CAVEAT

The views and conclusions expressed in this Preliminary Report are those of the authors and should not be construed to represent those of the management or Board of CIAT nor its donor agencies.

"If we could first know where we are, and whither we are tending, we could better judge what to do, and how to do it."

Abraham Lincoln

(Speech to the Republican State Committee, Springfield, Illinois, June 18, 1858)

"To say that a thing happened the way it did is not at all illuminating. We can understand the significance of what did happen, only if we contrast it with what might have happened."

Morris Raphael Cohen

[Quoted in R.P. Thomas (1965), "A quantitative approach to the study of the effects of British imperial policy upon colonial welfare: Some preliminary findings," Journal of Economic History Vol. 25, No. 4.]

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CONTENTS

1. INTRODUCTION

1.1 The setting

The contribution of technical change to agricultural productivity in developed countries (e.g., Griliches, 1958; Hayami and Ruttan, 1971) and in developing countries (e.g., Schultz, 1964; Evenson and Kislev, 1975) has been widely recognized. However, as noted by Ramalho de Castro (1974), it has only recently been fully appreciated that technical change can take alternative routes, emphasizing some products at the expense of others, concentrating on certain ecological zones, or stressing either biochemical or mechanical advances.

With continued pressure on food supplies in much of the developing world, together with some national and much international concern for the welfare of low-income people, attention is being increasingly focused on the allocation of public research monies for agriculture (Arndt et al., 1976; Fishel, 1971; Pinstrup-Andersen and Byrnes, 1975). In appraisal of potential research projects (Ramalho de Castro, 1974) and in the evaluation of existing or past research (Akino and Hayami, 1975; Ayer and Schuh, 1972), two central economic issues arise: efficiency and equity. The first is related to the economic return on the public investment in agricultural research; was a particular line of research a socially efficient way to invest scarce public research funds? Equity refers to the distribution of the net benefits by economic classes of the population.

It can arise that the two goals, efficiency and equity, may not be mutually exclusive. Investing in those lines of research which have high net payoffs may not necessarily result in an equitable distribution of the benefits of technical change. If a country invested research funds generating new technology for an export crop produced solely by a large-scale commercial agriculture, then while this may satisfy an efficiency goal of being profitable in terms of the economic payoff to the country, it might have little or no impact on improving the distribution of income. Wether or not new agricultural technology is an appropriate vehicle for achieving social equity is an open question; the answer will depend on the nature of the crop, the structure of consumption and production, and the alternative tools available for income distribution. While agricultural technology may prove a long-run catalyst for social and economic articulation (de Janvry, 1975), expectations that it can solve a broad spectrum of social ills in the short run may be unrealistic.

Whatever the final outcome, equity is becoming a more widely applied criterion for appraising investments in agriculture (McNamara, 1973). This study will be concerned with both efficiency and equity criteria in agricultural research. However, given the abundance of literature referring to social questions following the introduction of technological changes in agriculture (Falcon, 1970; Hill and Hardin, 1971; Pearse, 1975; Wharton, 1969) and the paucity of empirical studies at the national level, particular attention is focused on the question of equity.

1.2 Rice in Latin America*

Rice is one of the most widely produced crops in Latin America; it is grown in virtually every country of the region and under a wide range of ecological conditions. As a result of the development of high-yielding varieties of rice (HYV's), Latin America is experiencing part of the widely heralded Asian-born "green revolution" in rice production. Starting in the mid-sixties, new material stemming from the International Rice Research Institute in the Philippines has been transferred to and adapted for Latin America. The term HYV is used throughout this study to refer to the dwarf rices with a higher grain/straw ratio than the traditional varieties.

1.3 Objectives of the study

1. To measure the impact of HYV's on Latin American rice production

2. To measure the size and distribution of the economic benefits resulting from the introduction of HYV's in Colombia.

Colombia was selected as the country for detailed study, not only since the adoption of HYV's had been much more widespread than in any other country, but largely because as a result of a strong National Rice Growers Federation (FEDEARROZ), higher quality data was more readily available. In addition, the time available for the study did not permit a more extensive coverage in the detail required to fulfill the second objective.

1.4 Outline of the report

Chapter 2 presents an overview of rice production and trade in Latin America and concludes with some observations on trade prospects. Chapter 3 is dedicated to measuring the additional output of rice in Latin America due to HYV's, while Chapter 4 is intended to provide some economic background to the Colombian rice industry, presenting data which will form the basis of subsequent analyses. In Chapter 5 a

*Throughout this report, the term Latin America is used to include Mexico, Central America, the Caribbean and South America.

model is developed to measure the economic benefits of the introduction of HYV's, and the estimation of the parameters required by the model is discussed.

The gross benefits, costs, net benefits and rates of return are given in Chapter 6, while the distribution of net benefits by income level is discussed in Chapter 7. In Chapter 8, an analysis of the farm-to-retail marketing margin is presented, and a summary of the study is given in Chapter 9.

2. AN OVERVIEW OF RICE PRODUCTION AND TRADE IN LATIN AMERICA: 1950–1974*

2.1 Production

Table 1 presents a summary of the production data for various regions of Latin America. Regional production grew at an average annual rate of 3.6 percent between 1950 and 1974, compared with a world growth rate of 2.8 percent. Latin America produced 3.6 percent of world output in 1974. Latin American production is highly concentrated (Table 2); over half the output comes from Brazil, and five countries account for about 80 percent of the production. Yields have been static for 25 years in the region as a whole, averaging 1.7 tons/ha of paddy rice. However, this figure is heavily weighted by Brazil (1.2 tons/ha) and disguises such higher yields as Colombia (4.2 tons/ha), Uruguay and Peru (3.9 tons/ha), and Argentina (3.8 tons/ha) in 1974.

Table 1. **Production of paddy rice in Latin America and in the world: selected years.**

Region	1950	1960	1965	1974
	('000 t.m.)			
Mexico and Caribbean	405	823	509	1,022
Central America	211	228	332	503
South America	4,249	6,530	9,672	10,156
Latin America	4,865	7,581	10,513	11,681
World	161,900	239,500	256,617	323,201

*In Appendix Table 1, data for production, area, yields and trade in rice are given by country for Latin America for 1950-1974.

Table 2. **Contribution of five major rice-producers in Latin America: selected years.**

Ranking	1950 Country	(%)	1960 Country	(%)	1965 Country	(%)	1974 Country	(%)
1	Brazil	65	Brazil	63	Brazil	72	Brazil	56
2	Colombia	6	Colombia	6	Colombia	6	Colombia	13
3	Peru	4	Peru	5	Peru	3	Peru	4
4	Mexico	4	Mexico	4	Mexico	3	Mexico	3
5	Argentina	3	Cuba	4	Guyana	2	Cuba	3
Total		82		82		86		79

The pattern of growth of the Latin American rice industry is depicted in Table 3. Two periods were analyzed: 1950-54 to 1965-69 and 1965-69 to 1970-74. The first period saw the expansion in rice output coming from greater area under rice, especially in the land-extensive South American region. Yields were constant or falling Since the mid-sixties (and corresponding to the period of introduction of HYV's), yields have risen at an annual average rate of 2.5 percent, contributing much of the growth in total output. Central America has experienced a notable growth in yields in this latter period. Overall, the annual average improvement in yields has been higher than the world figure of 1.5 percent, although Latin America as a whole is still below the world average of 2.4 tons/ha in 1974.

