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Comparative Advantage and Public Policy in West African Rice

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INTRODUCTION

Pearson, Stryker, and Humphreys (9), in the introductory paper, suggest that the fundamental policy objectives concerning rice in West Africa are generating more income, distributing income in a more equitable fashion, and reducing the risk associated with production and consumption of essential foods. Self-sufficiency in these foods, another important goal of West African governments, is seen as a proximate objective which contributes in one way or another to each of the three fundamental objectives.

If self-sufficiency in rice is defined as a situation in which a country does not import the cereal, the effect on income of achieving this goal will depend on whether or not the country has a comparative advantage in the production of rice. If it does have such an advantage, income will be greater; if it does not, income will be less. At the core of the concept of comparative advantage lies the notion of social profitability, a measure of the economic efficiency with which a good is produced from the point of view of the nation. As shown in Appendix A, this measure differs from private profitability, the net incentive to individual producers, primarily because of government taxes, subsidies, and policies affecting prices and trade.

Combinations of all these policies may be used to promote self-sufficiency by encouraging the expansion of domestic production. Estimates of the contribution which such an expansion makes to each of the three fundamental national objectives are presented here for a number of different rice producing-processing-marketing activities in West Africa. These estimates are taken from individual country studies of the Ivory Coast (4), Liberia (7), Mali (6), Senegal (15), and Sierra Leone (10). Whereas the contribution of each activity to national income is measured quantitatively, the effects of the activities on the distribution of income and food security are discussed largely in qualitative terms. Comparisons are also made with other agricultural activities in West Africa and with those involving rice production in the United States and several Asian countries.

The next section reviews some of the geographical and institutional factors underlying comparative advantage of rice in West Africa. This is followed by a brief survey of the available production techniques. Estimates of private profitability are then presented and analyzed, and the effect on each activity of government taxes, subsidies, and price and trade policies is discussed. That section also analyzes the social profitability of producing rice in each of the West African countries in comparison with the cultivation of other crops in West Africa and rice in the United States and Asia. The impact of each rice producing activity on the distribution of income and the level of food security is then explored along with requirements of these techniques for scarce public revenue. Finally, some general conclusions are presented concerning the relative efficiency of the activities in achieving desired objectives.

GEOGRAPHY AND HISTORY

Several generalizations can be made about West Africa which influence its comparative advantage in rice production. First, because it is a region of low population density, the value of land is slight relative to that of labor and the costs of transport, marketing, and the provision of government services in rural areas are relatively high (12). Second, in comparison with many other areas of the world, most countries in West Africa have a poorly developed infrastructure. Irrigation is in its infancy, water flows are not regulated on any of the major rivers, and poor transport facilities impede access to many areas. Finally, there is often a severe shortage of government budgetary resources and of people with the training required to undertake major development projects.

In other respects, suggested in Table 1, there are substantial differences among countries and even between regions within countries. The first two indicators in this table describe key geographical features of these regions -- mean annual rainfall and distance to the nearest major port. There is a fairly sharp distinction between regions with 1,300 mm or more of rainfall, which can produce rice using rainfed techniques, and those which receive 700 mm or less but have substantial water resources for irrigation or flooding. In addition, important differences in water conditions exist within these rainfall zones. The Senegal River, for example, suffers from a number of disadvantages in comparison with the Niger-Bani system: smaller water flow, greater intra-annual variation and uncertainty of flooding, and salt incursion from the sea.

Table 1.--Key Characteristics of Several Rice Producing Regions of West Africa[a]

Region	Mean annual rainfall (mm)	Average distance to major seaport[b] (km)	Rural population density[c] (persons/km^2)	Unskilled rural wage rate (US $/day)	Rural per capita income (US $/person)	Degree of urban-ization[c] (%)	Density of all-weather roads (km/km^2)
Ivory Coast							
Forest	1,550	406	19	1.80	150	37	
Savannah	1,300	667	9	1.40	53	21	.0435
Liberia	2,000	225	7	1.25	168	23	.0189
Mali							
Mali-Sud	1,300	853	14	1.20	50	6	.0144[d]
Mopti	520	1,317	13	1.00	40	4	
Segou/Office du Niger	700	1,145	16	1.00/1.25	50/85	9	
Senegal							
Fleuve, delta	320	338	16	1.00	56	49	.0170
Fleuve, valley	420	513	7	1.00	75	18	.0170
Casamance	1,400	395	22	1.20	100	16	.0360
Sierra Leone	2,500/3,000	175	23	0.60/0.80	70	25	.0238

[a] Data are from individual country studies (4, 6, 7, 10, 15).

[b] Distance is defined from a major town or city near the geographical center of each region.

[c] Urban population is defined generally as those living in towns of 10,000 people or more.

[d] Total kilometers of all-weather roads divided by the one third of Mali's total land area which is in the zone where agriculture is possible.

Rice growing regions also vary substantially in their distance to the nearest seaport. The interior regions are provided with natural protection against rice imports because of high inland transport costs. But these transport charges also raise the cost of using inputs supplied from abroad and make it difficult for the interior countries to export to other West African countries, especially to the coast where the major markets are found.

The third indicator in Table 1, rural population density, is a key variable determining the types of production techniques which are appropriate for West African conditions.[1] As already noted, population density is generally low throughout the region. There is variation, however, and the density in Liberia is only about one-third that of the Casamance in southern Senegal or the southern Ivory Coast. In addition, there are important concentrations of population, not shown in the aggregate data, in such areas as the Senegal River Valley and the Lower Casamance.

The low ratio of labor to land influences the next two indicators, the wage rate of rural unskilled labor and rural per capita income. The wage rate is often considerably greater than in many Asian countries, were population densities are mugh higher. The world's most important rice exporter, Thailand, for example, had a rural wage rate equal to about $.60 at official exchange rates prevailing in the mid-1970s, or only one third that of the forest zone of the Ivory Coast and lower than that of any West African country studied here except Sierra Leone.[2] Aside from the southern Ivory Coast, which has experienced considerable rural development and where relatively high wages and per capita income are attracting large numbers of migrants from other regions, the Office du Niger in Mali,

a fully irrigated scheme for rice and sugar production, has been able to raise wages and incomes above the lower levels found in the surrounding regions of Mopti and Segou.[3]

The last two variables of Table 1, degree of urbanization and density of all-weather roads, are indicators of the level of commercialization and state of infrastructure development which exist in each region. These affect the cost of transporting and marketing rice, delivering inputs, and providing administrative and extension services. Urbanization and road development are generally much more advanced in the coastal than in the interior regions. This is a reflection of the sequential nature of development, which started during the colonial era along the coasts and only recently moved to an important extent into the interior (11).

Finally, there are special factors which influence comparative advantage but which are not easily summarized in tabular form. One is the continued existence of capital the investment of which was made in the past and therefore may be considered as sunk.[4] The most important example is the Office du Niger: its diversion dam and principal canals were constructed during the 1930s. The regions also differ with respect to the availability of data required for development. More is known about the hydrology of the Senegal River, for example, than about that of the Niger. Another special factor is past agricultural research. The results of this research, most of which has been conducted outside of West Africa, give rice an important advantage over food crops such as millet and sorghum on

which research is only beginning. Standing rice has also been the subject of considerably more research than have the floating and upland varieties traditionally grown in West Africa. There is a question, however, of whether rice techniques developed in Asia are appropriate for West African conditions, especially in view of the differences in population density on the two continents.

RICE PRODUCTION TECHNIQUES

The techniques used to produce rice in West Africa which are described in detail in the individual country papers range from traditional upland cultivation with no modern inputs and long periods of fallow to intensive mechanized cultivation under total water control. The techniques vary substantially with respect to yields, costs, dependence on outside inputs, and labor-land ratios. Several of these characteristics are shown in Table 2.

It is clear from this table that the techniques listed are far from homogeneous. Labor times, especially, vary enormously between countries and this variation is not very well correlated with differences in yields, which tend to be fairly similar for each technique.[5] Part of the variation in labor times may be due to the substitution of capital for labor, especially in the form of mechanization. But different methods used for estimating labor times may also have produced results which are not entirely comparable. Labor inputs in the Ivory Coast, Mali, and Senegal, for example, have been calculated from a number of sources, including information provided by farmers and extension workers, which suggest how much time should normally

Table 2. -- Characteristics of Rice Production Techniques[a]

Production technique	Paddy Yield (mt/ha/crop)	Land development cost (US $/ha)	Farm labor (mandays/ ha/crop)	Fertilizer (kg/ha/crop) N	P_2O_5	K_2O	Extension service costs (US $/ha/crop)
Traditional manual upland							
Ivory Coast	.89 -1.30	28-54	85-113	0	0	0	0
Liberia	1.05	0	214	0	0	0	0
Sierra Leone	.81 -1.17	0	205-238	0	0	0	0
Improved manual upland							
Ivory Coast	1.50 -2.20	28-72	97-117	50	27	27	31
Liberia	1.57	0	231	42	42	42	25
Sierra Leone	1.46 -1.87	0	225-258	50	50	0	8
Animal traction upland							
Ivory Coast	1.80	51	88	50	27	27	31
Senegal[b]	2.07	60	111	57	20	40	22
Mechanized upland							
Ivory Coast	2.00	520	30	50	27	27	31
Traditional manual swamp							
Liberia	1.55	50	243	0	0	0	0
Mali	1.20	0	120	0	0	0	0
Senegal	1.08	17	208	0	0	0	0
Sierra Leone	2.20 - 2.83	34-39	274-356	0-8	0-8	0-8	0
Improved manual swamp							
Ivory Coast	3.50	1,460	240-247	50	27	27	63
Liberia	3.50	750	331	42	42	42	49
Senegal	3.60	818	266	88	45	68	44
Sierra Leone	2.78 - 3.03	173	336-390	53	53	0	17

