31 3%	7 9%	25 9%	6 9%		
IR1529		11 1%	17 2%	5 2%		11 0%
IR8	3 1%	3 2%	17 2%	2 6%		12 7%
IR13240/S108	3 1%	8%				2 5%
SIPI		8%				
DJIBELORE		8%	1 7%	9%		
IR_18			5 25	5 2%		1 7%
OTHER						1 7%
MIXTURES						4 2%

Since these data were collected, however, there appears to have been substantial progress in improving rice varieties in the last two years in the Senegal River Valley with the rapid increase in popularity of Sahel 108 Sahel 108 is a short cycle variety that is not photosensitive It has physiological features that are particularly resistant to bird attack and has high yields (above 5 tons in farmers fields under good management) and good quality characteristics Although it was developed primarily for the dry season it has become a popular variety for the rainy season as well It has risen in popularity at the expense of I Kong Pao Table 4 5 appears to show the beginning of this trend with Sahel 108 increased from 3% to 7% of area between 1995 and 1996 plantings, while IKP fell from 7% to 2% in the same years, suggesting that one has displaced the other

4 2 2 Status of input use

Table 4 6 presents the progression of dose rates by year between 1993 and 1996 by perimeter type in the SRV delta It illustrates clearly that overall, for all commercial inputs, dose rates have fallen substantially over the period [3] The same trends are observed by perimeter type, in most cases, although former SAED extension perimeters do not show a reduction in fertilizer doses [4] This suggests that marginal returns to fertilizer application has remained positive for these farmers despite cost increases Nonetheless, overall, the reduction in commercial input use is as would be expected given the direct impact of the devaluation on prices for these inputs see discussion in previous section

[3] Differences in input doses between the three years of the survey were significant at least the 95% level for all inputs except Weedon for which significance was at the 90% percentile These results suggest that the trends in dose rates were not random but in fact reflected changes in behavior over time

[4] Differences by perimeter type were significant at the 99% percentile for all inputs except Furadan The insignificance of the relationship for Furadan appears to be because it is applied only when necessary as is indicated by the absence of any application in some years

Table 4 6 Input Use Rates in Rice Production

(Unit/ha, SRV Delta)

Perimeter Type	Crop Year	Quantity of Urea (kg)	Quantity DAP (kg)	Quantity of Furadan	Quantity of Propanyl	Quantity of Weedon
SAED Rehabilitated	1993/94	303 7	156 4	5	6 4	1 5
	1994/95	291 5	126 3	2	4 0	1 3
	1995/96	287 7	74 5	0	5 0	1 5
	Total	294 7	123 5	2	5 1	1 4
SAED Extension	1993/94	249 0	116 1	5	3 2	1 1
	1994/95	265 7	101 0	0	2 4	8
	1995/96	254 5	122 7	0	5 7	1 2
	Total	257 9	110 5	2	3 4	1 0
PIV	1993/94	603 8	235 3	0	10 1	3 8
	1994/95	150 0	50 0	0	4 0	8
	1995/96	226 7	49 3	0	3 3	8
	Total	315 1	101 7	0	5 4	1 6
PIP	1993/94	1943 8	798 0	1 5	36 5	20 4
	1994/95	1048 4	371 3	0	28 3	17 0
	1995/96	1163 3	229 6	0	18 9	5 2
	Total	1512 4	546 7	7	30 1	15 8
Total	1993/94	541 7	243 7	6	10 3	4 1
	1994/95	329 6	134 0	1	5 4	2 2
	1995/96	339 9	85 3	0	5 8	1 6
	Total	406 2	158 7	2	7 2	2 7

Source SAED Farmer Survey 1993 1996 Dagana department only

4 2 3 Labor use

Trends in the quantity of labor used per hectare of rice are indicated in Table 4 7 One apparent trend is the general increase in labor use in rice production in all perimeters over the period of the analysis This trend is confirmed statistically through regression analysis which illustrates that this increase is almost entirely due to increases in family labor use in all perimeter categories Levels of hired labor remain at roughly constant levels over the same period These trends suggest the displacement of machine services by manual labor and are explained by the relative reduction in unit costs for labor in comparison to machine services

Table 4 7 Labor Use in Rice Production in the SRV Delta

(Average person days per hectare)

Perimeter Type	Crop Year	Quantity of family labor	Quantity of hired labor
SAED Rehabilitated	1993/94	43 1	20 8
	1994/95	58 2	24 6
	1995/96	59 0	27 3
	Total	53 2	24 0
SAED Extension	1993/94	33 4	34 0
	1994/95	35 0	30 5
	1995/96	44 7	33 5
	Total	36 6	32 2
PIV	1993/94	45 2	33 2
	1994/95	38 9	18 2
	1995/96	64 8	18 3
	Total	53 6	22 6
PIP	1993/94	68 9	58 5
	1994/95	120 5	63 0
	1995/96	95 8	19 2
	Total	88 8	50 3
Total	1993/94	45 7	28 4
	1994/95	57 6	27 5
	1995/96	61 9	25 3
	Total	54 7	27 2

4 2 4 Cultivation techniques

Seeding

In the valley rice is seeded either by direct broadcast or by transplanting Through the early eighties, a strong emphasis was placed on promoting transplanting as a means of raising yields, and shortening land occupation to increase the capacity to plant two crops The disadvantage of transplanting, however, was the high labor requirements required These times exceeded 200 person/days per hectare in some perimeters, but rates as low as 60 person days per hectare were achieved in others In the Delta, labor was too scarce to adopt transplanting but it became popular in the middle valley where labor was more abundant, Currently, transplanting remains a fixture, particularly in perimeters of Matam and Podor department however, with as much as (83% of area under transplanting in the Matam region)