2.2 Trade and trade prospects

Latin America as a whole is a net rice-importing region (Table 4), although its imports represented only about 1.5 percent of world trade in rice in the period 1970-

Table 3. **Average annual growth rates of production, area and yields in Latin America (by regions).**

Region	1950-54 to 1965-69 Production (%)	Area (%)	Yields (%)	1965-69 to 1970-74 Production (%)	Area (%)	Yields (%)
Mexico and Caribbean	2.5	1.7	1.0	8.1	5.9	1.9
Central America	3.1	2.8	0.0	2.3	−1.3	4.0
South America	3.8	4.4	−0.4	3.0	0.9	1.3
Latin America	3.6	4.1	−0.4	3.3	1.2	2.5

Table 4. **Average annual net exports of milled rice in Latin America: five-year averages (1950-1974).**

Region	1950-54	1955-59	1960-64	1965-69	1970-74
			('000 t.m.)		
Mexico and Caribbean	−301*	−235	−232	−244	−381
Central America	3	−16	−11	−10	−4
South America	160	105	141	293	253
Latin America	−138	−146	−102	39	−132

* Negative sign indicates imports.

1974. However, there are marked regional differences in rice trade. South America is a significant rice exporter; but generally the import demands of Mexico, the Caribbean and Central America exceed the exportable surplus of South America, making Latin America as a whole a net rice importer.

Tables 5 shows the major rice importing and exporting countries. Imports of 350,000 m.t. enter the Caribbean annually, about two thirds going to Cuba. This pattern of imports has been constant for the last twenty-five years. However, the pattern of exports is much less consistent. Because so much of Brazilian rice comes from the upland sector, which is subject to seasonal fluctuations, Brazil's exportable surplus is variable. Uruguay, Guyana, Surinam and Argentina have been consistent exporters in the last fifteen years. It is thought that almost all South American countries will either be self-sufficient or exporting in the next few years. Central America as a region is also self-sufficient. Hence, in the Western Hemisphere, there are only two rice deficit areas, Canada and the Caribbean, representing a combined annual market of about 400,000 m.t. of milled rice.

However, the United States, the world's largest exporter (over 2 million m.t.) is well located to serve these markets. Improved relations with Cuba could well provide the U.S. once more with a major market for rice exports in Cuba. Both private (Morrison, 1974) and public (U.S. Department of Commerce, 1975) pronouncements have shown the interest and importance of the Cuban market for U.S. rice.

The Caribbean import market is partially governed by the Caribbean Rice Agreement, which ties many of the principal importing countries to Guyana for 50 percent of their imports until all of Guyana's exportable surplus is marketed (U.S. Department of Agriculture, 1972). Hence if Latin American exporters are to significantly increase their level of exports in the future, markets outside the Western Hemisphere will have to be sought in Europe, Africa and perhaps Asia.

Data on world trade flows in rice are difficult to obtain and assemble. Table 6 presents such data for one year only, 1970. First, the relative insignificance of Latin

Table 5. **The five major rice-importing and exporting countries in Latin America: selected years.**

	Importers						Exporters					
Ranking	1950	Vol.*	1960	Vol.	1974	Vol.	1950	Vol.	1960	Vol.	1974	Vol.
1	Cuba	– 293	Cuba	– 160	Cuba	– 220	Brazil	95	Guyana	65	Uruguay	73
2	Other Caribbean	– 54	Other Caribbean	– 87	Other Caribbean	– 160	Ecuador	62	Ecuador	27	Guyana	71
3	Venezuela	– 28	Bolivia	– 8	Peru	– 104	Guyana	30	Surinam	23	Argentina	48
4	Bolivia	– 8	Venezuela	– 4	Mexico	– 100	Mexico	28	Uruguay	6	Surinam	35
5	Costa Rica	– 2	El Salvador	– 3	Chile	– 22	Chile	12	Argentina	5	Venezuela	30

* Milled rice, '000 m.t.

America in world trade is evident; this suggests that changes in Latin American exports would have no influence on world prices; the region is a "price-taker." Of the total Latin American exports of 375,000 m.t., only 25 percent went to other Latin American countries. Africa and the EEC were important markets for South American exporters. Even if South America could capture all of the Caribbean market in the future, it must continue to look toward Europe and Africa for any expansion in export markets. The U.S. Department of Agriculture (1971, p. 67) projected a growing import demand to 1980 in both these regions. Blackeslee et al. (1973, p. 314) also predict growing import demands in Africa, Eastern Europe and the USSR until the year 2000.

Table 6. **World rice flows with emphasis on Latin America (1970).**

Importers	Exported by South America	Latin America	USA	Asia	EEC	Others	Total
	('000 m.t.)						
Mexico					16		16
Central America	1	1	1			2	4
Caribbean	75	75	32	130		9	246
South America	17	17	11			11	39
Latin America	93	93	44	130	16	22	305
U.S.A.	1	1					1
Canada	8	8	53	1			62
EEC	87	87	104	16	77	37	321
Other W. Europe	41	41	82	49	51	33	256
Eastern Europe	17	17		81	15	108	221
U.S.S.R.	7	7		44		330	381
Asia	25	25	1,232	2,951	126	299	4,633
Africa	83	83	161	318	133	175	870
Oceania			13	8	3	56	80
Others	13	13	6	11	19	106	155
Total	375	375	1,695	3,609	440	1,166	7,285

Source: **Adapted from U.S. Department of Agriculture (1972)**

Instability in the world price of rice will continue to characterize export markets in the absence of any global stockholding scheme. Only a very small percentage (generally less than 5 percent) of world rice production is traded, and most of this is within the Asian region. Both major exporters and importers are located in the same monsoonal belt. Poor seasonal conditions, therefore, simultaneously reduce export surpluses and raise import demands, the reverse occurring in good seasons; price instability is in part a consequence of this phenomenon. In addition, a large proportion of world trade in rice is based on concessional sales and government-to-government contracts. Hence a fairly thin market in freely traded rice exists, and this has to absorb the residual excesses of demand and supply, resulting in sharp sawings in world export prices. The rapidity and magnitude of changes in the world rice situation is reflected in the fact that by July 1, 1976 world stocks are expected to be 30 percent higher than a year before and will have returned to the levels prevailing before the monsoon failure in 1972 (U.S. Department of Agriculture, 1975c, p. 3).

A formal projection model used by the U.S. Department of Agriculture* (1971) concluded that in general the outlook for rice to 1980 was poor, with continued downward pressure on world prices to be expected. The World Bank (1975) has predicted rice prices (Bangkok, f.o.b., 5 percent broken grain) of $(US) 240/m.t. (in 1973 dollars) for 1980 and 1985, down 31 percent on 1973 prices, although still well above the level of the 1960's. The difficulties in making such market price projections are notorious. Efferson (1971) writing in 1971 predicted prices of $(US) 100-140 for Latin American rice exports up until 1976; by 1974, exporters were receiving $(US) 333 per ton.

*The U.S. Department of Agriculture is presently further developing a global model of rice production, disappearance, prices and trade (U.S. Department of Agriculture, 1975a).