Table 2. -- Characteristics of Rice Production Techniques[a]

Production technique	Paddy Yield (mt/ha/crop)	Land development cost (US $/ha)	Farm labor (mandays/ ha/crop)	Fertilizer (kg/ha/crop) N	P_2O_5	K_2O	Extension service costs (US $/ha/crop)
Improved manual mangrove							
Sierra Leone	1.74 - 2.80	0	445	0	0	0	0
Animal traction swamp							
Mali	1.80	600-2,000	100	0	0	0	7
Partially mechanized swamp							
Ivory Coast	4.00	1,680	181	50	27	27	63
Liberia	3.50	1,504	235	42	42	42	135
Improved manual uncontrolled flooding							
Sierra Leone	.96	0	112	9	9	0	0
Animal traction uncontrolled flooding							
Mali	.60	0	60	0	0	0	0
Mechanized uncontrolled flooding							
Sierra Leone	1.13 - 1.82	0	68-91	0-13	0-13	0	0
Animal traction controlled flooding							
Mali	1.40	800-1,000	70-80	0	0	0	10-12
Improved animal traction controlled flooding							
Mali	2.50	800-1,000	95-100	32	23	0	20

Table 2. -- Characteristics of Rice Production Techniques[a]

Production technique	Paddy Yield (mt/ha/crop)	Land development cost (US $/ha)	Farm labor (mandays/ ha/crop)	Fertilizer (kg/ha/crop) N	P_2O_5	K_2O	Extension service costs (US $/ha/crop)
Animal traction irrigated single crop							
Mali	2.25	sunk	90	15	0	0	20
Improved animal traction irrigated single crop							
Mali	3.50	440	120	64	46	0	40
Mechanized irrigated single crop							
Senegal	2.50	4,794	92	69	72	0	10
Manual irrigated multiple crop							
Ivory Coast	4.00	6,812	247	50	27	27	63
Senegal	4.75	315	270	122	96	0	52
Mechanized irrigated multiple crop							
Ivory Coast	2.75	4,972	34	50	27	27	63
Senegal	3.80	3,116	135	81	92	20	24

[a] Data are from individual country studies (4, 6, 7, 10, 15).

[b] Yields are higher than is usual for upland rice cultivation because of the peculiar "grey soils" on which the rice is grown. These permit the plants to be nourished by a high water table after the rains have stopped.

be required for each agricultural task. Estimates for Liberia and Sierra Leone, on the other hand, are based primarily on multiple-interview surveys of farmers, which indicate the number of days actually devoted to each task but say relatively little about the amount of time or effort expended in performing that task on a given day. It is likely that the former approach tends to underestimate and the latter to overestimate actual labor inputs.

Another source of variation in labor times relates to the treatment of labor used for land development. If freshly cleared land is cultivated for several consecutive years, the time involved in clearing is treated in Table 2 as a land development cost. In several instances, however, time spent developing the land is included with other labor inputs as a current operating cost, either because the land is only farmed for one year or because, as for Sierra Leone, the data do not allow a distinction to be made between these two types of labor input. Although this results in some error in these variables in Table 2, whether these land development costs are treated as a capital or current input probably does not affect very much the overall calculation of private and social profitability.

While the data in Table 2 are not strictly comparable, it is useful, nonetheless, to draw a few conclusions from the table. One is that yields are positively correlated with degree of water control.[6] Not only does better water control by itself improves yields, but also the fixed cost associated with land development encourages greater use of yield-increasing variable inputs such as fertilizer.[7] The

yield response to fertilizer is particularly great, moreover, because of the improved seed varieties used and because existing levels of fertilizer utilization are generally very low.[8]

Labor inputs, on the other hand, are not very closely linked with degree of water control.[9] Traditional and improved manual rainfed techniques, including upland and swamp cultivation, use up to 400 man-days per hectare or more, whereas manual irrigated cultivation, such as that found in the Senegal River Valley, uses less than 300 man-days. Animal traction techniques yielding about 2 t/ha employ 88 to 111 man-days per hectare in rainfed cultivation, 70 to 100 man-days in controlled flooding, and 90 man-days under irrigated conditions. Fully mechanized cultivation, on the other hand, appears to use at least as much labor with rainfed as with irrigated techniques, though this conclusion is based on only one example of rainfed farming. Some of the reasons why labor, in contrast to other variable inputs, is used relatively less in irrigated agriculture might be that less land clearing is required, good water control lessens the need for weeding, and where natural conditions permit rainfed swamp techniques are often similar to those involving irrigation.

There is a fairly strong correlation between yields and extension costs, but this may be because these costs are closely associated with the delivery of modern inputs not otherwise included in Table 2, rather than because of the usefulness of extension advice per se.[10] Furthermore, the relation between these costs and the services

actually provided by the extension agents is complicated by such factors as the locational concentration of farmers, the extent to which project overhead expenses are charged to the extension service, and the administrative efficiency of that service. Nevertheless, the relatively high correlation between yields and extension costs suggests the usefulness of this variable as a proxy.

To test the validity of these conclusions with several different influences on yields operating at once, a single-equation, least-squares regression was run using the 33 country-specific techniques shown in Table 2. With paddy yield as the dependent variable, the following regression coefficients were obtained (with standard errors in parentheses):

Land Development Cost	Farm Labor	Nitrogen Fertilizer	Extension Service Cost
.151	3.212	17.427	11.708
(.057)	(.845)	(3.184)	(3.591)

All coefficients are significant at the 95 percent confidence level, as is the coefficient of determination of .813.

One of the most interesting conclusions from this analysis is that each of the last three input variables exerts a separate influence on yields beyond that of land development costs. Nevertheless, water control clearly remains a necessary, if not a sufficient, condition for obtaining high yields in many of these areas because of insufficient rainfall and other natural conditions.[11]

To test for the possibility that yields might vary systematically among countries, dummy variables were introduced into the regression equation with the following results:

Constant	Ivory Coast	Liberia	Senegal	Sierra Leone
878.032	-455.811 (247.620)	-867.400 (305.571)	-526.138 (315.141)	-643.439 (290.249)
	Land Development Cost	Farm Labor	Nitrogen Fertilizer	Extension Service Cost
	.138 (.055)	4.697 (1.012)	17.748 (3.954)	12.782 (4.146)

The inclusion of the dummy variables has relatively little influence on the regression coefficients of the inputs, except for that of labor which is almost 50 percent greater than without the dummies. All these coefficients remain significant as does the coefficient of determination, which equals .842.

The most interesting results are revealed by the coefficients of the dummy variables, which allow for shifts in the constant term of the regression equation. This term is a maximum for Mali for which the dummy variable equals zero. For each of the other countries, however, the coefficient of the dummy variable is negative, indicating that, other things equal, yields are lower than in Mali. The downward shift of the constant term is greatest and highly significant for Liberia. It is less pronounced, but still significant, for Sierra Leone. The coefficients for the Ivory Coast and Senegal, on the other hand, are sizeable but not statistically significant at the 95 percent level of confidence. Overall, country-specific yield variations may be as great as 867 kg/ha.[12]

These results suggest that Mali has a significant natural advantage compared with the other countries in producing rice. One reason may be the good flood conditions of the Niger River. Another is

the sunk capital investment in the irrigation system of the Office du Niger. At the other extreme, Liberia and Sierra Leone appear to have natural disadvantages in rice production. This may be because, as Spencer (10, p. 15) observes,"...cultivation in heavy rain forest areas is more labor demanding than in more open savannah regions and thinner rain forests such as in the Ivory Coast."

MILLING AND MARKETING TECHNIQUES

A range of techniques also exists for milling and marketing. Chief characteristics of three different milling techniques -- industrial, small hullers, and hand pounding -- are given in Table 3. The three techniques vary substantially with respect to scale. The largest industrial mills are capable of milling 30,000 tons of paddy per year whereas a single person can hand pound only about 5 or 6 tons during the same period. The former technique is also very capital intensive, employing on a single shift only 10 to 15 workers in an entire mill, whereas one woman pounding rice by hand uses only a crude mortar and pestle. Between these two extremes are the small-scale mills, with which two persons at a time can annually hull 400 to 500 tons of paddy.