Curiously, in the Bakel department the reverse has occurred as farmers have shifted to the least labor-using technique of planting, which consists of seeding on dryland prior to irrigation This technique is practiced on most (83%) of the cropped area and appears to be due to a number of factors (a) lack of labor due to seasonal and long term out-migration of labor from the upper valley, (b) high pumping costs due to small scale pumps and sandy soils, (c) higher rainfall

Soil preparation

No direct evidence of changes in soil preparation techniques is available, although data from Table 3 6 show that overall expenditures per hectare for machine services have increased by more than 50% for plowing but by only half that for offset plowing These numbers are difficult to interpret because they include both price increases and changes in use rates In discussions in the delta, farmers stressed their continued reliance on machine services for soil preparation because of the difficulty of the task and the need to prepare soils in a timely fashion This impression appears inconsistent with evidence of increasing labor displacement of machine services, noted in Table 4 7 above, but probably reflects a shift to use of labor in activities other than soil preparation, such as weeding and harvesting

Harvesting

Combine harvesting techniques remain popular despite fears that with devaluation, demand for such mechanical operations would fall Between 1995 and 1996 rainy season harvests, SAED data shows an overall increase in use of combines from 41% to 44% of rice area The rate of use of combine harvesters is concentrated in the Dagana department and declines as one moves up the valley This trend appears to be associated with the decrease in farm size and the greater availability of farm labor per area of rice production in the middle valley Surprisingly, however, the greatest comparative increase in combine harvester in recent years has been in the middle valley Combine harvester use rates rose from 51 to 55 % in the Dagana department, while in Podor the rate of use increased from 25% to 35% of harvested area These results suggest that rural labor markets are becoming more constrained in the middle valley as well

4 3 Changes in Rice Farmer Activities

The realization that rice farmers are too dependent on rice production for income appears to be a present concern of both research, extension, and credit institutions as well as farmers This realization has been a part of many recent assessments of the situation, but what may have driven it home to actors in the valley has been the dramatic oscillations in the fortunes of rice production since liberalization measures have been introduced (see section 4 1)

Efforts to diversify production are not new to the river valley Since the early seventies, plans for irrigation have included strategies to raise other grains (primarily maize, and sorghum) as well as a variety of vegetables, fruits, legumes, forages and cash crops Nonetheless, large efforts to promote other crops have been largely limited to tomatoes (based around two tomato canneries in delta), and sugar (for which all production is by a single sugar company at Richard Toll) Of these, tomato production reached a maximum of 8000 tons in 1990, but since has fallen off It reached a loss of 2,400 tons in 1996/1997 although low levels also reflected a very poor harvest caused by a disease problem

"Other" vegetable production (including onions, gumbo, peppers and potatoes) is the only crop category which has grown rapidly in recent years Production increased by more than 60% last year surpassing tomato production for the first time This production appears to have come entirely from private investments in the area Onion production is the most important activity and has grown rapidly since the import of a variety from Niger called Violet de Galmi, which grows well in the region and preserves well The market for these vegetables is currently principally the large urban centers in Senegal which suggests that unless more distant markets can be developed, demand may become saturated easily

The experience of *Agri-Nord*, a large private horticultural farm which produces horticulture for local production and export illustrates this problem Its initial attempts to grow potatoes and onions for the national market met with initial success in 1995 but then had disastrous results in 1996 because of the strong competition from imports and increasing production by other domestic firms On the other hand, the farm continues to produce tomatoes for canning and green beans for export under contract to the local tomato canning firm, SONACOS This activity has proven sufficiently lucrative to keep the farm operating despite losses in other crops This experience suggests that expansion of horticulture in the valley requires the development of additional large buyers who can guarantee markets for produce for either fresh export or processing The competitiveness of imports apparently was due to dumping strategies of Europe in its export markets, and a failure of Senegal's tariff structure to provide any protection against these imports

SAED and the ISRA research stations have also conduced substantial research on maize and sorghum, and some vegetables and extension efforts have been successful in introducing these crops in the middle and upper valley However, yields for these crops have not improved noticeably over this period, and there has been very little expansion of these crops Nonetheless, research for diversification has become a principal theme of ISRA St Louis program, and is also the focus of a FED project housed in SAED Finally there is an Israeli pilot project at Lac de Guere which is also concentrating on developing horticulture production

Several new crops are only now being tried in the valley under irrigation SODIFITEX has begun to test cotton production under irrigation, with the intention of initially developing production of cotton seed Because of irrigation and the ability to

produce two crops per year, the rational is that production in the valley would allow much faster replication of cottonseed, and much better control of seed quality In 1996/1997, SODIFITEX created an experimental cotton production perimeter with a producer group in Donaye near Podor The first year's results were deemed highly successful, with average harvest yields exceeding 3 tons per hectare, and some farmers obtaining as high as 3 5 tons Moreover, the producer's group with which they worked has asked to continue the crop this year, and even opted to expand participation in the trials Noted advantages of the crop was the capacity to diversify income growth, the greater certainty with respect to the price of inputs and outputs, and the easy access to financing for the crop

On the other hand in conversations with the farmers, they voiced several problems with the scheme, notably the very high production costs, the high labor requirements, and, most importantly, the conflict between cotton and rice in competing for labor for planting at the beginning of the rainy season This is a particular problem because farmers chose to transplant rice in the perimeter