3. IMPACT OF HYV's ON RICE PRODUCTION IN LATIN AMERICA

3.1 Area sown to HYV's

In 1975, CIAT conducted a postal survey of Latin American countries in an endeavor to provide up-to-date information on the sowings and yields of HYV's in the region. This effort was only partially successful, and the data have been supplemented with other sources as indicated. Only those countries for which data was available are listed in Table 7, which shows the estimated HYV area in 1974.

3.2 Contribution of HYV's to output*

The data in Table 7 were used as a basis for estimating the contribution** of HYV's in 1974 (Table 8). The traditional yields were based on the regional averages for 1950-1964, a period prior to the introduction of HYV's. The irrigated sector of Colombia is included to illustrate the potential impact when adoption is widespread. For Latin America (excluding Brazil), 1974 rice production was estimated to be 40.3 percent higher than it would have been in the absence of HYV's. If Brazil is included, the corresponding figure is 14.5 percent. This result compares most favorably with the estimate of 4.9 percent for Asian rice in 1972-1973 (Dalrymple, 1975, p. 35) and should help dispel the not uncommon impression that the impact of HYV's of rice has been largely an Asian phenomenon.***

Two additional comments are in order. The yield superiority attributed to HYV's

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*The authors acknowledge the close cooperation of Dana G. Dalrymple in obtaining the information in this section.

**The method used follows Dalrymple (1975).

***Pearse (1975) states that "rice is the second cereal in total production in Latin America, but there have been few attempts to introduce IRRI seeds. . . in Latin America. . . little progress has been made in promoting the use of HYV's."

th HYV's in Latin America* (1974).

Area (ha)	Source
108,420	CIAT survey, 1975
145,600	Dalrymple, 1976
10,000	Dalrymple, 1974
264,020	
2,200	CIAT survey, 1975
11,130	CIAT survey, 1975
20,700	Dalrymple, 1976
64,173	CIAT survey, 1975
5,100	CIAT survey, 1975
165,303	
270,221	
38,237	CIAT survey, 1973
40,000	Dalrymple, 1974
61,900	Dalrymple, 1976
28,130	CIAT survey, 1975
438,488	
807,811	

which data was obtainable. It is understood that no HYV's

the fact that they have been sown on superior land
tary inputs. Of course, in the absence of improved
rior land and higher input levels may not have been
f the percentage contribution of HYV's (Table 8) is
regional areas and outputs have been included in
for the reporting countries is included. Provided the
lar yield margins, then the additional production
were the total HYV area known.

Table 8. **Estimated contribution fo HYV's in Latin America, excluding Brazil; by regions (1974).**

Item	Mexico and Caribbean	Central America	South America	Colombia (irrigated)	Latin America (Excluding Brazil)
1. Total area ('000 ha)	452.0	257.1	1,088.0	273.0	1,797.0
2. Total production ('000 m.t.)	1,022.0	472.2	3,647.1	1,420.1	5,141.4
3. **Yield (tons/ha)**	2.261	1.837	3.352	5.203	2.861
4. HYV area ('000 ha)	264.0	105.3	438.5	270.2	807.8
5. Traditional area ('000 ha)	188.0	151.8	649.5	2.7	989.2
6. Traditional yield (tons/ha)	1.779	1.284	2.399	3.100	2.040
7. Traditional prod. ('000 m.t.)	334.5	194.9	1,558.2	8.4	2,018.0
8. HYV production ('000 m.t.)	687.5	277.3	2,088.9	1,411.7	2,123.4
9. HYV yield (tons/ha)	2.604	2.633	4.764	5.225	2.867

BIA: SOME ECONOMIC ASPECTS

nbia for almost 400 years and today is one of the ucts. Outside of Asia, Colombia ranked fifth in world sia, it ranked twentieth (U.S. Department of Agricul- ras the single most important source of calories in the 13.6 percent of the calorific intake, or 286 calories it was the second most important source of protein ent of the protein intake, or 6.3 g per person per day ıeación, 1974).

port to trace the total development of the Colombian ure contains a wealth of information. Historical as- Jennings (1961), the technical aspects by Rosero ıey and Jennings (1975), economic and institutional rquin (1967), and finally a broad range of informa- y by López (1966). The present report cannot ailed material documented in these references, and consult them.

program began in 1957, with a national rice program and the cooperation of the Rockefeller Foundation.

iety Bluebonnet-50 was extensively grown; but in isease, "hoja blanca," causing extensive losses. The vith a primary objective of selection for resistance

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ee Hertford (1976) and Rosero (1974).

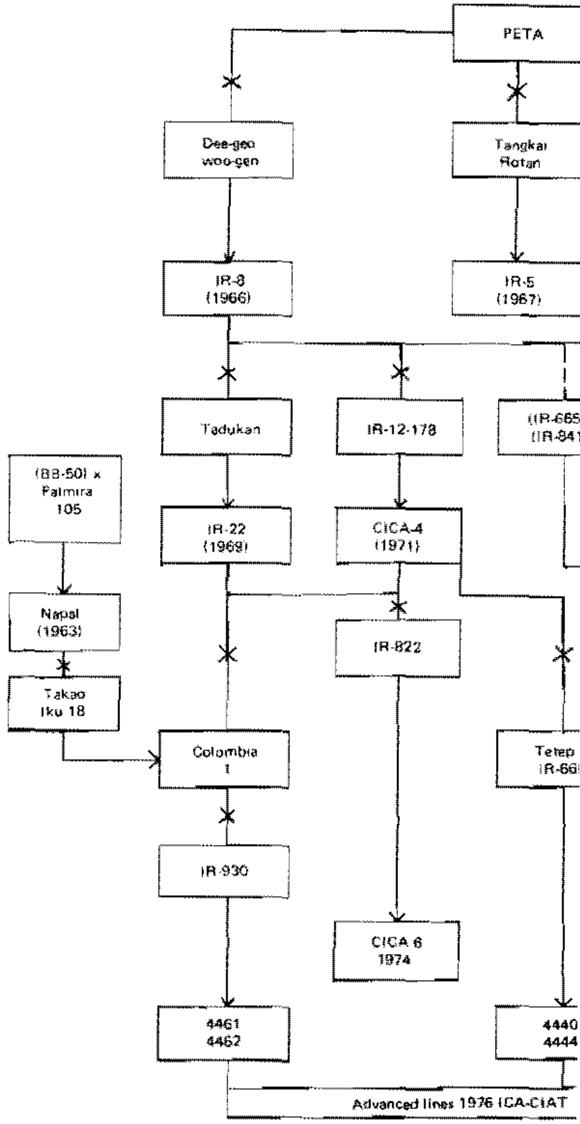

Figure 1. **A simplified genealogy of IRRI and ICA-CIAT rice**

1, another U.S. variety showing some resistance

ected Napal for release (see Figure 1), a cross net-50 and a selection (Palmira 105) for resistance. susceptibility to rice blast disease in an attack in riety with partial resistance, was released in 1965.

ce Program of CIAT joined in a collaborative effort d dwarf lines from IRRI were introduced into the was released, which was resistant to hoja blanca, y. IR-22 was recommended in 1970. Two additional e never widely grown due to their lower yields com-

program released their first variety, CICA-4, which ad better grain quality. This variety was followed nt six advanced lines* (see Figure 1) are undergoing and release of a further variety. In the regional tests roughout Colombia in the first semester of 1975, a, compared with 5.8 tons/ha for the dwarf varieties e principal problem facing the breeding program is gus readily adapts; and one or two years after planting, release become susceptible. The present strategy is to or two years; a longer term strategy is the incorpora- ne varieties incorporating a number of sources of y.

portant characteristics of the varieties, and Table 10 in Colombia based on the seed sales of FEDEARROZ, l seed. The introduction of the dwarfs has been eplacing the previously predominant Bluebonnet-50. made: first, much of the new material has been ather than locally developed; the remainder (Napal r, based on imported lines. This serves to underline technology transfer, combined with strong national fusion (Evenson, 1976). Second, Colombian rice ence with varietal changes; the introduction of nusual problems of adoption, an aspect generally development and introduction of new agricultural pread adoption of dwarf rices was, of course, largely sponsiveness to higher input levels and improved nca.

rice research and the use of new varieties would be o the role of FEDEARROZ. With its strong network

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these lines in regional trials, see Rosero (1975).