Processing costs differ substantially between techniques and countries. The cost of milling a ton of rice in the large industrial mills varies inversely with rates of capacity utilization and at current rates is considerably higher than in the small hullers for all countries. Handpounding is cheaper than large-scale milling except in the Ivory Coast and Mali, where rates of capacity utilization in the industrial mills are fairly high. The cheapest milling

Table 3. -- Characteristics of Rice Milling Techniques[a]

Milling technique	Projected full capacity[b] (mt paddy/year/unit)	Capacity Utilization in 1976	Unit Cost (US $/mt milled rice)	Milling ratio	Quality of output
Industrial					
Ivory Coast	15,000-20,000	.64	56	.66	25-35% broken
Liberia	10,000	.06	119	.67	25-35% broken
Mali	6,000-18,000	.94	27-33	.57-.67	40-70% broken
Senegal	10,000-30,000	.15	104	.65	40-90% broken
Sierra Leone	3,750-15,000	.25	67[c]	.64	10% broken
Small huller					
Ivory Coast	500	.10	20	.63	fresh, some parboiled
Liberia	400	.38	52	.66	25-45% broken
Mali	375	.44-.69	16-30	.45-.70	60-70% broken
Senegal	500	.05-.15	28	.66	25-40% broken
Sierra Leone	433	.50	14	.67	20-40% broken
Hand pounding					
Ivory Coast	6.25	n.a.	133	.65-.69	stones, some parboiled
Liberia	6.9	n.a.	78	.60	40-50% broken
Mali	4.5	n.a.	60	.70	80-100% broken
Senegal	6	n.a.	21	.65-70	40-60% broken
Sierra Leone	5.7	n.a.	31	.67	20-40% broken

[a] Data are from individual country studies (4, 6, 7, 10, 15).

[b] Assumes 5,000 hours (250 days at 20 hours/day) of operation per year for industrial mills, 2,500 hours (250 days of 10 hours/day) per year for small hullers, and 1,500 hours (250 days at 6 hours/day) for hand pounding.

[c] Adjusted from the cost estimate of Spencer (10) to reflect actual rates of capacity utilization.

n.a. not applicable

technique, however, is small-scale hulling. Only in Senegal, where rates of capacity utilization are very low because of a highly fragmented market for rice which is locally produced and consumed, are small-scale mills more expensive than hand pounding. On the other hand, paddy and milled rice must be transported to and from the small hullers, which for on-farm consumption decreases their advantage over hand pounding.

Milling ratios do not seem to differ markedly between techniques or countries in any consistent way. Hand pounding yields a higher percentage of broken rice, and quality is decreased by the presence of foreign matter. Small-scale hulling also increases the percentage

of brokens compared with large-scale milling, except in the drier regions where breakage rates in the large mills are quite high.

The collection of paddy and distribution of rice generally take place within a dual marketing system. On one hand, public marketing agencies purchase paddy from the farmer at an officially prescribed producer price, deliver it to publicly or privately owned industrial mills, and provide for its distribution and sale to the consumer at an official retail price. Large quantities of paddy and milled rice, however, are also typically traded in a private marketing network, where prices are established principally by supply and demand and where processing is done either by hand or in small-scale mills.

Marketing costs are influenced by the density of population and the relative adequacy of the existing road network. They are also affected by the location of consumption in relation to production. There are numerous different possibilities, including delivery from interior producing regions to coastal markets, distribution to markets within the producing regions, and on-farm consumption. In general, the farther apart are the points of production and consumption, both physically and vertically within the marketing chain, the higher is the total cost of collection and distribution and the lower is the border price used to calculate the social value of rice output.[14] The first stage in the marketing chain is often the most costly, however, because of high charges for short-distance transport, which are especially important if the paddy is collected from widely dispersed areas for delivery to a few centrally located industrial mills.[15]

This is very important in areas, such as Liberia, where the population density is low and the road network is poorly developed.

PRIVATE PROFITS, PUBLIC INCENTIVES, AND NET SOCIAL PROFITABILITY

Appropriate production, milling, and marketing techniques have been combined to form the rice sector activities analyzed in detail in the individual country papers. Indicators of private profitability (PP), the effects of public incentives, and net social profitability (NSP) are shown in Table 4 for the major rice producing activities, with consumption assumed in each case to take place in the capital city.

Private Profitability

Private profitability equals the value of output minus the value of all inputs, each measured in terms of the appropriate domestic market prices faced by farmers, millers, or traders. These prices are inclusive of government taxes and subsidies. The resulting PP indicator shows the incentive, for each activity, to alter the existing allocation of resources. If private profitability is positive, resources are encouraged to flow into the activity; if PP is negative, the direction of resource flow is likely to be away.

Private profitability, as shown in Table 4, is nearly always positive. The only exceptions are in Liberia and Mali, where PP assuming delivery to the capital city is negative for several activities which, instead, usually produce only for the farm. On-farm consumption raises the value of output and causes private

Table 4 -- Private Profitability, Public Incentives, and Net Social Profitability[a]
(US $/mt milled rice)

Production technique	Private profitability	Domestic price minus border price	Net subsidy	Net social profitability
Traditional manual upland				
Ivory Coast forest	156	48	226	-117
Ivory Coast savannah	213	48	233	-70
Liberia	-96	144	-9	-231
Sierra Leone south	80	25	--	55
Sierra Leone north	26	25	--	1
Improved manual upland				
Ivory Coast forest	189	48	262	-104
Ivory Coast savannah	213	48	288	-120
Liberia	-62	144	13	-219
Sierra Leone south	128	30	36	62
Sierra Leone north	75	33	46	-4
Animal traction upland				
Ivory Coast savannah	235	48	286	-95
Senegal Casamance	106	78	36	-8
Mechanized upland				
Ivory Coast savannah	230	48	328	-143
Traditional manual swamp				
Liberia	-6	144	-9	-141
Mali	-64	-122	-16	74
Senegal Casamance	n.a.	n.a.	n.a.	n.a.
Sierra Leone south	137	30	--	107
Sierra Leone north	92	31	3	58

Table 4 — Private Profitability, Public Incentives, and Net Social Profitability[a] (continued)
(US $/mt milled rice)

Production technique	Private profitability	Domestic price minus border price	Net subsidy	Net social profitability
Improved manual swamp				
Ivory Coast forest	136	48	291	-180
Ivory Coast savannah	174	48	305	-155
Liberia	42	144	12	-114
Senegal Casamance	79	65	72	-58
Sierra Leone south	158	44	49	65
Sierra Leone north	140	44	51	45
Improved manual mangrove				
Sierra Leone south	117	23	--	94
Sierra Leone north	64	16	--	48
Animal traction swamp				
Mali	-7	-123	21	95
Partially mechanized swamp				
Ivory Coast forest	144	48	288	-146
Liberia	108	144	138	-174
Improved manual uncontrolled flooding				
Sierra Leone Boliland	147	33	6	108
Animal traction uncontrolled flooding				
Mali	-118	-107	-15	4
Mechanized uncontrolled flooding				
Sierra Leone Boliland	165	24	117	24

Table 4 -- Private Profitability, Public Incentives, and Net Social Profitability[a] (continued)
(US $/mt milled rice)

Production technique	Private profitability	Domestic price minus border price	Net subsidy	Net social profitability
Animal traction controlled flooding				
Mali	-21	-126	26	79
Improved animal traction controlled flooding				
Mali	8	-126	13	121
Animal traction irrigated single crop				
Mali	6	-133	4	135
Improved animal traction irrigated single crop				
Mali	6	-133	22	117
Mechanized irrigated single crop				
Senegal Fleuve	4	131	138	-265
Manual irrigated multiple crop				
Ivory Coast savannah	202	48	360	-178
Senegal Fleuve	90	150	8	-68
Mechanized irrigated multiple crop				
Ivory Coast forest	166	48	456	-334
Senegal Fleuve	64	139	57	-132

[a] Data are from individual country studies (4, 6, 7, 10, 15). The sum of the last three columns equals private profitability, except for the Ivory Coast where net social profitability differs from private profitability because of differences in social and private prices of land in addition to the effects of government incentives.

profitability in most of these cases to be positive.[16] In addition, part of the harvest from these activities in Mali is sold on the free market at prices higher than the low official producer price used to calculate private profitability in Table 4. When both these adjustments are made, virtually every activity is privately profitable[17]

The incentive to produce for market, however, varies enormously among countries and techniques. At one extreme, private profitability is so low that efforts to improve manual cultivation of rice in the uplands of Liberia are unlikely to succeed as long as this rice is distributed to Monrovia. In the Ivory Coast, on the other hand, price incentives and input subsidies enable farmers to earn profits of over $200/mt for several different production techniques.

Most of this variation is due to differences in profitability between countries rather than between techniques within the same country. An unweighted average of private profitability for each activity shown in Table 4 is $197/mt in the Ivory Coast, $111/mt in Sierra Leone, $46/mt in Senegal, $.3/mt in Liberia, and $-26/mt in Mali. Variation among techniques, on the other hand, is much less. For the Ivory Coast, Liberia, and Sierra Leone taken together private profitability averages $76/mt in traditional manual upland, $109/mt in improved manual upland, and $130/mt in improved manual swamp cultivation. To take another example, private profitability in Ivory Coast upland, swamp, and irrigated cultivation varies only slightly with different levels of mechanization, and the direction of variation is not consistent. Finally, private profitability for each of the improved techniques in Mali differs remarkably little from zero.