From the perspective of SODIFITEX, the experience was very encouraging, and, as a result, the project will again expand production next year The same problems that were identified, by farmers, were also noted by the project, however In particular, the labor conflict during planting, and the need to coordinate planting with irrigation water availability posed a problem for expanding area under cotton To resolve this problem, the project reached an agreement with the production association which sets a calendar for both rice and cotton planting Interestingly, in the agreement, rice was designated to be planted first because of the priority placed on it by farmers as a food crop, and the yield losses that it faces if planted late SODIFITEX accepted this solution because of its expectation that both can be accommodated in the calendar This drama points to one area where agronomic and farm systems research might focus to facilitate crop diversification

4 4 Modeling Changes in Farm Systems

To further explore how rice sector reforms could affect farm management behavior of rice producers in the long run, a linear program model was developed for three farms selected as prototypes of typical rice farms in the delta of the Senegal River Valley [5] These farms were selected based upon cluster analysis of variables indicating patterns of farm evolution, Family characteristics, farm size, and physical and social capital The selection was based on an initial sample of 1577 farms using the 1993–1995 SAED farm survey data set This analysis identified three farm types based upon technical, economic and social characteristics which determined its fundamental orientation These farm types where

[5] This analysis was conducted by Youssou Diagne as part of his dissertation research at the University of Dijon His thesis entitled Adjustement Structurel et impacts sur les systemes de production Cas du Delta du Fleuve Senegal Dec 17 1997 reports the full results of his research

- A small traditional noncommercial farm oriented towards providing food security to the family,
- A farm in transition from a noncommercial to becoming a commercial farm, and
- A large modern commercial farm

Summary characteristics of these farm prototypes where

Table 4 8 Characteristics of Prototype Farm Types

Farm Type	Noncommercial Food Security	Transformation to Commercial	Commercial Profit
Farm Evolution	Old and stagnant	Old with moderate growth	New with rapid growth
Family situation	Maturity	Dissolution	Expansion
Labor force	Family	Family + hired	Hired
Farmed Land area	4 ha	8 ha	140 ha
Share irrigated	80%	100%	100%
Tractor Mechanization	None	little	Full
Capitalization	Weak	Strong	Strong

For each of these farm types, a linear programming model of farm behavior was built, including all cropping activities of each farm, subject to constraints on land categories, labor (by fortnight), water, capital, and consumption Alternative crops, and alternative production techniques for current crops were also introduced in each model

The models were used to attempt to examine how rice sector reforms would affect reallocation of resources and diversification of production in farm systems The modeling analysis first sought to simulate current production conditions and Table 4 9 presents some of the results of this simulation It shows that while the model predicted less diversification that in actual fact, the commercial model suggested more diversification than was actually the case The transitional farm was very closely captured by the model

Table 4 9 Comparison of Simulation Results to Actual Farm Behavior

Farm Type	Non Commercial		Transitional		Commercial	
	Actual	Simulated	Actual	Simulated	Actual	Simulated
Income	890	460	2333	3096	11000	51387
Area used	4	4	8	8	140	140
Rainy season Rice	3	3	6	6	140	140
Tomato	1	0	1	1	0	0
Sorghum	1	1	0	0	0	0
Onions	0	0	0 5	0 5	0	0
Okra	0	0	0 5	0 5	0	0
Off season peanuts	0	0	0	0	0	140
Hired Labor (hours)						
Before harvest	0	0	0	0	496	1310
During harvest	170	345	2255	1591	250	390

These models were then used to examine changes in farm comportment to changes in input and product prices between 1990 and 1995 as a result of rice sector reforms These analyses suggest that for neither non-commercial nor transitional farmers have production activities changed However, nominal farm incomes fell slightly in each case, reflecting the deterioration in product prices relative to inputs In real terms these changes represent a much greater change because of strong inflation over the period of reform

The solution for commercial farms changes substantially for dry season production The model suggests that farmers would have given up a small amount of production of dry season rice, while assuming a much larger production of peanuts The predicted reduction in dry season production has occurred however, the predicted large increase in peanut production has not

Table 4 10 Comparison of Simulation Results Before and After Reform

Farm Type	Non Commercial		Transitional		Commercial	
	Before	After	Before	After	Before	After
Income	481	460	3197	3096	13300	51387
Area used	4	4	8	8	140	140
Rainy season Rice	3	3	6	6	140	140
Dry season Rice					7	0
Tomato	0	0	1	1	0	0
Sorghum	1	1	0	0	0	0
Onions	0	0	0 5	0 5	0	0
Okra	0	0	0 5	0 5	0	0
Off season peanuts	0	0	0	0	3 5	140
Hired Labor (hours)						
Before harvest	0	0	0	0	1310	1310
During harvest	345	345	2255	1591	390	390

To further explore the opportunities for diversification in the commercial model a sensitivity analyses was conducted to investigate at what price new crops would enter the model Dry season rice enters if prices rise by 20 cfa/kg, tomatoes by 38 CFA/kg onions by 55 CFA/kg and cotton by 56 CFA/kg (Alternatively, yield increases of the same proportion at the same costs would provide the same results) Varying the rice price shows that at low rice prices, production of tomatoes displaces rice in the model because the two crops compete for land and labor resources As the rice price rises, however, rice displaces tomatoes in the rainy season and permits other crops, (peanuts, onions and cotton) to enter the model as well in the dry season, presumably because tomatoes intrude on production in both seasons [6]

The model results are simplistic in a number of respects The models do an inadequate task of reflecting changes in production techniques to raise economic productivity in a particular crop by changing factor and input mixes It also provides only a few of the diversification opportunities which exist for irrigated production in the SRV Thus response functions are extremely rudimentary Nonetheless they do provide an illustration of both the opportunity to produce other crops in these production systems, and the constraints that are likely to arise in pursuing diversification Most importantly, the results suggest that diversification is not likely to occur to crops other than tomatoes unless either yields are raised, or prices are improved through either better marketing opportunities, or reductions in transaction margins between valley producers and final markets