Table 9. **Percentage distribution of varieties in Colombia (1964-1974).**

Year	Blue-bonnet-50 (%)	Napal (%)	Tapuripa (%)	ICA-10 (%)	Dwarfs IR-8 (%)	IR-22 (%)	CICA-4 (%)	Others (%)
1964	87	5	—	—	—	—	—	8
1965	87	5	—	—	—	—	—	8
1966	90	—	—	—	—	—	—	10
1967	80	—	7	—	—	—	—	13
1968	53	—	42	—	—	—	—	5
1969	50	—	36	1	5	—	—	8

Blue Belle	Tall	S	S	S	EX	EX	EX	Long
Tapuripa	Tall	MR	S	S	Poor	EX	Good	Long
IR-8	DWF	S	R	S	Poor	Good	V. Poor	Long
IR-22	DWF	S	MS	R	EX	Good	EX	Long
CICA-4	DWF	S	R	R	EX	EX	Fair	Long
CICA-6	DWF	MR	R	R	EX	Good	Good	Long

1 Dwarfs (DWF) have a higher grain/straw ratio.
2 S = susceptible, R = resistance, M = moderately
3 Poor milling quality is due to high proportion of grains splitting crosswise.
4 Cooking quality is poor when there is a low amalose content, resulting in "sticky" product (characteristic of Japonica varieties).
5 Because of the presence of "white belly," a characteristic which, although totally unrelated to cooking properties, is difficult to remove through breeding and has been a source of consumer bias, as well as lower prices for IR-8, especially.

of advisory services, input sales, training courses, pub
data gathering services and collaboration with the Na
regional testing, FEDEARROZ has been an importan
the Colombian rice industry.

4.3 Production and disappearance

The basic data on area, production and yields for
are given in Table 11. Colombia produces rice under
n. 1, p. 221):

1. In leveed fields with controlled water supply (the

2. Swamp rice planted on river banks and "irrigated

3. Upland rice which depends on rainfall.

The classification used by FEDEARROZ (and th
(the first category, together with that part of the thi
and upland (the remainder).

The upland sector is now relatively unimportant;
production came from this sector, it produced only
has in part been due to the introduction of new vari
first impact on yields was felt, the upland area starte
suited to irrigated culture gave a comparative advant
upland production with its static yields commenced

In the irrigated sector, where yields had averaged
duction rose until 1970, due solely to higher yields.
crop relative to irrigated alternatives, the irrigated ar
Total production more than doubled between 1970
average yield was 4.4 tons/ha. This was only 0.4 ton
gated commercial checks in ICA's regional trial netw
1975. This remarkable closeness of farm and experin
with the gap between potential and actual yields of
Philippines (Herdt and Wickham, 1975, p. 167).

Table 12 sets out a summary of the annual flows
are all from FEDEARROZ (1975). The reliability of
trial use is probably questionable; certainly wide vari
Based on U.S. Agricultural Attaché reports, Gislason
human and industrial use in 1974, compared with 7
closing stocks of 287,000 m.t. compared with the pr
Rice is used for livestock feed, for beer and breadma
known with any certainty. However, the important

1959	153,610	180,366	1,174	52,190	241,734	4,632	205,800	422,100	2,051	57	43
1960	160,230	186,770	1,166	67,070	263,230	3,925	227,300	450,000	1,980	58	42
1961	132,100	200,150	1,515	105,000	273,450	2,604	237,100	473,600	1,997	58	42
1962	154,200	231,310	1,500	125,350	353,690	2,822	279,550	585,000	2,093	60	40
1963	138,600	206,000	1,486	115,400	344,000	2,981	254,000	550,000	2,165	62	38
1964	178,300	215,000	1,206	124,200	385,000	3,100	302,500	600,000	1,983	64	36
1965	244,750	275,600	1,126	130,000	396,400	3,049	374,750	672,000	1,793	59	41
1966	236,000	338,600	1,435	114,000	341,400	2,995	350,000	680,000	1,943	50	50
1967	180,850	280,500	1,551	109,850	381,000	3,468	290,700	661,500	2,276	58	42
1968	150,200	250,600	1,668	126,925	535,000	4,221	277,125	786,300	2,837	68	32
1969	134,570	220,275	1,637	115,890	474,225	4,092	250,460	694,500	2,773	68	32
1970	121,113	198,248	1,637	112,100	554,347	4,945	233,213	752,595	3,220	74	26
1971	109,130	173,696	1,590	144,380	730,652	5,061	253,510	904,348	3,567	81	19
1972	103,220	160,524	1,555	170,620	882,724	5,174	273,840	1,043,284	3,810	85	15
1973	98,840	154,769	1,556	192,020	1,021,102	5,318	290,860	1,175,871	4,043	87	13
1974	95,600	149,830	1,570	272,950	1,420,110	5,200	368,550	1,569,940	4,260	90	10
1975	95,000	152,000	1,600	273,650	1,480,100	5,408	368,650	1,632,100	4,427	91	9

* Data for the breakdown between the irrigated and upland sectors for 1955-1962 were estimated on the basis of state data. For the remaining years, data are from FEDEARROZ, except 1975, which were estimates by the Oficina de Planeación del Sector Agropecuario, Ministerio de Agricultura.

have been no imports and virtually no exports[1] in the 1
outside of some recent rises in stocks, all of the expand
sumed on the domestic market; whether this consumpt
in bread, beer, pork, poultry or eggs, need not concern

4.4 Regional shifts in production[3]

In the last forty years, the regional pattern of rice p
changed markedly. The production of upland and swam
serve the major consumption centers of Barranquilla, C
represented over 50 percent of Colombian output in 19
decline in importance of upland rice, production becam
middle Magdalena Valley; the states of Huila and Tolima
the national output in 1974. With greater use of machin
tion has spread rapidly in the Llanos, and the state of M
important area in Colombia (Figure 2). The Cauca Valle
in importance as the area of sugar cane has expanded. I
of the country was in the Cauca Valley (Leurquin, 196
cent of the irrigated area was in this region (FEDEARR
toward greater regional specialization were already appa
of HYV's; it is probable these have been reinforced by t
have increased the comparative advantage of the irrigate
consequent decline in upland production.