Public Incentives

Private profitability of rice production in West Africa is influenced to an important extent by public incentives consisting of taxes, subsidies,and price and trade policies. In Table 4, these incentives are aggregated into two groups. The first is the net effect of price and trade policies causing the domestic price of rice to differ from its border price -- either c.i.f. or f.o.b. depending upon whether rice is imported or exported. The second consists of net taxes and subsidies on intermediate and capital inputs. The sum of these two groups of incentives is equal to the difference between private and net social profitability.[18]

There are substantial differences between countries in the magnitude and type of public incentives offered to encourage rice production. In Mali, the low official price of paddy purchased by the government, which controls about 50 percent of the total tonnage marketed, tends to discourage substitution of domestic production for rice imports. Mali is practically self-sufficient in rice, however, and in good years even exports the grain. Therefore, the f.o.b., rather than the c.i.f., price may be more relevant as a yardstick with which to compare the domestic price. If this is the case, the disincentive resulting from Mali's official price policy is greatly reduced and is offset for most improved production by net subsidies paid by the government on inputs.

The Ivory Coast, Senegal, and Sierra Leone all protect domestic production to a moderate degree through their trade policies and pricing systems. They differ substantially, however, in the extent to which they subsidize inputs. The Ivory Coast provides input subsidies averaging over $300/mt, mostly as a subsidy to the government-owned mills which enables them to offer the farmer a high purchase price for his paddy. Input subsidies in Senegal and Sierra Leone, on the other hand, average only $62/mt and $27/mt respectively. In all of these countries, net input subsidies increase with mechanization and higher degrees of water control. In addition, these subsidies are somewhat greater in the drier northern regions of each country than they are in southern areas which receive more rainfall. This is partly because the subsidies are measured per ton of milled rice and yields in the southern areas are higher, but it is also due to the more elaborate water control structures required in some of the drier region, such as northern Senegal.

Liberia differs from the other countries in that it relies primarily on import restrictions as a means of promoting local rice production. The domestic price in Monrovia in 1975-76 was $144/mt greater than the comparable c.i.f. price, and agricultural inputs received only very slight subsidies, except in partially mechanized cultivation where the net subsidy was $138/mt. Inputs into traditional rice production are on balance slightly taxed in both Liberia and in Mali.

Social Profitability

The magnitude of incentives offered to rice production is such that private profitability is an unreliable guide to the efficient allocation of resources. Net social profitability, measured in world prices or their equivalents, in fact, diverges widely from the private measure of net benefits. Furthermore, there is significant variation in NSP among countries and between techniques.

The NSP indicators in Table 4 suggest that only two countries--Mali and Sierra Leone--are able to substitute profitably local production of rice for imports consumed in the capital city.
In all of the other countries, NSP is negative for each activity. Liberia appears to be especially disadvantaged since there is no technique which can be used to produce rice without a loss of at least $114/mt. An unweighted average of NSP for each activity in Liberia is $-176/mt, compared with $ -148/mt in the Ivory Coast and $-106/mt in Senegal. This is consistent with the regression analysis of yields, presented earlier, which gives as the coefficients of country-specific dummy variables: -867 for Liberia, -456 for Ivory Coast, and -526 for Senegal. Although productivity, according to these results, might be slightly greater in the Ivory Coast than in Senegal, this advantage is more than offset by higher Ivorian wages.[19]

The opposite occurs in Sierra Leone, for which the coefficient of its dummy variable is -643, indicating a substantial productivity disadvantage. Yet Sierra Leone's net social profitability is positive in every activity but one -- improved manual upland cultivation in the north -- and even that activity is only marginally unprofitable.

The principal explanation for this apparent anomaly seems to be that wage rates in Sierra Leone are very low in comparison with other West African countries.[20] In addition, as was noted earlier, techniques of production in Sierra Leone are very labor-intensive.[21] Since differences between countries in the shadow prices of the other inputs are relatively unimportant as a percentage of total production costs, low wage rates in Sierra Leone could compensate for its productivity disadvantage.

Mali clearly has the highest rates of net social profitability of any of the five countries. These range from $4/mt for ox-drawn cultivation under uncontrolled flooding conditions to $135/mt for single-crop, irrigated cultivation using animal traction at the Office du Niger. High rates of NSP in Mali appear to reflect the natural advantages mentioned earlier, such as the relatively predictable flooding of the Niger River and the sunk capital investment in the Office du Niger. In addition, wages in Mali are fairly low compared to other countries, especially the Ivory Coast.[22] Finally, the c.i.f. price of rice in Mali, which is used to value the benefits from production, is higher than that of the other countries because of the cost of transport from the coast to the frontier.

Within countries, there are also some generalizations which can be made concerning net social profitability of different techniques. In both the Ivory Coast and Sierra Leone, for example, social profitability is increased by improving manual rainfed cultivation in the south, but it is decreased when this is done in north. NSP is also increased in the same way throughout Liberia, where

the amount of rainfall is uniformly high. This appears to be because the yield response to the introduction of improved varieties and fertilizer is lower in zones of lesser rainfall than in those where rainfall is abundant.[23] It suggests that increased water control is necessary if the full potential of improved cultivation is to be realized in drier areas. The evidence concerning the effects on NSP of introducing improved practices into swamp cultivation is mixed, however, indicating that water there appears to be less critical. In Liberia, social profitability is increased, whereas in both northern and southern areas of Sierra Leone and the Ivory Coast NSP is reduced, with improved methods of cultivation. On the other hand, control of flooding in Mali raises NSP considerably and, in addition, makes possible further increases in social profitability through greater intensification of cultivation.[24]

There is some evidence that use of animal traction is more profitable than manual cultivation. This is true of improved upland cultivation in the Ivory Coast and of traditional swamp production in Mali. The advantage of partially mechanized swamp cultivation, involving use of power-tillers, is less well established, however, since it is more profitable than manual cultivation in the southern Ivory Coast but less profitable in Liberia. In any case, full mechanization with tractors has a lower NSP than other less mechanized techniques in every instance for which comparisons can be made --upland cultivation in the Ivory Coast savannah, uncontrolled flooding in Sierra Leone's Bolilands, and irrigated multiple-crop production in Senegal. The intermediate stages of mechanization, therefore, appear to have the greatest chance for success.[25]

Finally, the data show clearly the problems associated with trying to produce rice in total water control irrigation systems where only one crop per year can be grown. In the delta region of the Senegal River, salt incursion from the sea during the dry season prevents pumping water from the river for a second crop, resulting in very high social costs of production. Further upstream, two crops can be grown, which spreads some of the high overhead and capital costs associated with this kind of irrigation.

Exports

The profitability estimates shown in Table 4 all assume that consumption of locally grown rice takes place in the largest urban center — in each case the capital city. Positive net social profitability in Mali and Sierra Leone, however, suggests that these countries might have a comparative advantage in exporting to other countries in West Africa. This would reduce net social profitability, however, because the f.o.b. value of rice is less than its c.i.f. value due to the influence of transport costs. Revised NSP estimates for rice exported from Mali and Sierra Leone to several West African markets are given in Table 5 for a few selected techniques which could be expanded to generate exportable supplies.

It appears from this table that there are opportunities for profitable exports of rice from both countries. The decline in net social profitability resulting from using an f.o.b. rather than a c.i.f. price to value rice output, however, is considerably greater for Mali than for Sierra Leone because of the much longer distances involved. This is evident from the gain in NSP which results from shipping rice to Bouaké, in the center of the Ivory Coast, rather

Table 5 -- Net Social Profitability of Rice Exports
(US $/mt milled rice)

Production Technique	Consumption Point	
	Monrovia	Freetown
Traditional manual upland Sierra Leone south	40	55
Improved manual upland Sierra Leone south	47	62
Traditional manual swamp Sierra Leone south	92	107
Improved manual swamp Sierra Leone south	50	65

	Abidjan	Bouaké	Dakar	Bamako
Improved animal traction controlled flooding				
Mali (Ségou)	11	47	-32	121
Mali (Mopti)	-25	12	-83	71
Animal traction irrigated single crop				
Mali (Office du Niger)	25	61	-18	135
Improved animal traction irrigated single crop				
Mali (Office du Niger)	7	43	-36	117

[a] Data are from individual country studies (6, 10).

than to Abidjan on the coast. It can also be seen by comparing the NSP of rice exported from Ségou with that produced near Mopti, closer to the center of the interior delta of the Niger River, the major area for potential growth of rice cultivation. Aside from long distances, Mali suffers an additional disadvantage in trying to supply the Dakar market because of competition from inexpensive broken rice imported from Asia.

The ranking of NSP by technique is the same as when rice is produced for domestic consumption. The techniques vary, however, in the degree to which they can contribute to exports. In general, the improved techniques, with their higher yields, offer greater supplies of rice available for export. An increasing proportion of expanding exports will therefore come from improved cultivation. This implies some increase in the profitability of upland rice, but a considerable decline in that of swamp rice, produced for export in Sierra Leone. Similarly, the profitability of growing irrigated rice for export at the Office du Niger in Mali is likely to decline in the future as an increasing proportion of that rice comes from improved techniques of cultivation. On the other hand, rapid development of rural areas in the Ivory Coast is enlarging the interior Ivorian market for rice which Mali could supply. This will increase the f.o.b. price of Malian exports and improve their social profitability.