4 5 Evaluating Productivity Changes

A more liberal production environment which reforms in the rice sector where to have introduced, may be expected to raise farmer productivity in rice production by improving the allocation for farm resources in response to market prices, and by reducing technical inefficiency associated with suboptimal technical choices imposed by poorly performing markets Analyses reported in this section sought to investigate this expectation using econometric tests of field survey data of farm parcels in the SRV Delta

The concept of productivity is meant to capture the efficiency of production This concept may be divided into two components Technical efficiency evaluates the physical relationship of production obtained per unit of input It is thus a function of the technology employed in production and of the producer's mastery of this technology A second aspect of efficiency is allocative efficiency This has to do with the producer's capacity to use each input to that level at which the marginal cost of its use equate to its marginal return in production

To measure technical productivity the study sought to construct a production function to measure the relationship between quantities of factors used in production and

[6] Details of these values are provided in Diagne s thesis but are not presented here because they are not thought to be highly realistic

output This function was then used to test for changes since the reform by examining changes in the coefficients which reveal the technical efficiency of use of each factor of production before and after reform

As a first step in creating a production function, a separate analysis was conducted to construct a predictive model to explain yields This analysis sought to identify predictive variables which could improve yield projections It also contributed to the production function analysis, however, by identify structural and managerial variables in the available data set which could be used to assess differences in technology or environment that affect production These variables where then introduced in the production function analysis as proxies for technological differences The yield predictive model is therefore presented below followed by the production function analysis

An analysis of economic efficiency was also attempted using a profit function approach Profit functions seek to examine the economic efficiency of production by examining the response of production profits to prices of factors and inputs The results of this exercise were unsuccessful, however, because no significant correlations could be established between input or factor prices and profits This failure appeared to be because input and factor price data in the sample were highly suspect Both were imputed from total declared costs for each input or factor by dividing these costs by declared quantities used However, the resultant implicit prices varied widely in any given season implying either market failures in the input delivery or poor data The latter explanation appeared to be true both because definitions appeared to be inconsistent in the data [7]

4 5 1 Structural predictors of yield

Econometric models to explain rice yields were constructed using structural, management, and market parameters as independent variables Variables were chosen based upon the prospects that they could be known at the beginning of a production season in order that the models might be used as short-run predictive tools to project yield performance based upon information known at the beginning of a crop season Separate models were built for rainy and dry season rice

Table 4 11 presents the variables examined in these models and results of OLS regressions using stepwise entry of a variety of alternative variables into equations in which yields were the dependent variable The results presented there for are of regressions only of the retained variables Coefficients for excluded variables represent the parameters at which these variables would have entered the equation if they had been significant

[7] In particular declared costs of inputs do not always have corresponded to the same quantities used in production, thus derived implicit prices are erroneous

Perimeter management and structural variables

Dummy variables were introduced to distinguish four types of perimeters based upon SAED definitions (see description in section 2) These are

1 Rehabilitated SAED perimeters
2 Extensions of SAED perimeters
3 Private perimeters
4 Village perimeters

The first two categories distinguish respectively SAED perimeters which have been rehabilitated and turned over to farmer group management although typically with substantial SAED support, and those which are privately constructed extensions of SAED perimeters undertaken by farmers with land in SAED perimeters While both of these classifications include farmers who are or had been under SAED supervision, it was expected that the degree of SAED control decreased between categories 1 and 2 and that this would be reflected in yield performance In the econometric analysis, however, these two different subcategories of SAED perimeters proved to be indistinguishable in predicting yields and so were not included in the final model

On the other hand, the village perimeter dummy proved highly significant in predicting yields in both rainy and dry seasons, with these perimeters showing reductions in yield of a ton in the dry season and 614 kg in the rainy season, holding other variables constant Private perimeters showed a similar and highly significant reduction in yields (-1 45 ton/ha) in the rainy season but no difference in yields from all SAED perimeters in the dry season

In both cases, this reduction is thought to reflect the relatively modern infrastructure and high level of management expertise in SAED or former SAED perimeters, in comparison to village and private perimeters in the Delta This distinction is particularly true since the arrival of relatively inexperienced farmers in the delta after the "land grab" of the early 1990s These conclusions are consistent with straightforward comparisons of yields in the delta by Perimeter type It should be noted however that these conclusions are reversed in the Middle valley, where private and village perimeters have higher yields than the large perimeters

In the rainy season, these differences are explained in large part by the type of perimeter drainage system In particular those perimeters which had pump drainage systems showed 691 kilogram lower yields than those that did not Because nearly 92% of SAED perimeters but only 4% of private perimeters and 15 % of village perimeters had these facilities, this factor alone explains a large component in the overall yield discrepancies between these two perimeter types The apparent perverse effect of sophisticated drainage systems on yields, is thought to reflect the underlying problem of water logging and salinization in perimeters which have these systems Thus it suggests that, while drainage systems have been put into systems that have these problems, the

systems are inadequate in correcting the problem, either by design or because they are not correctly managed

Drainage infrastructure was not a significant contributor to yields in the dry season This is not surprising because there is little need for drainage in the dry season when low water tables and high evaporation rates reduce the need for drainage

Farm management variables

Use of a motor driven pump (groupe moto-pompe) to deliver irrigation water, instead of water delivered through large centrally managed pumping station was found not to have a significant effect on yields in either season This finding implies that these technologies are equally reliable in water delivery This finding suggests that GMP technology has been mastered to a degree that breakdowns or other problems with these pumps are no longer an important constraint on production On the other hand, it also suggests that the potential increase in irrigation flexibility that these pumps might provide, is not a factor in improving productivity