4.5 Prices

Nominal and real prices for rice in Colombia are sho
prices are affected so greatly by inflation that attentio
prices. Farm prices averaged $1,437 per ton[4] in 1965-
1970-1974, a fall of 28 percent during the period of sig

---

[1] The question of exports in 1974 is far from clear. A lands
Llanos cutting off a major rice-producing area from the Bogot
ported to Venezuela during this period. The official export fig
show 1,000 tons of rice exported in 1974. The U.S. Departme
reports 176,000 tons of exports in 1974 and alternatively no e
culture, 1975c, p. 5).

[2] When considering the distribution of benefits of the expa
the form in which rice is consumed is of obvious importance.
and entered the market as high-income livestock products, the
fits would be markedly affected. However, while sketchy, the
total amount used outside direct human consumption is small.
figure of 64,000 tons (net of seed) and the Ministerio de Agric
81,000 tons.

[3] Leurquin (1967) presents a detailed analysis of historical
graphical pattern of rice production.

[4] All monetary data in this report are in Colombian pesos,

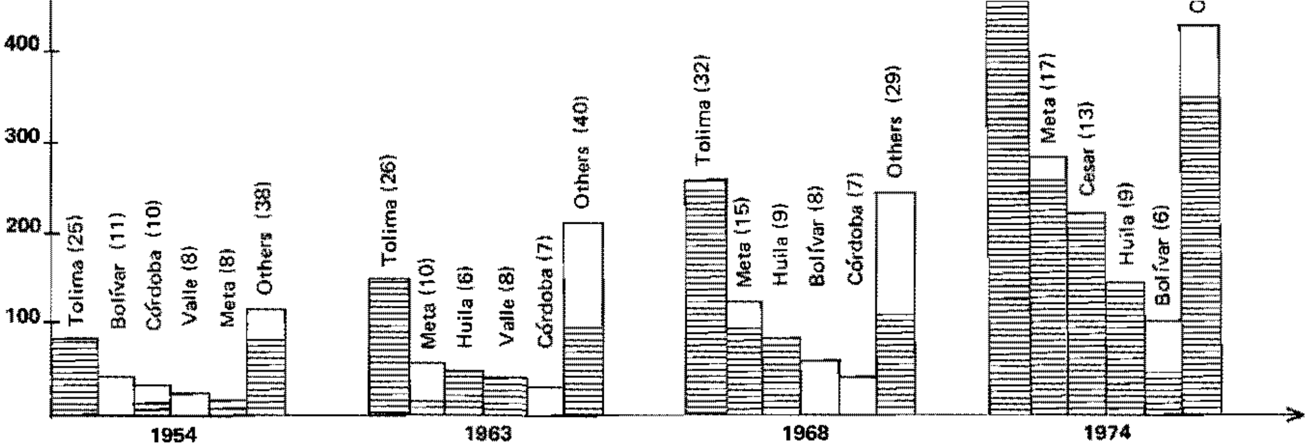


Figure 2. **Regional distribution of rice production by principal states: selected years.**

Table 12. **Production and disappearance of milled rice: Colombia (1962-1974).**

Year	Production*	Beginning stocks	Total available	Human consumption*	Exports*	Seed*	Industrial* use	Total used	Ending stocks
	('000 m.t.)								
1962	356	50*	406	309	6	20	–	335	71
1963	333	71	404	374	3	19	–	396	8
1964	369	8	377	344	–	21	–	365	12
1965	414	12	426	380	–	22	–	402	24
1966	416	24	440	406	–	20	–	426	14
1967	414	14	428	404	–	17	–	421	7
1968	511	7	511	439	–	17	–	456	62
1969	436	62	498	453	21	16	–	490	8
1970	474	8	482	478	5	14	–	497	(–15)

	Atlántico, Sucre, Cesar, Magdalena*	52	28	32	17	31	27
Eastern Llanos	Caquetá, Meta	5	6	9	14	21	17
Middle Magdalena Valley	Huila, Tolima, Cundinamarca, Caldas, Quindío, Risaralda**	11	35	30	40	35	40
Cauca Valley	Cauca, Valle	13	15	10	10	6	3
Other areas	--	19	16	19	19	7	13
Total	20	100	100	100	100	100	100

* Bolívar, Córdoba and Magdalena were divided to create the new states of Sucre and César included in 1967 and 1974.

** Caldas was divided to created Quindío and Risaralda included in 1967 and 1974.

Sources: 1934, 1949 and 1963 are from Leurquin (1967); 1959, 1967 and 1974 are from unpublished data of FEDEARROZ

Table 14. **Colombian rice prices (1950-1974).**

Year	Nominal prices			
	Farm[3]	Wholesale[4]	Retail[4]	Farm
	($/m.t)			
1950	350	976	1,020	1,207
1951	465	944	1,060	1,453
1952	345	728	920	1,113
1953	400	1,128	1,240	1,176
1954	470	1,032	1,160	1,270
1955	475	928	1,160	1,284
1956	485	1,048	1,190	1,244
1957	615	1,472	1,700	1,337
1958	750	1,480	1,800	1,471
1959	770	1,456	1,720	1,375
1960	883	1,936	2,180	1,497
1961	954	1,864	2,360	1,490
1962	919	1,728	2,360	1,372
1963	1,040	2,232	2,569	1,321
1964	1,347	2,928	3,480	1,347
1965	1,703	3,616	4,120	1,592
1966	1,884	3,824	4,460	1,507
1967	1,914	3,848	4,400	1,418
1968	2,106	4,032	4,520	1,452
1969	1,887	3,744	4,460	1,217
1970	1,850	4,200	4,500	1,121
1971	1,931	4,272	5,060	1,044
1972	1,884	4,408	5,260	893
1973	2,514	7,080	8,000	978
1974	3,694	8,960	10,660	1,151

1 Deflated by the price index given in the last column

2 Based on the price index for workers for 1954-1974 and linked to total price index for 1

3 Paddy rice prices from Boletín Mensual de Estadística No. 277, DANE, p.53

4 Source: December price for 1st grade rice in Bogotá, Banco de la República (unpublished

The retail price of first grade rice in Bogotá fell from $3
decline of 14 percent over the same period.*

A frequent source of confusion is the apparent inconsist
price and expanded rice production. If the farm price fe
output continue to rise so strongly? The simple answer
technology, rice production costs per ton fell, making e
able even at the lower prices. Based on data from Gislaso
of irrigated rice production in 1964 pesos was $1,494 pe
and $976 per ton, for 1961-1964, 1965-1969 and 1970-

*A detailed examination of the marketing margins is made in C

real production costs per ton fell by 30 percent
t exactly the same amount as the fall in the farm
of new technology in the face of falling farm prices
en widely documented. Cochrane (1958, pp.106-
notes that the farmer "reasons 'I can't influence
own costs. I can get my costs down . . .thus the
ut for new cost-reducing technologies. Built into
riculture, then, is a powerful incentive for adopt-
peacetime tendency for aggregate supply to outpace
prices relatively low." Cochrane refers to this as
Ve have no reason to doubt that a similar effect has
ian rice industry. Early adopters (be they larger,
viced farmers) test cost-reducing (i.e., yield-increas-
ional output initially has little effect on price,thus
al profits. Further adoption is then stimulated; but
es fall, so that the remaining nonadopters are forced
raw. The data in Table 9 are dramatic evidence of
ge in Colombia's irrigated sector.

of rice fall as a result of the new varieties, but rice also
ner major food items (Table 15). For example, in 1959,
sed 1.67 kg of rice; but by 1974, it purchased 3.47 kg
4, corresponding to the major impact of the HYV's, saw
ces of major foodstuffs relative to rice (Figure 3). Be-
had been no clear change in the relative price of rice,
a. But in the final period (1970-1974), rice became 45
e other commodities.

e that could be purchased with one kilogram of other selected
olesale market: selected years.