Local Consumption

In the Ivory Coast, Liberia, and Senegal, production of rice for consumption in the capital city is socially unprofitable for each activity. This does not imply, however, that rice which is

consumed closer to the areas of cultivation is also necessarily unprofitable. Just as costs of transport and handling make it easier to meet competition from imports than to export profitably, so the cost of imported rice, and thus the shadow price of domestically produced rice, rises as the consumption point is shifted closer to the areas of production. In addition, of course, the cost of marketing local rice also declines.

The effect of shifting the consumption point closer to the farm is seen in Table 6. Net social profitability rises as consumption is transferred from the capital city to regional and local markets and finally to the farm. Transport costs are reduced, and various stages in the marketing chain may also be eliminated. In addition, the use of small-scale hullers to process rice for the local market results in further savings over large-scale milling. Furthermore, when consumption takes place on the farm, the elimination of collection and distribution costs more than offsets the higher cost of hand pounding over that of small-scale hullers.

As a result, a number of techniques which are not profitable when rice is consumed in the capital city become socially profitable when consumption takes place closer to the farm. This is especially true for Senegal because of the long distances between the producing regions and the Dakar market, but it is also true for traditional manual upland cultivation in the Ivory Coast savannah and almost true of traditional manual upland cultivation in the Ivory Coast forest, upland cultivation involving animal traction in the Ivory Coast savannah, and improved manual swamp production in Liberia.

Table 6 -- Net Social Profitability of Rice for Local Consumption (US $/mt milled rice)

Production Technique	Consumption Point			
	On-farm[b]	Local market[c]	Regional market[c]	Capital city[d]
Traditional manual upland				
Ivory Coast forest	-8	-44	-87	-117
Ivory Coast savannah	34	18	-38	-70
Liberia	-128	n.a.	n.a.	-231
Improved manual upland				
Ivory Coast forest	n.a.	-31	-75	-104
Ivory Coast savannah	n.a.	-34	-87	-120
Animal traction upland				
Ivory Coast savannah	n.a.	-8	-62	-95
Senegal Casamance	87	n.a.	29	-8
Traditional manual swamp				
Senegal Casamance	-39	n.a.	n.a.	n.a.
Improved manual swamp				
Ivory Coast forest	n.a.	-110	-150	-180
Ivory Coast savannah	n.a.	-72	-122	-155
Liberia	-4	n.a.	n.a.	-114
Senegal Casamance	37	n.a.	-21	-58
Mechanized irrigated single crop				
Senegal, Fleuve	n.a.	n.a.	-249	-265
Manual irrigated multiple crop				
Ivory Coast savannah	n.a.	-95	-146	-178
Senegal Fleuve	100	n.a.	-51	-68
Mechanized irrigated multiple crop				
Ivory Coast forest	n.a.	-272	-305	-334
Senegal Fleuve	-25	n.a.	-116	-132

[a] Data are from individual country studies (4, 7, 15).
[b] Assumes rice is hand pounded.
[c] Assumes rice is processed in small-scale hullers.
[d] Assumes rice is processed in large-scale mills.
n.a. not available.

On the other hand, mechanized cultivation is not profitable for consumption anywhere, and except for the techniques mentioned, which have NSPs close to zero, the Ivory Coast and Liberia do not appear to have a comparative advantage in rice production even for on-farm consumption.

Comparison with Asia and the United States

Since the production of rice in West Africa to supply its major markets is socially unprofitable for some countries and is only moderately profitable for others that are potential exporters within the region, the question arises as to which countries elsewhere in the world have sufficiently low social costs that they can profitably supply West Africa with rice.[26] A previous study of comparative advantage of rice production in Asia and the United States, using a methodology similar to that employed here, provides estimates of net social profitability for four countries, including two of the world's most important rice exporters -- Thailand and the United States (8).

These estimates are shown in Table 7, together with some obtained for the West African countries. The results are straightforward. Thailand, the world's most important rice exporter, has by far the highest net social profitability. Production in the United States, which is the second largest exporter, is only marginally profitable. The other two Asian countries, the Philippines and Taiwan, as well as the Ivory Coast, Liberia, and Senegal, have NSPs which are negative as long as they are substituting for imports of rice going to their major markets.[27] Of the African countries, only Mali and Sierra Leone have positive NSP, and this would be reduced if these two nations were to export within the region. If they should try to export outside of West Africa,

Table 7 -- Net Social Profitability of Rice in Asia, the United States and West Africa[a]
(US $/mt milled rice)

Production technique	Philippines	Taiwan	Thailand	United States	Ivory Coast	Liberia	Mali	Senegal	Sierra Leone
Improved upland	--	--	84/122	--	-143/-95	-219	--	-8	-4/62
Improved swamp, mangrove, and flooding	--	--	165/196	--	-180/-155	-114	79/121	-58	24/108
Partially mechanized irrigated	-99	-161/-68	--	--	-146	-174	--	--	--
Mechanized irrigated single crop	--	--	--	-30/20	--	--	--	-265	--
Mechanized irrigated multiple crop	-105/-123	--	--	--	-334	--	--	-132	--

[a] Data are from Table 4 and Monke, Pearson, and Akrasanee (8). The latter estimates have been revised to reflect world prices of rice in 1975-76 rather than 1974, the year for which they were originally calculated. All estimates have been corrected for any differences which may exist between official and shadow rates of foreign exchange. Where estimates exist for several activities within each category of production technique, low and high values are given. Prices used to value rice output are f.o.b. for Thailand and the United States and c.i.f. for the other countries.

moreover, the f.o.b. price of rice would drop to the point where NSP would be negative. This problem should not arise, however, since the size of the West African market considerably exceeds the capacity of these two countries to supply it. In summary, world, as well as national, economic efficiency would be improved if West Africa would not try to be self-sufficient in rice but would rely more on foreign producers.

Comparison with Other West African Agricultural Activities

If resources in the agricultural sector of some of the West African countries were to be reallocated away from rice production, are there other rural activities which are more profitable? Estimates of net social profitability are available for a number of other crops in the Ivory Coast, Mali, and Senegal. These results cannot be compared with NSP in rice production, however, because the units are not comparable. Instead, it is necessary to make use of an indicator which is independent of units, such as the resource cost ratio (RCR) described in Appendix A. This ratio compares the social value of domestic resources used to produce a given quantity of output with the value added in world prices created in producing that output. If this ratio exceeds unity, the opportunity cost of the domestic resources, expressed in terms of world prices, is greater than value added in world prices, and net social profitability is negative. If the RCR is less than one, on the other hand, NSP is positive. Since both numerator and denominator of the RCR are expressed in the same units, the ratio itself is independent of these units, and comparisons can be made between activities producing different products.

The lower is the RCR of a given activity in relation to all other activities, the greater the comparative advantage which the country has in that activity.

An indicator of incentives comparable to the resource cost ratio is the effective protection coefficient (EPC), also discussed in Appendix A. This ratio compares value added in domestic market prices with value added in world prices. Since both are measured in the same currency, the EPC, too, is a ratio which is independent of units. If the EPC is greater than unity, there is an incentive for value added to be created locally; if the EPC is less than one, there is no such incentive. Unlike private profitability, which includes all taxes and subsidies, however, the EPC takes into account only those assessed on tradable outputs and inputs. It is only a partial indicator, therefore, of total net incentives affecting the allocation of domestic resources.

Estimates of the RCR and the EPC are given in Table 8 for each rice production technique plus a number of other agricultural activities. Valuation is c.i.f. or f.o.b. depending upon whether the product is customarily imported or exported.

The results for the rice activities parallel those discussed previously from Table 4. In addition, Table 8 permits comparison of rice with alternative rainfed crops. The results are very striking. In the Ivory Coast, rice competes very poorly with coffee, cocoa, palm products, copra, and maize. Each of these other crops can be produced with at least one technique for which the resource cost ratio is less than unity. Hence, each is socially profitable, and

Table 8 -- Resource Cost Ratios and Effective Protection Coefficients for Various Agricultural Activities[a]

Production technique - crop	Resource Cost Ratio	Effective Protection Coefficient
Traditional manual upland		
Ivory Coast forest - rice	1.43	1.16
Ivory Coast forest - coffee	0.58	0.60
Ivory Coast forest - cocoa	0.46	0.84
Ivory Coast Savannah - rice	1.26	1.17
Ivory Coast Savannah - maize	0.88	1.00
Liberia - rice	1.78	1.46
Senegal Casamance - peanuts	0.80	0.76
Senegal Casamance - millet	1.30	1.01
Sierra Leone south - rice	0.87	1.02
Sierra Leone north - rice	1.09	1.02
Improved manual upland		
Ivory Coast forest - rice	1.43	1.24
Ivory Coast forest - coffee	0.44	0.60
Ivory Coast forest - cocoa	0.42	0.84
Ivory Coast forest - palm products	0.43	0.91
Ivory Coast forest - copra	0.38	0.92
Ivory Coast Savannah - rice	1.53	1.29
Ivory Coast Savannah - cotton	1.03	0.49
Ivory Coast Savannah - maize	0.84	0.98
Liberia - rice	1.99	1.62
Sierra Leone south - rice	0.82	1.12
Sierra Leone north - rice	1.13	1.15
Animal traction upland		
Ivory Coast Savannah - rice	1.41	1.26
Ivory Coast Savannah - cotton	0.84	0.52
Ivory Coast Savannah - maize	0.81	0.99
Senegal Casamance - rice	1.04	0.90
Senegal Casamance - peanuts	0.48	0.78
Senegal Casamance - millet	1.27	1.25
Senegal Casamance - cotton	0.80	0.76
Senegal Casamance - maize	0.80	1.25