Of the management variables only past debt on farm loans is significant in predicting yields in both rainy and dry season models In both cases, this variable is highly significant statistically, resulting in a 4 3 kilogram and 200 gram reductions in yields per thousand CFA of debt in the dry season and rainy seasons respectively Because debts averaged 29 thousand CFA in the dry season but 169 thousand in the rainy season, these results imply an average yield losses of 124 and 34 kg/hectare respectively due to debt The reason for this relationship may be surmised to reflect the increased constraint on credit and therefore on input use in current years due to past debt

In the dry season, the only other management variable that is important in determining farmer yields is the number of parcels that the farmer cultivates and farmer debt Although the vast majority of farmers only cultivate one dry season field, each additional field results in a 3 8 ton reduction in yield per parcel This drastic reduction suggests that management difficulties associated with a large number of parcels are difficult in the in the dry season

The type of management of parcels has a strong impact on yields in the rainy season, with fields cultivated by the head of household producing 681 kg more than others This is to be expected and likely reflects the greater experience of these individuals and their greater access to inputs and other resources

The use of certified seed in production is highly significant in the rainy season but does not appear important for dry season production

Reflecting the quality value of improved seed, the use of certified seed adds 1208 kg/hectare to yields Ironically, this variable does not appear significant for the dry

season, yielding only a 15kg improvement in yields with low significance (13% probability of no relationship)

The date of first seeding is also significant in the rainy season only, with each week of delay in seeding resulting in a yield reduction of 125 kg/ha This result confirms agronomic testing which has found this loss in yields due to the impact of cooler shorter days on panicle sterility, this effect begins particularly if planting is delayed past mid-August As would be expected, this variable was not significant in the dry season, because delays in planting only increase the crop's exposure to heat and light

Market variables

Prices of inputs (urea, DAP, Weedon, and Propanil, the principal inputs) were introduced to reflect the cost of inputs at the beginning of the crop season, with the expectation that these prices would influence input use rates and therefore yields However, none of these prices proved significant in either rainy or dry season models These results seem to suggest either that farmer use of inputs is not responsive to price changes, or that input use is not important in determining yield behavior Another explanation is simply that the price data used was poor This may be because there was little variation in input prices in the cross-sectional sample in any given year On the other hand prices did rise substantially after the devaluation Prices derived from total input costs and use levels also appeared to be based on inconsistent assumptions (see footnote 7)

Table 4 11 Rice Yield Predictive Models Dry and Rainy Season in the Senegal River Valley Delta

		DRY SEASON				RAINY SEASON			
	R squared	0 17				0 265			
	Adjusted R squared	0 138				0 241			
	F Statistic	5 207				10 882			
	Dependent Variable yield								
	Variables		Beta	t	Sig		Beta	t	Sig
1	Constant	**INCL**	**8639 77**	**5 393**	**0 000**	**INCL**	**1226 003**	**6 108**	**0 000**
Perimeter Management/Structural Variables									
2	Communal perimeter (dummy)	**INCL**	**-1066 15**	**-2 173**	**0 033**	**INCL**	**-614 62**	**-1 837**	**0 068**
3	Rehabilitated SAED perimeter (dummy)	EXCL	-0 049	-0 377	0 707	EXCL	0 047	0 452	0 652
4	Private perimeter (dummy)	EXCL	-0 001	-0 009	0 993	**INCL**	**-1451 85**	**-3 851**	**0 000**
5	Extension to SAED perimeter (dummy)	EXCL	0 043	0 401	0 690	EXCL	-0 03	-0 452	0 652
6	Drainage infrastructure	EXCL	0 016	0 114	0 909	**INCL**	**-691 25**	**-2 765**	**0 006**
7	Motor-driven pump	EXCL	0 026	0 127	0 899	EXCL	0 097	0 893	0 373
Farm Management Variables									
8	Management by owner (dummy)	EXCL	0 115	1 069	0 288	**INCL**	**681 10**	**2 382**	**0 018**
9	Owner-operated (dummy)	EXCL	0 02	0 107	0 915	EXCL	0 034	0 494	0 622
10	Number of fields	**INCL**	**-3819 89**	**-2 442**	**0 017**	EXCL	-0 005	-0 083	0 934
11	CNCAS (past debt on farm loans)	**INCL**	**- 0043**	**-2 684**	**0 009**	**INCL**	**-0 00021**	**-2 498**	**0 013**
12	Seed type	EXCL	0 015	0 133	0 894	**INCL**	**1208 15**	**5 862**	**0 000**
13	Mechanized soil preparation (dummy)	EXCL	0 111	1 062	0 292	EXCL	0 02	0 32	0 749
13	Week of first sowing	EXCL	0 155	1 391	0 168	**INCL**	**-125 147**	**-3 253**	**0 001**

Results of the yield predictive model are interesting in demonstrating the impact of a number of perimeter and farm level variables on yield First, they suggest the importance of certain perimeter characteristics in yields The presence of drainage pumps appears to be a proxy for drainage problems and therefore is correlated with reduced yields In this regard, a better yield predictor would be a direct assessment of salinity and waterlogging problems in perimeters

The negative impact of village and private perimeters in the lower valley appears to give evidence of the value of SAED assistance to perimeters in their management This suggests the continued need for a SAED-like institution to provide management and technical assistance advice to perimeter managers

The significance of credit arrears as a negative predictor of yields, suggests both that the CNCA does reduce credit availability to past debtors, and that this constraint does have repercussions on performance

The value of improved seed is clear for rainy season production, but not for the dry season suggesting that varieties developed for the dry season were not effective at the time of the research However, since then the extension of Sahel 108 may have changed this conclusion

While these result could help to predict yields if the data on each were collected in a timely fashion at the beginning of each cropping cycle, the overall value of the exercise in explaining yields is weak