Kg of rice purchased with 1 kg of				
ans	Cassava	Maize	Potatoes	Beef
.67	0.31	0.49	0.63	1.43
.59	0.29	0.41	0.45	2.60
.99	0.16	0.36	0.37	2.18
.82	0.34	0.36	0.37	1.88
.38	0.48	0.45	0.29	2.64
.47	0.79	0.51	0.55	2.95
46%	–65%	–13%	–90%	–12%

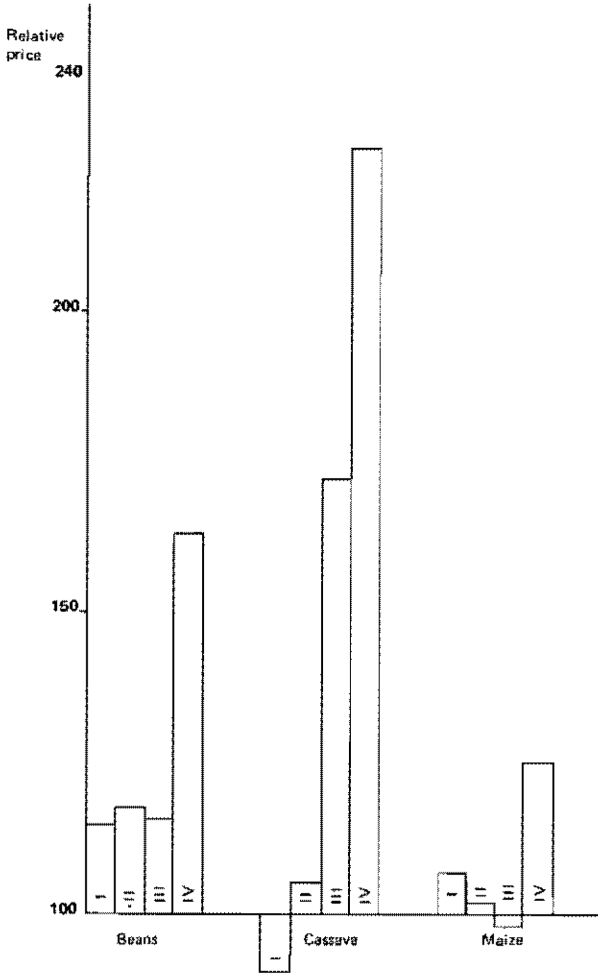


Figure 3. **Changes in the relative price of five commodities to**
(1950-1954 = 100).

The increased proportion of new varieties, some with
qualities than the traditional variety (Bluebonnet-50), h
of the various grades of rice entering the market. While
quantities are available, Table 16 shows that first grade
expensive relative to second and third grade rice; in the
the change has been most marked in the period 1970-19

4.6 Government price support scheme

Since 1944, the Government has operated a price sup
initially through the Instituto Nacional de Abastecimien
through its successor, the Instituto de Mercadeo Agrop

grade: Bogotá wholesale market (selected years).

Price of first grade rice relative to	
econd grade	Third grade
1.07	1.32
1.04	1.57
1.02	1.66
1.04	1.73
1.11	1.79

other years, for December.

sticas, DANE (various issues).

arate support prices based on the type of rice, npurities. The maximum and minimum prices are o 1964 pesos, together with the average price paid sed. The stated role of IDEMA has been to stablize hough it is doubtful whether it has had either "the age capacity to influence price levels significantly" érrez and Hertford (1974, p.23) estimated that MA 's actions reduced the coefficient of variation

r rice (1965-1974).

ces		
Minimum	Av prices paid by IDEMA**	Av farm price***
)	($/m.t.)	($/m.t.)
692	n.a.	1,592
932	1,115	1,507
1,048	1,536	1,418
903	1,246	1,452
742	1,029	1,217
751	963	1,121
670	790	1,044
588	842	893
440	n.a.	978
704	1,097	1,151

ta supplied by the Unidad de Estadística,

of farm prices by 13 percent although simultaneously t
slightly lower due to state intervention. The data in Tal
price paid by IDEMA was generally lower than the aver
orientation of IDEMA to the low-income consumer, by
rice.

Table 18 shows various measures of the intensity of
rice market. Between 1950 and 1965, IDEMA purchas
tion of the rice crop, averaging 2 percent per year (Gut
p. 11). Since 1965, the purchases have been increased,
funds invested by IDEMA in rice has grown (Table 18)
1970-1974 IDEMA purchased an average of 10 percen
price paid by IDEMA during 1966-1969 and 1970-197
the average farm price in both periods. This suggests th
in IDEMA's purchasing strategy in terms of the quality
introduction of HYV's.

Table 18 also gives the percentage of IDEMA's purch
irrigated sector, together with the proportion of the na
in that sector. If IDEMA were to be following a neutra
its source of purchases (rather than say favoring smalle
political reasons, favoring the larger irrigated producer
IDEMA's purchases to follow the observed national tre
of output. In fact, a Chi-square test provided no eviden
sis that IDEMA was in fact merely shifting its purchase
production trends from the irrigated and upland secto
no deliberate policy of favoring one sector or another.
ing a policy of supporting farm incomes, then we woul
proportion of its purchases to have come from the upla
comparatively disadvantaged due to the introduction o
ogy.

4.7 Credit

Limited data on the public sources of credit available
19) indicate that there was no apparent rise in the real
hectare made available publicly during the period of ad
varieties.

4.8 Chemical inputs

Attempts to examine whether the use of chemical p
rose with the introduction of HYV's meet with severe
available data (Table 20) for fertilizers, while incomple
the total quantity applied, implying a perhaps surprisin
of fertilizer per ton of total rice production in 1971 to

A very crude approximation to the input of herbicid
cides suggested that their use per unit of rice production

1968	8.9	7.6	87.2	73	68
1969	20.6	17.6	148.9	76	68
1970	8.1	6.9	58.6	87	74
1971	14.2	10.7	101.4	89	81
1972	12.7	9.1	84.6	90	85
1973	3.6	n.a.	n.a.	81	87
1974	9.9	9.7	175.6	92	91

1 Calculated as (average price paid by IDEMA x quantity purchased by IDEMA) / (average farm price x national output)
2 In 1964 pesos
3 Based on unpublished state data supplied by the Unidad de Estadística, Oficina de Planeación, IDEMA
4 From Table 11

Table 19. **Public credit* for rice production (1968-1974).**

Year	Credit for rice production	
	Caja Agraria	FFA**
	($m)	
1968	161	108
1969	161	87
1970	179	72
1971	197	81
1972	176	111
1973	114	157
1974	183	229

* Expressed in 1964 pesos
** Fondo Financiero Agrario

1965-1967 and 1971-1973, suggesting that the intro
accompanied by some intensified use of these produ

The standard commentaries on the green revolut
that improved genetic potential of seed is only expr
when applied as a "package" with high levels of che
control). Sketchy as they are, the Colombian data d
support to this notion, at least in the case of chemic
applications were constant* during a period of rapid
HYV's (implying a lower fertilizer use per unit of ou
other chemical products per unit of output rose ver

4.9 Labor usage

In Table 21, an estimate of the total labor usage i
In the period since the introduction of new varieties
usage has apparently declined by 33 percent. The av
a comparative advantage to mechanized irrigated pr
percent of the man-days per hectare of the upland m
production. However, it is almost certain that labor
and distribution sector rose as a result of the large ir
tion, the expanded demand for farm inputs would h
labor for their provision, es:·ecially where the produ

Finally, there are two indirect effects of expandec

*Fertilizer prices rose during this period, which undoub
their use and perhaps a slower increase in yields than would
been constant.

ice production (1965-1974).