Table 8 -- Resource Cost Ratios and Effective Protection Coefficients for Various Agricultural Activities[a] - Continued

Production technique - crop	Resource Cost Ratio	Effective Protection Coefficient
Mechanized upland		
Ivory Coast Savannah - rice	1.67	1.26
Traditional manual swamp		
Liberia - rice	1.48	1.46
Mali - rice	0.72	0.58
Sierra Leone south - rice	0.69	1.02
Sierra Leone north - rice	0.90	1.03
Improved manual swamp		
Ivory Coast forest - rice	1.75	1.22
Ivory Coast Savannah - rice	1.65	1.23
Liberia - rice	1.44	1.52
Senegal Casamance - rice	1.26	0.93
Sierra Leone south - rice	0.82	1.08
Sierra Leone north - rice	0.94	1.09
Improved manual mangrove		
Sierra Leone south - rice	0.74	1.02
Sierra Leone north - rice	0.98	1.02
Animal traction swamp - rice		
Mali - rice	0.65	0.66
Partially mechanized swamp		
Ivory Coast forest - rice	1.61	1.22
Liberia - rice	1.69	1.70
Improved manual uncontrolled flooding		
Sierra Leone Boliland - rice	0.72	1.04
Animal traction uncontrolled flooding		
Mali - rice	0.99	0.59
Mechanized uncontrolled flooding		
Sierra Leone Bolilands - rice	1.01	1.06

Table 8 -- Resource Cost Ratios and Effective Protection Coefficients for Various Agricultural Activities[a] - Continued

Production	Resource Cost Ratio	Effective Protection Coefficient
Animal traction controlled flooding		
Mali - rice	0.74	0.65
Improved animal traction controlled flooding		
Mali - rice	0.59	0.61
Animal traction irrigated single crop		
Mali - rice	0.56	0.72
Improved animal traction irrigated single crop		
Mali - rice	0.59	0.64
Mechanized irrigated single crop		
Senegal Fleuve - rice	232.22	114.34
Manual irrigated multiple crop		
Ivory Coast Savannah - rice	1.74	1.22
Senegal Fleuve - rice	1.41	0.97
Mechanized irrigated multiple crop		
Ivory Coast forest - rice	2.99	1.28
Senegal Fleuve - rice	2.35	1.55

[a] Data are from individual country studies (4, 6, 7, 10, 15) and Stryker (13).

in some cases very much so, whereas none of the RCRs for rice is less than one. Moreover, the effective protection coefficients are greater than unity for all of the rice activities but less than or equal to one for each of the other crops in the Ivory Coast -- an indication of the protection which is required if rice is to be produced locally using inefficient techniques.

In Senegal, on the other hand, the competition between rice and other crops is closer. Peanuts seem to have a strong advantage and maize and cotton a slight edge, but rice production in some cases is more profitable than cultivation of millet, particularly in the Casamance Region of the south. In the Fleuve area to the north, rice is more expensive to produce than is either rice or millet in the Casamance. The EPCs in Senegal tend to correspond fairly closely to the RCRs except for rice, which, with the EPC less than the RCR, in each case receives less protection in relation to need than the other crops. This is offset for a number of techniques by subsidies on nontradable inputs, such as irrigation, which increase private profitability. Maize, on the other hand, appears to be somewhat overprotected since the EPC is generally greater than the RCR.

Rice grown in Mali does not have to compete with other crops for land, since it is not an upland crop, but it does compete for labor and capital. The RCRs from Table 8 suggest, however, that all these crops can be grown profitability using a number of different techniques. The low level of producer prices in Mali, which reflects this comparative advantage in agriculture, is indicated by the low EPC for each activity.

Sensitivity Analysis

The two appendices, concerned with methodology and shadow price estimation, discuss the specific assumptions underlying the previous estimates and the errors to which these estimates may be subject. The implications of these assumptions and errors for the empirical conclusions presented here are tested in the individual country studies using sensitivity analysis. One of the most useful indicators calculated as part of this analysis is the proportion by which yields, the world price of rice, or the cost of each primary factor input would have to change before NSP would equal zero.[28]

The sensitivity analysis suggests that the empirical results indicating whether rice production is socially profitable are quite robust. In most instances, the results are very insensitive to changes in the cost of capital or skilled labor. They are more sensitive to variation in the cost of unskilled labor, especially for traditional and improved upland production. Nevertheless, costs of unskilled labor would have to be less than half the assumed values for any technique in the Ivory Coast and Liberia and for irrigated cultivation in northern Senegal before production for the major urban market would become socially profitable. At the other extreme, unskilled labor costs for irrigated or controlled flooding cultivation in Mali would have to be twice their assumed values before NSP would be reduced to zero. Lesser variation in the cost of unskilled labor would be required to adjust estimated values of NSP to zero in Sierra Leone and the Casamance Region of Senegal.

The effects of assuming a positive, rather than a zero shadow price of land have been analyzed only for Mali and the Ivory Coast. In Mali, rents of US$180-250 per ha would be required to make production in the Office du Niger socially unprofitable. Irrigated land in the Ivory Coast, on the other hand, would have to be subsidized at US$400-600 per ha before production would become socially profitable.

The net effects of changes in yields or the world price of rice are similar to those for unskilled labor costs. In the Ivory Coast, Liberia, and the Fleuve Region of Senegal, yields or the world price would have to rise 25 to 80 percent before production would become socially profitable. The value of these two variables for irrigated or controlled flooding in Mali, on the other hand, would have to fall by 30 percent or more to make production for consumption in Bamako unprofitable. The results for Sierra Leone and southern Senegal, as well as for traditional upland cultivation in Mali, are again more sensitive to errors in these variables.

OTHER OBJECTIVES AND CONSTRAINTS

The analysis thus far has been concerned primarily with indicators of economic efficiency as a national objective. The countries of West Africa, however, are not interested solely in generating more income. They are also concerned about distributing income in a more equitable manner and reducing the risk of shortfalls in the availability of food. In addition, many of the countries hold self-sufficiency in essential foods to be an important proximate objective which helps them to achieve their more fundamental goals. The contribution of rice production to each of these other objectives, however, often implies some loss of national income.

Some indicators which are related to national objectives other than increasing income are given in Table 9, with consumption again assumed to take place in the capital city. One is the number of man-days of unskilled labor per ton of milled rice, which is an indicator of employment opportunities generated and thus of the distributional effects of each activity.[29] A second indicator is the degree of security attached to production relative to rainfed cultivation in areas of lower rainfall. This is very roughly estimated on the basis of past experience with yields, variability of rainfall or flooding, and the type of water control system, if any, employed. The third indicator suggests the degree to which each technique is oriented toward market sales as opposed to on-farm consumption and, consequently, the extent to which it can contribute to national food self-sufficiency, especially in urban areas. This will depend on yields, size of land holding, family size, and the system which exists for paddy collection. The effectiveness of this system, at least when the public sector is involved, will be influenced by such factors as the degree to which fields are physically concentrated, the level of mechanization, and the way in which payment for services or credit is linked with the sale of the crop. In addition, of course, factors not directly related to the production technique, such as paddy and other crop prices and the availability of consumer goods, will be important.

The last indicator in Table 9 shows the influence of each activity on the public budget. Although this is not a fundamental constraint influencing the pattern of comparative advantage in the long run, it can act powerfully in the short run to lessen the options of governments. The expansion of rice production as a substitute for

Table 9 — Objectives and Constraints Indicators for Milled Rice Activities

Production technique	Unskilled labor[a] (days/mt)	Degree of security[b]	Market orientation[b]	Budgetary loss[c] (US $/mt)
Traditional manual upland				
Ivory Coast forest	134	medium	low	274
Ivory Coast savannah	145	low	low	281
Liberia		medium	low	144
Sierra Leone wouth	290	medium	low	25
Sierra Leone north	488	low	low	25
Improved manual upland				
Ivory Coast forest	99	medium	medium	310
Ivory Coast savannah	166	low	medium	336
Liberia		medium	medium	157
Sierra Leone south	206	medium	medium	66
Sierra Leone north	298	low	medium	79
Animal traction upland				
Ivory Coast savannah	98	low	medium	334
Senegal Casamance	102	low	medium	114
Mechanized upland				
Ivory Coast savannah	48	low	high	376
Traditional manual swamp				
Liberia		medium	low	135
Mali	191	medium	low	-138
Senegal Casamance	n.a.	medium	low	n.a.
Sierra Leone south	196	medium	low	30
Sierra Leone north	280	medium	low	34

Table 9 -- Objectives and Constraints Indicators for Milled Rice Activities - Continued