Much more important are likely to be variables such as the dosage of various inputs during the cropping season, and the amount and type of machines services and labor used These variables are introduced and explored below in the analysis of production functions

4 5 2 Production efficiency

A production function model was constructed from the SAED data to examine the technical efficiency of production, and the impact of devaluation on it The analysis incorporates the structural factors identified in the predictive model to represent the technology employed Use rates of factors of production were introduced to identify the contribution of each of these to production In addition, shift and slope dummies were introduced into the model as well to test for differences in technical efficiency before and after the devaluation and paddy price liberalization in 1994, and for differences between rainy and dry seasons The devaluation and paddy price liberalization are assumed to have occurred concurrently in January 1994 The dry season is assumed to cover all crops seeded before June, this would also include the "interseason" crop planted late in the dry season or early in the rainy season

Table 4 12 Cobb Douglas Rice Production Function

	Baseline Coefficient			Devaluation Effect			Seasonal Effect		
	Coefficient	Std Error	Sig	Coefficient	Std Error	Sig	Coefficient	Std Error	Sig
Factor Elasticities									
Capital	**0 430**	0 107	0 000	**0 534**	0 143	0 000	**0 225**	0 167	0 178
Labor	**-0 034**	0 047	0 461	**0 139**	0 059	0 018	**-0 189**	0 070	0 007
Land	**0 459**	0 112	0 000	**-0 529**	0 152	0 001	**-0 075**	0 169	0 658
Shift dummies									
Constant	**3 079**	1 289	0 017						
Devaluation				**-7 330**	1 756	0 000			
Dry season							**-2 012**	2 046	0 326
Management	**0 129**	0 059	0 028						
Seed	**0 059**	0 049	0 227						
Village P	**-0 019**	0 072	0 791						
Private P	**-0 085**	0 084	0 312						

Note

Cobb Douglas form dependent Variable is Rice Production (ln), All factors are introduced as natural logs in regression

Adjusted R2 0 769, Durban Watson 1 885

ANOVA Fstat 98 45 Significance at 0 000

The Cobb Douglas form provides immediate interpretation of coefficients as elasticities [8] Thus the results imply a capital elasticity of production of 0 43, a labor elasticity of -0 03 and a land elasticity of 0 45 While capital and land are each significant at the 1% level, the labor coefficient is entirely insignificant The insignificance of the labor results, may be in part due to the extreme difficulty of measuring labor use, given differences in labor quality, and effort For reasons that are unclear, the data for the 1994 and 1995 seasons appears to be much more complete and consistent in this regard Using only this sample, the results for labor become significant at the 5% level and suggest an elasticity of 0 1 Capital and land elasticities remain highly significant and at approximately the same level Assuming these numbers, the results concord with expectations They imply that for irrigated rice production, land and capital are the most constraining variables, while labor is more abundant, and therefore much less instrumental in obtaining production

The impact of the policy variable on technical productivity is surprisingly pronounced in the SAED data sample, particularly given the short time series included in the sample All factor elasticities are impacted significantly If one assumes unchanged returns to scale, it is inherent in the functional form that one factor's elasticity should fall if another increases In this case, the contribution of land falls while labor and especially capital contributions increase after reform This is logical since of the three factors, capital costs where most affected by the devaluation due to the large tradable component of these costs The negative and highly significant coefficient for the devaluation shift variable suggests that the overall effect on rice production was negative This too is not surprising, particularly in the immediate aftermath of the devaluation because of the adverse impact that the change had on farmer's ability to obtain inputs and to completely exploit their land

The effect of the production season on technical efficiency was significant only in the case of labor, suggesting that in the dry season the labor elasticity of production is reduced by 19 The shift dummy for the dry season is also entirely insignificant These results suggest that with the exception of labor, technical efficiency is not affected by season It is plausible that labor is negatively affected by the much more difficult working environment in the dry season due largely to the much greater heat

All variables representing differences in technology or management behaved as was found in the yield predictor model, but only the management variable, (whether the farmer was the head of household) appears highly significant Parcel management by the head of household contributes 13% to production Seed quality and whether the perimeters where village, private or SAED are not significant in the analysis Interestingly, given the fact that many new private perimeters have failed, this analysis suggests that this has not been because private perimeters are inherently less efficient but rather that they are more often managed by individuals other than the head of household

[8] Elasticities are defined as the percent change in the dependent variable (in this case rice production) with respect to a percent change in the use of the independent variable (in this case land labor or capital)

Differences between the two types of SAED perimeters were introduced but as in the predictive model, where found to be entirely insignificant Similarly the presence of drainage, the crop season, and the number of parcels in the farm each proved entirely insufficient Credit arrears where also introduced, but where highly correlated with capital needs and therefore was discarded Overall, with the exception of the management variable, none of the other characteristics identified in the predictive model were useful in the production function This suggests that those variables which were included in the predictive model, serve largely as proxies for predicting factor use during the production season, rather than independent indicators of the technology employed

4 6 Conclusions

It should be noted that the results of the analyses presented in this chapter are largely drawn for a subset of farmers in the Senegal river delta only, and the data on which the analysis is based concerns only three years during the period In this context, the negative impact of the reform dummy variable in the production function may be interpreted to reflect a loss of technical efficiency in the period just after the devaluation as farmers began to shift their allocation of factors and inputs in production in response to price changes This transitional drop in technical efficiency is not surprising since this would entail adopting new techniques of production Moreover, this loss is likely to have been offset by improvements in economic efficiency since evidence of allocative decisions to increase use of labor, and to minimize use of commercial inputs suggest that these decisions have caused the readjustment of factor use reflected in the production function The improvement in profit margins detected in the analysis of net financial returns also substantiates this interpretation