Insecticides	Herbicides	Fungicides
('000 liters or kg of active ingredient)		
547	424	19
954	740	38
962	680	25
1,344	457	103
1,430	374	120
1,550	394	129
1,773	400	144
1,673	675	270
2,304	960	384
n.a.	1,082	303

products for 1972-1974 from the Ministerio de
; the remaining data from ICA (1973)

due to increased incomes of rice producers, their
service increases. Secondly, if the price of rice is low
ressure for increased industrial wages is diminished
). This has the effect of cheapening the cost of
d hence stimulating the demand for labor in the
f this effect depends on the proportion of total
ce. These data for five major Colombian cities
cate that especially among the lower income
part of the total household expenditures. Between
n the industrial sector rose by 104 percent while

Colombian rice production: selected years.

Sector		
*	Upland**	Total
	('000 man-days)	
	9,976	12,918
	14,593	16,420
	23,251	27,801
	12,919	16,975
	9,120	18,698

terio de Agricultura, 1973, p.30)
terio de Agricultura, 1973, p. 30)

Table 22. **Proportion of household expenditures spent on ric[e] Colombian cities (1970).**

City	Income level ($		
	0-18	18-42	42-72
	(%)		
Bogotá	3.0	2.1	1.5
Cali	5.1	4.0	2.5
Bucaramanga	2.3	1.7	1.0
Barranquilla	5.2	4.3	3.6
Pasto	4.8	3.6	2.2

Source: DANE: Boletín Mensual de Estadísticas No. 264-265

the retail price of first grade rice in Bogotá rose only as a wage good, rice represented a dampening effect o wages.

In conclusion, despite the apparent decline in on-f tion, it would be presumptuous to conclude that HY technological change. Indirect expansion of the dema the large increases in rice production due to HYV's c in on-farm labor usage.

4.10 Distribution of rice farms, area and proc

In this section we present a review of the structure try by farm size categories and indicate how this has b The principal purpose of this somewhat detailed secti tions of rice production by farm size for both the up in 1970. This information will be needed subsequent the distribution of costs and benefits of the new rice

The analysis is based on unpublished census data p and 1970 and on a special tabulation by DANE for 19 Unfortunately no data exist for years subsequent to 1 of the introduction of HYV's on the structure of the cannot be assessed. However, some clear trends were a there is no reason to believe that the pattern of chang 1970 has not continued.

The census data for 1959 and 1970 were available b

d" or "Irrigated," on the basis of the percentage of the
Fortunately, in almost all cases, these geopolitical
ably closely to the two types of rice-production
sed on FEDEARROZ data for 1963 (the closest year
ch state production data were available (Leurquin,
sented in Appendix Table 2. The data show a high
ystem by states. The only low value of concern is the
roduction from the irrigated sector in Meta; this
ssified the remaining 43 percent upland as irrigated

is the 1970 figure of 57 percent of production from
s implies we have incorrectly classified the remain-
ed production.

tion, Appendix Tables 3, 4 and 5 were constructed
for 1970. The data for 1966 are shown in Appen-
eakdown by states was not available. The 1959 and
that reported rice as the principal crop, whereas the
ucing farms.

vealed by these data is the concentration of rice pro-
959, farms of greater than 100 ha represented 15 per-
as the principal crop, yet they sowed 53 percent of
bia. In 1966, 32 percent of the farms were over 50
the total rice output, 42 percent coming from farms

has been some tendency for the concentration to
all- and medium-size groups declining relative to the
ha and over). This trend was particularly marked in
s over 50 ha accounted for 59 percent of all farms
op in 1959 and 50 percent in 1970 (Table 24). The
farm size are shown for 1966 in Appendix Table 6;
fferences, except for the largest size group (over 500
higher yields.

duction has become more concentrated in the larger
ms declined substantially between 1959 and 1970
s in the upland sector and evenly distributed across
sector, the number of small and medium producers
e number of large producers increased. In 1970, the
of the farms, yet produced 74 percent of the national

timating the distribution of production in 1970 by
pland and irrigated sectors.

of estimating the number of farms in each time period
he data **not** in parentheses). A constant annual rate

Table 23. **Percentage distribution of rice farms by three cat**
(selected years).

Size group (ha)	1959
Small (0–5)	30
Medium (5–50)	43
Large (50 +)	27
Total	100

of change between 1959 and 1970 was assumed and t producers for 1966 estimated as 35,721. The relation producers for 1959 and 1970 was assumed to be the s bers of the total irrigated and upland producers for 1 on the basis of the known proportions of principal pr

For the upland sector the area sown by the i-th siz based on the area sown in 1959 ($A_{59,i}$) adjusting upw producers in 1959 and downward for the decline in u

This method assumes that changes in area were pro an assumption supported by the evidence in Table 25 tribution of area for nonprincipal growers was similar (as supported by Appendix Table 8, where the inclusi not alter the distribution significantly).

Table 24. **Percentage distribution of farms where rice is the p**
farm size, by sector: Colombia (selected years).

	Upland sector	
Size group (ha)	1959	1970
Small (0–5)	32	31
Medium (5–50)	44	42
Large (50 +)	24	27
Total	100	100

*As shown in Appendix Table 8, the size distribution for 1 differed very little from that for the two end periods (1959 a ducers.