Production technique	Unskilled labor[a] (days/mt)	Degree of security[b]	Market orientation[b]	Budgetary loss[c] (US $/mt)
Improved manual swamp				
Ivory Coast forest	124	high	medium	339
Ivory Coast savannah	124	high	medium	353
Liberia		high	medium	156
Senegal Casamance	133	high	medium	137
Sierra Leone south	186	high	medium	93
Sierra Leone north	235	high	medium	95
Improved manual mangrove				
Sierra Leone south	219	high	medium	23
Sierra Leone north	265	high	medium	16
Animal traction swamp				
Mali	115	high	medium	-102
Partially mechanized swamp				
Ivory Coast forest	96	high	medium	336
Liberia		high	medium	282
Improved manual uncontrolled flooding				
Sierra Leone Boliland	215	low	low	39
Animal traction uncontrolled flooding				
Mali	202	low	low	-122
Mechanized uncontrolled flooding				
Sierra Leone Boliland	160	low	medium	141
Animal traction controlled flooding				
Mali	98	medium	medium	-100

Table 9 -- Objectives and Constraints Indicators for Milled Rice Activities - Continued

Production technique	Unskilled labor[a] (days/mt)	Degree of security[b]	Market orientation[b]	Budgetary loss[c] (US $/mt)
Improved animal traction controlled flooding				
Mali	74	medium	medium	-113
Animal traction irrigated single crop				
Mali	84	high	medium	-129
Improved animal traction irrigated single crop				
Mali	74	high	high	-111
Mechanized irrigated single crop				
Senegal Fleuve	76	high	medium	269
Manual irrigated multiple crop				
Ivory Coast savannah	115	high	medium	408
Senegal Fleuve	108	high	medium	158
Mechanized irrigated multiple crop				
Ivory Coast forest	48	high	high	504
Senegal Fleuve	74	high	high	196

[a] Calculated from the first and third columns of Table 2.
[b] Based on best judgements of the authors of the individual country studies (4, 6, 7, 10, 15)
[c] Equal to the sum of "domestic price minus border price" and "net subsidy" in Table 4.

imports has two principal budgetary effects the sum of which, as was shown in Table 4, equals the difference between private and social profitability. First, it increases public expenditures on input subsidies; second, it decreases revenues earned from levies on rice imports. These effects may be partially offset by an increase in tax receipts from expanded inputs, but on balance there is usually a budgetary loss associated with the expansion of rice production.

The data in Table 9 show a high degree of labor intensity of activities in Liberia and Sierra Leone relative to the other countries. While this is consistent with profitable production in Sierra Leone because of the low wages in that country, it is not so in Liberia, where wages are higher and all production for the Monrovia market is socially unprofitable. High labor intensity helps to ensure abundant employment opportunities and an equitable distribution of rural income in both countries. But this is accomplished with a much higher loss of economic efficiency in Liberia than in Sierra Leone.

Requirements for unskilled labor also vary markedly between techniques. They are generally greatest for traditional methods of cultivation because of the limited use of other inputs and low yields involved. As cultivation is improved, labor requirements decrease to some extent, but they continue to remain high as long as advanced stages of mechanization are avoided. Even the introduction of animal traction and hand-operated power tillers has only a modest impact on labor requirements. Once tractors are introduced, however, the use of unskilled labor drops off markedly, and income distribution is adversely affected.

Security of production depends largely on two factors — amount and variability of rainfall and degree of water control. In southern West Africa, security of rainfed agriculture is fairly high, but as cultivation is undertaken further north, fluctuations in yields become more pronounced. This is less important for swamp rice than for upland varieties, but even cultivation of lowlands is hazardous in the drier regions. As a result, rainfed agriculture becomes increasingly impractical, and either irrigation or river flooding must be employed. These methods vary markedly in the costs and risk involved and often there is a trade-off between profitability and security. For example, the controlled flooding perimeters in Mali are quite low cost and profitable, but they involve a fair degree of risk since the flooding may be late or inadequate. Total water control systems, such as those in Senegal, on the other hand, are secure but expensive.

There are some schemes for which this trade-off does not have to be made. Because of the capital already sunk into the Office du Niger, Mali has the capability of producing rice both profitably and securely. In Senegal, even though the cost of constructing total water control systems using capital-intensive methods is high, there are also labor-intensive schemes employing manual techniques of construction and cultivation which not only are less unprofitable than the mechanized perimeters, but also have a high degree of production security

The average quantity marketed from traditional rice production is low on average, even though total marketings may be fairly substantial in some countries, such as Liberia and Sierra Leone, because most West African rice is grown in this way. As improvements are made, raising yields and farm size, the quantity harvested by each family which is available for marketing generally increases. Sometimes, however, expanded production is accompanied by an increase in the amount of rice eaten relative to other foods so that the gain in marketings is less than anticipated.[30] Governments wishing to reduce such switching can require payment of fees and debt service to be made in kind or demand that a certain amount of each harvest be sold to the public buying agency.[31] These practices are more successful for large-scale, mechanized irrigated schemes than they are for holdings which are dispersed and use few modern inputs. Consequently, governments trying to increase government-controlled supplies of locally produced rice for the cities have a special interest in promoting these types of projects, especially if they can be used to produce a high level of output per family.

Budgetary losses associated with the promotion of domestic rice production to replace imports in the Ivory Coast are very large. They are less, but still substantial, in Liberia and Senegal, though the form taken differs between these two countries. In Liberia, the major loss is of revenue foregone from taxes on rice imports, which does not show up explicitly in the budget as a subsidy. Senegal's budget, on the other hand, should register most of its losses as subsidies on inputs. In practice, however, many of these

subsidies are financed through foreign aid. As long as this continues, Senegal will not feel the full budgetary implications of its policies to promote rice. Mali has a net budgetary gain from rice production used to replace imports which otherwise must be subsidized in order to be sold at the low domestic official retail price. In most years the country is self-sufficient, however, so that this apparent budgetary gain is largely spurious and would disappear if the border price were taken to be the f.o.b. rather than the c.i.f. price. Nevertheless, Mali provides only very modest input subsidies, so that there would be little claim on the public budget in any case. Finally, Sierra Leone occupies an intermediate position, with moderate budgetary losses associated with domestic rice production.

As expected, budgetary losses within each country are greater for techniques of production which are less profitable. Especially high losses are associated with mechanized cultivation in the Ivory Coast, Liberia, and Senegal and with irrigation in the Ivory Coast. Losses are lowest for all countries in traditional agriculture.

SUMMARY AND CONCLUSIONS

The aim of this paper has been to examine the contributions made by rice producing activities in five West African countries to some of their major national objectives -- increasing income, distributing income in a more equitable way, and reducing the risk of food shortages. In addition, the analysis has shed light on the question of how movement towards self-sufficiency in rice helps to fulfill these objectives.

The countries vary markedly in the extent to which there are conflicts between these goals. Mali, for example, clearly has a strong comparative advantage in domestic production as a substitute for rice imports and also for export to other West African countries. Its advantages include the relatively predictable flooding of the Niger River, the sunk capital investment in the Office du Niger, fairly low wages, and the high c.i.f. border price which results from its interior location. This last factor is an advantage, however, only when Mali imports rice. In addition to generating more income while assuring self-sufficiency, expansion of rice production using improved techniques in Mali leads to greater security of cereal production and has few, if any, harmful distributional effects.

Sierra Leone has higher costs than Mali, resulting from a relatively low level of productivity, but production is still profitable because wages are very low. Furthermore, Sierra Leone can export rice more profitably than Mali because of lower transport costs to neighboring markets. Finally, as in Mali, the growth of rice cultivation in Sierra Leone is consistent with all of its other national objectives.

At the other end of the spectrum, the Ivory Coast and Liberia have a comparative disadvantage in producing rice for their national markets. This is true of every technique and region in which rice is grown. In Liberia, inefficiency stems from high costs of annual clearing, major pest and weed problems, and heavily leached soils. Negative net social profitability in the Ivory Coast, on the other hand, is principally the result of the relatively high wages in that

country. This is due to competition from other crops such as coffee, cocoa, and cotton in which the Ivory Coast has a strong comparative advantage. The same high wage phenomenon is probably also true to a lesser extent in Liberia. Only if production is limited to on-farm use, can these countries grow rice at the margin of profitability. There is thus a considerable conflict between the goal of self-sufficiency and the more fundamental objective of generating additional income.

Although rice production in the Ivory Coast and Liberia is unprofitable, the governments of these two countries have persisted in promoting this sector in order to redistribute income toward the north in the Ivory Coast and toward the rural sector in general in Liberia. Private profitability of production in the Ivory Coast savannah is quite high under the current incentive structure, so that the expansion of rice production should benefit farmers in that region, albeit with large public resource transfers. In Liberia, on the other hand, private profitability is negative in upland cultivation, so that this activity cannot be used to increase rural incomes beyond the need for rice consumed on the farm unless incentives are altered. Some progress might be made, however, with swamp rice. The chief problem in both countries, though, is that these redistribution goals can be much more effectively accomplished by promoting crops other than rice. The only way that expanded rice production can be justified, then, is through the increased security of production associated with irrigation and cultivation in swamps. This gain may be important in northern Ivory Coast, but it is hardly likely to be so in the southern part of that country or in Liberia.