Thus overall, the analysis of changes in farmer behavior in response to reforms remains is inconclusive Profit margins appear to have increased, but the real absolute value of profits have remained roughly constant In the immediate aftermath of reform, tests of technical efficiency suggest an initial decline subsequent to the devaluation, apparently reflecting adjustment problems as farmers adapted their production methods to new relative prices of factors and inputs This adjustment appears to have included a substitution of labor for other factors and a general reduction in commercial input use, particularly for crop protection chemicals

5 WHAT ARE THE LONG TERM CONSEQUENCES OF REFORMS FOR RICE PRODUCERS?

The consequences of reform for the long run viability of rice production are reflected in analyses of the underlying economic comparative advantage of production insofar as a movement to freer markets and away from public support for the sector implies that the sector will be forced to stand or fall on its own economic value This perspective is examined in the section below It is followed by broader conclusions for the prospects of rice producers drawn from the previous sections

5 1 Economic Comparative Advantage

Various previous studies have examined the economic comparative advantage of rice production in Senegal [9] All of these studies have demonstrated a range of comparative advantage for rice production in the Senegal, but overall, conclusions have consistently found that most production systems, and in particular, irrigation systems are not economically attractive

The project reevaluated economic comparative advantage for Senegalese rice production using models developed by Tom Randolph Revisions incorporated SAED production coefficient data and prices for the 1996/1997 cropping season These data reflect changes in use of inputs and production factors since reforms of the rice sector and the devaluation The base case analysis also uses current world prices for broken rice ($216/ton) All rice produced in the Senegal River Valley is assumed to be consumed in St Louis, while rice produced in the Casamance is consumed in the production region Results are reported in Table 5 1 The table reports Domestic Resource Cost (DRC) ratios for each system [10] The results suggest that in competition with brokens, no rice production systems except production on traditional lowland or mangrove systems in the Casamance and using hand pounding or rice hullers to process the rice are economically competitive at current prices These conclusions are not surprising given that these systems use practically no tradables in production, while all other systems are more input intensive and based on higher irrigation development costs, such as is the case with large scale perimeters in the Senegal River Valley

[9] These include Scott Pearson Dirck Stryker Rice in West Africa Abdoul Barry and Tom Randolph

[10] Note that DRCs are a ratio of the value of domestic resources in production to the tradable value added in production Thus a DRC ratio below one indicates that the tradable value added in production exceeds the resource costs used in production and thus confirms an economic surplus and so a 'comparative advantage in production A DRC greater than one indicates the opposite and therefore implies that economic value is negative

Table 5 1 Comparative Advantage of Rice Production In Senegal

(Domestic Resource Cost Coefficients)

Subsystems	Small de-huller	Small-scale Mill	Industrial Mill
Production system			
Traditional mangrove, South	0 78		
Traditional flooded lowland, South	0 35	1 13	
Traditional rainfed, South	1 06		
Irrigated semi-intensive, South (SODAGRI)	2 64	3 48	3 52
Large independent perimeters, Delta	1 19	1 23	1 27
Private perimeters, Delta	1 30	1 35	1 42
Large independent perimeters, Middle Valley	1 25		1 85
Private operations, Middle Valley	1 19		1 34
Irrigated communal perimeters	1 53		

One reason for this lack of comparative advantage for all Senegal River production systems include, first, the high cost of irrigation infrastructure and the recurrent costs of its maintenance This is particularly the case where irrigation entails pumping as in most of the Senegal River Valley

The high cost of infrastructure in the valley is compounded by the failure of nearly all valley production systems to produce two crops Thus investment costs must be amortized over one crop per year although most were designed to produce two crops

A second reason for the poor performance of economic returns to rice production in Senegal is the low assumed reference price of rice, due particularly to its sale in competition with broken rice This problem is peculiar to Senegal because of the preference of the local rice consumer for broken rice This preference results in locally produced whole grain rice being sold in competition with heavily discounted broken rice, thereby lowering the economic value of production

In Table 5 2, the sensitivity of the results to both of these problems is examined First of all, regarding the high cost of infrastructure, for systems which have already been built, one can pose the question of the marginal comparative advantage of production In this analysis, the amortization costs of building perimeters is deleted Costs still include amortization of pumping infrastructure and equipment, and recurrent costs of infrastructure maintenance, as well as all production costs This analysis (reported in column B) shows that in comparison to the base case (column A), the assumption that perimeter construction costs are sunk costs results in all large scale former SAED perimeters become economically competitive These results imply that current SAED perimeter production is economically competitive, assuming that no new perimeters are constructed

Table 5 2 Comparison of DRC for Assumptions of Infrastructure Amortization and Rice Quality

Quality hypothesis	100% Brokens (216 $/ton)		35% Brokens (262 $/ton)	
Infrastructure amortization hypothesis	with A	without B	with C	without D
Delta				
Large perimeter	1 55	0 65	1 26	0 53
Private perimeter	1 43	1 33	1 13	1 03
Middle Valley				
Large perimeter	1 59	0 75	1 32	0 62
Private perimeter	1 30	1 20	1 07	0 97
Irrigated communal perimeter	1 90	1 11	1 56	0 91

Note All scenarios assume rice milled by hulling machines

Columns C and D of the same table examines the issue of rice quality They assume that instead of 100 % broken rice, the market for domestic rice production is improved to compete with 35% broken rice from world markets This represents the approximate quality of rice that is produced in the valley using dehullers The basis of this analysis is that either regional export markets can be found that prefer at least this quality of rice instead of brokens, or that the valley can begin to supply a segment of the domestic market that prefers whole grain rice Neither of these assumptions are farfetched given recent exports of Senegalese whole grain rice to Mali and Guinea Bissau, and evidence that orders for this rice are increasing in the domestic market as well Moreover, with existing milling infrastructure even higher quality rice is already being obtained from some mills in the valley, although this scenario assumes the lowest quality (hulled) output

Under this hypothesis, the scenario in Column C presents the competitiveness of Senegal River Valley rice production systems assuming infrastructure costs are included in production costs This analysis suggests that while large former SAED perimeters remain largely uncompetitive, private perimeters in both the Delta and middle valley become nearly competitive This implies that there may be an economic argument for investing in new private perimeters if they can target higher valued rice markets

Finally the scenario in column D represents the case in which both a higher quality market is found for rice and sunk infrastructure costs are ignored Under this most optimistic scenario, the results imply that all production in these systems becomes economically viable (or nearly so for Delta private perimeters)

This scenario provides justification for maintaining production in existing perimeters in combination with a strategy to find higher quality markets for rice It suggests that existing Senegal River Valley farmers can compete with world markets for

rice if they can find regional markets for their rice in competition with at least low quality (35% broken) rice from world markets However, it also suggests that there is little prospects that expansion of perimeter infrastructure is justified under these conditions Only if even higher priced markets can be found or if other parameters of production such as yields can be raised, will the prospects for new investments be attractive

5 2 The Legacy of Reform on the Rice Sector

Reforms in the rice sector have included liberalization of input markets and domestic product markets, reductions in protection from outside markets, and a withdrawal of public subsidies for a variety of services ranging from machine services, credit and extension Lastly, a strong devaluation in 1994, occurred coincident with liberalization of international rice trade These changes have strongly affected production levels and patterns in the Senegal River Valley due to the highly commercial nature of rice production there, but it has left the Casamance relatively untouched because of its state of relative isolation from rice markets

With respect to paddy prices, the resultant impact has been a stagnation in real prices due to the offsetting effects of devaluation, which raised domestic price equivalents and market liberalization which has served to lower these prices In addition to real price stagnation, the liberalization has increased the variability of paddy prices to the internal market This has occurred despite a proposed protection scheme which would have dampened international price fluctuations in the domestic market, because of problems in the practical application of the scheme and also due to an apparent lack of will by some segments of government to implement the scheme

At the same time input markets have also felt the full impact of the devaluation on real price increases However, a narrowing of margins for intermediaries in the market due to increased competition, and an increase in the quality and reliability of delivery of these products has somewhat mitigated the rise in prices and has dampened the adverse impact on demand for these inputs Markets for machine services have also been influenced by reforms as all machine services have been fully taken over by the private sector The availability and reliability of service delivery has improved, and despite devaluation-driven nominal increases in price, these prices increased but not kept pace with inflation As a result use of some machine services has actually increased in some areas The increase in machine service price is still continuing, however, due to the gradual renewal of capital stock

Factor markets have been only indirectly or partially influenced by reforms Labor markets appear to have tightened due to shifts to more labor-intensive techniques in production subsequent to increasing prices of services and a shift towards use of family labor

The strategy of input and factor market liberalization created a brief rush by investors to invest in the valley, both to bring land under irrigation and to open businesses to provide inputs and services to producers and to process rice A rapid expansion of irrigated areas occurred between 1988 and 1991, nearly all of which was devoted to rice production The immediate impact of new land investments on production and farmer welfare where clearly positive

However, difficulties in establishing a viable credit market for farmers have had severe negative effects on rice producers Evidence of these negative impacts is most clear in the reduction of dry season production In addition, credit shortages translated into shortages of certified seed in one year, and have also been blamed for a slight decline in yields due to a clear decline in commercial input use Analysis of rice production functions in the valley also shows the very high capital elasticity of production, and suggests the priority of increasing credit availability to farmers

The aggregate impact of reforms on net profitability to produces has also been mixed Whereas real profits per hectare have only kept pace with inflation, the profit margin in comparison to financial expenses has improved, suggesting an improvement in economic efficiency in rice production A second trend that has been detected has been an increasing stratification of producers Experience with rice farming, business management, new technologies, and access to capital have begun to differentiate the performance of producers Thus some producers have become highly professional commercial farmers who consistently obtain high profits in rice production, while others have much lower productivity but continue to grow rice primarily for self sufficiency, but not as a commercial crop Reforms of the rice sector have resulted in a gradual suppression of the latter type in the Senegal River Valley, while the isolation of the Casamance has allowed this type of farmer to continue to operate largely unaffected by reforms

Despite the expectation that reforms would bring about an increase in private investment in the rice producing areas and a diversification of production to other higher valued crops, there has been little development along these lines to date in the Senegal River Valley A few tentative investments have been made by agribusiness but their experiences point to technical and policy problems which constrain investment and diversification of agriculture These include difficulty in obtaining credit from local banking institutions, high risks in marketing domestically due to strong competition from dumped imports, inability to enter export markets due to phyto-sanitary problems, poor communication and unresolved procedural obstacles Nonetheless, because of the manageable nature of these problems and because production of alternative crops such as cotton, peanuts and a wide range of horticulture has been a technical success, there is substantial optimism that these types of investments offer a long run strategy for rice farmers to diversify and raise incomes

Aside from these prospects for new production, economic analyses suggest that rice farmers using existing SAED built infrastructure in the valley, have developed viable

production systems in competition even with very low quality world imports Moreover, the prospects that a higher quality market for rice will grow in the region could improve returns to these farmers However, there is little prospect that private investors would find investments in new rice production without heavy protection, which will be costly to the state Moreover, as the state withdraws from direct support to rice production only productive commercial farmers are likely to survive