Senegal occupies an intermediate position between Mali and Sierra Leone, on one hand, and the Ivory Coast and Liberia, on the other. With Dakar as the market, net social profitability is negative for every technique, but there are several activities -- animal traction upland and improved manual swamp cultivation in the Casamance and manual irrigated production in the Fleuve -- for which social losses are relatively modest. An important reason for negative NSP is the remoteness of the producing regions from Dakar. When the location of consumption is shifted toward the producer, several techniques are socially profitable. In addition, most of the rice-growing activities, especially the full water control systems of the Fleuve, offer some improvement in the security of food production. Finally, the regional distribution of income is improved by expanding rice production in Senegal, though the extent of that improvement depends upon whether labor-intensive or capital-intensive techniques are employed. Incomes in the Casamance, however, can be increased more by expanding peanut and maize production than by promoting rice.

The evidence suggests that outside of the areas of highest rainfall, improvements in production are only profitable if there is some degree of water control. Where natural conditions are appropriate, as in the swamps of southern Senegal or along the Niger River in Mali, this can be accomplished fairly easily. In other areas, such as the Senegal River basin, the risks are such that expensive total water control systems are required. This implies a need for double cropping -- with the many agronomic, hydrological,

and sociological problems which that entails. Except for the Office du Niger, with its sunk capital costs, these systems of total water control have not yet proved to be profitable for other than local consumption. As a result, they must be justified on the basis of the additional security of food production they provide, the potential rice marketings they create, or their desirable distributional effects. In this respect, there may be a trade-off between the greater marketings generated by the mechanized schemes and the better distributional characteristics of manual production methods. Given the high costs and substantial subsidies associated with these mechanized techniques, however, it may well be more efficient to induce greater marketing of rice from labor intensive activities by offering farmers a higher paddy purchase price.

Intermediate techniques of rice cultivation involving animal traction may present the best opportunities for fulfilling all objectives. The empirical results suggest that they have reasonably high rates of social profitability, distribute their benefits fairly equally, place limited demands on budgetary resources, and generate regular marketings if paddy prices are adequate. Fully mechanized techniques, on the other hand, are very socially unprofitable, worsen the distribution of income, and are a continuing drain on the public budget. The only advantage these techniques have, which may partially explain their popularity, is that they generate fairly sizable marketings which can be shipped to the towns and cities.

In summary, the empirical results discussed here suggest that there should be greater specialization in West Africa rice production from the point of view of both location and technique. Outside of cultivation for on-farm or local consumption, which is profitable nearly everywhere and generally improves equality of income distribution and security of food production, rice destined for the major West African markets should be promoted primarily in Mali, Sierra Leone, and possibly Senegal. Highly mechanized techniques should be avoided, since they are ineffective in achieving most national objectives, and greater stress should be placed on use of animal traction and improved manual techniques. Increased water control is necessary in the drier regions to improve security of production and to take advantage of other technical innovations, but this should be limited, where conditions permit, to low cost control systems. Where extensive total control structures are necessary, the gain in security must be weighed against the corresponding loss in national income which such structures entail.

Comparative advantage in West African rice production will not remain static. Supplies of labor coming from traditional agriculture are not infinitely elastic, and growing population density will increase the social opportunity cost of land. As a result, capital intensive techniques are likely to increase in profitability relative to those which are intensive in the use of labor or land. Furthermore, many of the conditions which make irrigated production in the more arid regions unprofitable today -- high construction and transport costs, lack of river regulation, low population density giving rise to

weak local demand and scarcity of labor -- will change in the future as the major river basins are developed. It is important, therefore, to perceive the social costs and benefits of rice production in a dynamic way which will evolve with the course of West African development.

FOOTNOTES

[1] For a discussion of the relationship between population density and agricultural technique, see Ester Boserup (1).

[2] The problems associated with making comparisons of this type at official exchange rates have been discussed elsewhere (3).

[3] See Appendix B for a discussion of the West African labor market.

[4] Capital investments which were made in the past and the costs of which are not going to be incurred again over the relevant planning horizon are considered as sunk, that is, their costs are not included in the calculation of private or social profitability.

[5] The simple correlation coefficient between labor and yields across both techniques and countries in Table 2 is .34.

[6] The simple correlation coefficient between land development cost and yields, using data from Table 2, is .48. Although highly correlated with degree of water control, land development cost is not a perfect proxy for this variable since this cost also depends on natural conditions and input prices, which differ substantially between countries.

[7] The simple correlation coefficient between nitrogen fertilizer and land development cost is .32; that between fertilizer and yields is .78. One instance in which land development has not led to relatively high rates of fertilizer use is the Office du Niger ("Animal traction irrigated single crop" in Table 2), which with its capital costs already sunk is able to operate using a very land-extensive technique resulting in yields of only 2.25 mt of paddy per hectare.

[8]Humphreys and Pearson (5) estimate that response rates of 10-15 kg of paddy per kg of nutrient should be attainable in irrigated cultivation under average West African conditions.

[9]The simple correlation coefficient between land development cost and labor input per crop is -.16.

[10]The simple correlation coefficient between yields and extension costs is .72.

[11]The statistical results reported here are only a first step toward estimating a production function for rice cultivation in West Africa. Many of the econometric problems associated with estimation have not been considered, only a linear relationship has been fitted, and several important variables have been either excluded (e.g., level of mechanization) or somewhat misspecified (e.g., degree of water control). Nevertheless, the conclusions of the analysis, even at this stage, are suggestive of interesting possibilities for further research.

[12]These coefficients help to explain why the regression coefficient of farm labor is increased when the dummy variables are introduced into the regression equation. Liberia and Sierra Leone generally have high labor inputs in relation to the other countries. Without the dummy variables, the coefficient of labor is biased downwards because of the effect of these omitted country-specified dummy variables. Once the variables are introduced, the bias is eliminated.

[13]Hand pounding in the Ivory Coast is also relatively expensive because of the high wage rates prevailing in that country.

[14]See the individual country papers and Appendix B for more detailed discussions on this point.

[15]On this issue, see Humphreys and Pearson (5)

[16]Monke (7) shows this to be true, for example, in Liberia.

[17]The only technique remaining unprofitable is traditional flooded cultivation, which has yields of only 600 kg/ha, resulting partly from the drought conditions of recent years. This may be a case, discussed in Appendix B, in which the market wage overestimates the shadow price of family labor in a traditional technique.

[18]This is true of each country except the Ivory Coast, for which PP and NSP also differ because of relatively small differences between private and social prices of land. Other possible reasons for private profitability varying from social profitability, such as the existence of externalities or monopoly power, could not be measured for any of the countries.

[19]The shadow price of unskilled labor in the Ivory Coast varied in 1975-76 from 275 to 450 CFA francs per day, depending upon sex and region. In Senegal, it was 250 CFA francs in the Fleuve and 300 CFA francs in the Casamance for both males and females. For further details, see Appendix B.

[20]Wages of unskilled labor in Sierra Leone in 1975-76 were the equivalent of about 130-200 CFA francs per day, compared with a range of 200-450 CFA francs in the other countries.

[21]This may be at least partly because wages are low, inducing the use of labor relative to other inputs.

[22]Wages of unskilled labor in Mali varied from 200 to 350 CFA francs in 1975-76.

[23]In Sierra Leone, the profitability of improved cultivation in the north is also decreased because of relatively high wages in the vicinity of Makeni, where this technique is being introduced.

[24]Although intensification of cultivation increases profitability in the controlled flooding perimeters of Mali, it does not do so in the fully controlled irrigation system of the Office du Niger. This is primarily because all investment costs are considered to be sunk for the current Office du Niger technique, but if further

intensification is to raise yields from 2.25 to 3.5 t/ha, greater investment to improve water control will be required. In the controlled flooding perimeters, on the other hand, no increase in water control is necessary to raise yields from their current level of about 1.4 t/ha to close to 2.5 t/ha.

[25]This evidence concerning the relative social profitability of different levels of mechanization is consistent with the findings of Humphreys and Pearson (5), which suggest that only the use of animal traction is more profitable than manual cultivation and even this leads to only about a 10 percent reduction in social costs.

[26]Although it might be answered that these countries can be easily identified as those which actually export rice, this overlooks the possibility of subsidies to encourage exports of rice which is not being profitably produced.

[27]Local production for on-farm consumption might be socially profitable, but calculations employing this alternative assumption have not been made for the Asian countries.

[28]The costs of each primary factor input can vary because of errors in either the shadow price of that input or the technical coefficient relating it to output.

[29]An excellent survey of the determinants of rural income distribution, including its link to employment is contained in Cline (2). It is possible, of course, that agricultural employment has a less important influence on income distribution in Africa, where population density is relatively low, than in other areas of the world. A recent survey of irrigation projects in the Sabelian countries by Stryker, Gotsch, McIntire, and Roche (14), however, suggests that labor intensive schemes generally have better distributional characteristics than those which are more capital intensive. Other important dimensions of income distribution are its urban-rural and regional characteristics. To the extent that rice production contributes more

than other alternatives to rural income in general and that in poorer regions in particular, this aspect of the distributional objective is furthered. Among these poorer regions are the Ivory Coast savannah and both the Casamance and the Fleuve in Senegal.

[30]This has occured, for example, in Senegal, where rice has tended to replace millet in the diet.

[31]Both of these requirements exist at the Office du Niger and the controlled flooding perimeters in Mali.

[32]Some of these are discussed in Stryker, Gotsch, McIntire, and Roche (14).

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