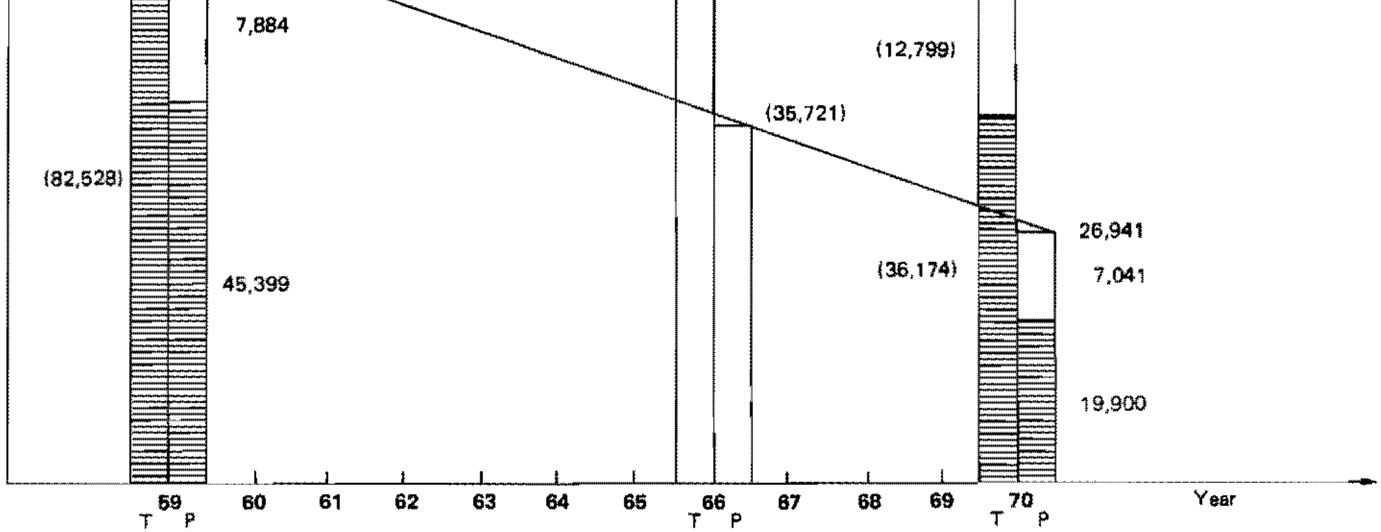


Figure 4. Number of rice farms in Colombia in selected years.

Table 25. **Changes in the number of farms between 1959 and 1970 w**
three categories of farm size, by sector: Colombia.

Size group (ha)	Upland sector		
	No.	(%)	No.
Small (0–5)	– 7,738	–55	– 60
Medium (5–50)	–11,885	–59	– 79
Large (50 +)	– 5,876	–52	+56
Total	–25,499	–56	– 84

For the irrigated sector the above method could n

1. The area reported by principal growers exceed that year.

2. The change in total area was not evenly distrib (Table 25).

The following procedure was therefore adopted:

1. The reported number of farms in each size grou of 14,332/7,884 (see Figure 4), giving $NF_{59,i}$.

2. The reported area sown in each size group in 1 52,190/86,078, or the reported total to the rep the irrigated sector, to give $A_{59,i}$.

3. The area per farm ($A_{59,i}/NF_{59,i}$) in 1959 was t and multiplied by the number of farms in each $A_{70,i}$. Each of these was then raised by the ra in the irrigated sector to the estimated total (Σ_i estimated for 1970 by size groups were compa 1966 (Appendix Table 9) and showed the exp concentration among the larger size groups. Ap number of principal producers in each size grou the reported data for 1959.

Finally, the average reported yields in both secto estimated areas by size group, to give the distributio size for each sector in 1970 (Tables 26 and 27). It is subsequently be used to allocate the distribution of by farm size.

s 26 and 27 is summarized graphically in Figure 5. The tion of output in the irrigated compared to the upland that year, it is estimated that the lower 50 percent of 25 percent of the upland output; in contrast, only 9 ut came from the lower 50 percent of irrigated farms. ns for the distributional impact of the benefits of the Chapter 7.

e reiterated that the structural changes noted in rice rior to any possible significant influence of HYV's. The ve not been examined; such an inquiry would form a

n of rice production by farm size: upland sector (1970).

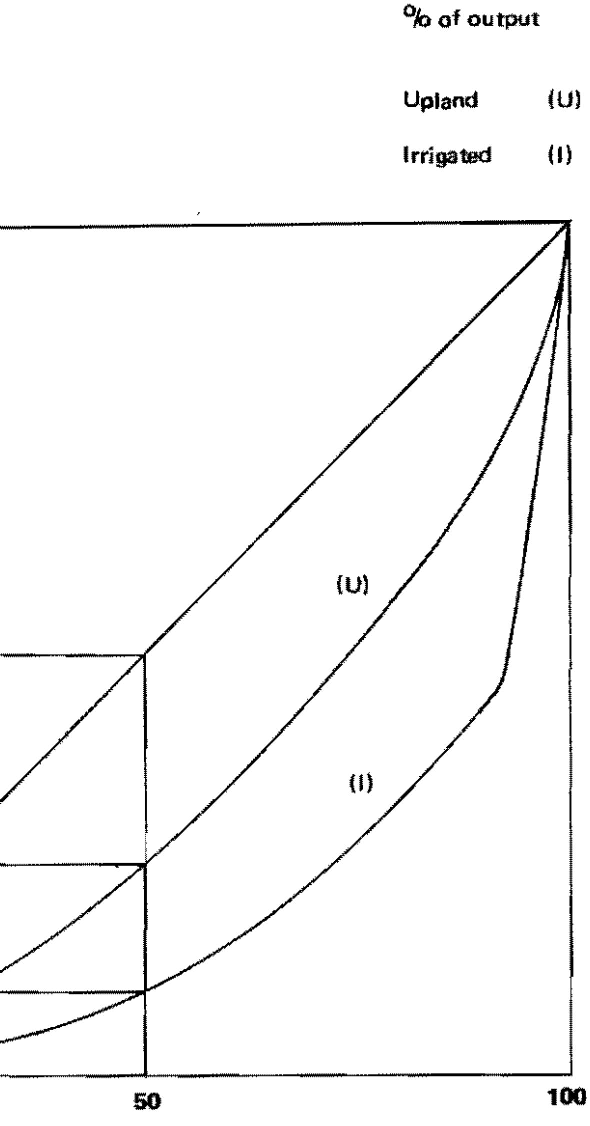
of farms	Area (ha)	Prod. (m.t.)*
,180	719	1,177
,402	486	4,069
,707	3,280	5,368
,825	3,193	5,226
,458	3,025	4,951
,255	9,821	16,076
,374	12,342	20,202
,563	7,355	12,039
,916	5,855	9,583
,652	5,265	8,618
,743	18,543	30,354
,485	16,338	26,745
,036	15,444	25,281
380	8,491	13,899
131	4,861	7,957
67	4,095	6,703
,174**	121,113***	198,248***

of 1,637 kg/ha (Table 11)

Table 27. **Estimated distribution of rice production by farm size**

Farm size (ha)	No. of farms	Area (
0 – 1	162	32
1 – 2	498	164
2 – 3	427	133
3 – 4	265	151
4 – 5	293	266
5 – 10	885	908
10 – 20	1,362	2,336
20 – 30	920	1,934
30 – 40	816	2,100
40 – 50	721	2,147
50 – 100	2,060	8,262
100 – 200	2,560	21,071
200 – 500	1,065	22,569
500 – 1,000	351	16,049
1,000 – 2,500	276	16,747
2,500 +	138	17,231
Totals	12,799**	112,100

* Assuming a constant av yield of 4,945 kg/ha (Table 11)
** From Figure 4
*** From Table 11



...a output in Colombia by sector (1970).

5. AN ECONOMIC MODEL TO MEASURE
OF HYV's IN COLOMB

The desirability of investment in any particular line judged using a wide variety of technical, social, econor this study, we propose to examine the impact of inves lombia using two criteria: efficiency and equity (Akin efficiency, we understand the social return on the scar research; i.e., was it a socially efficient way to invest t refer to the distribution of the net benefits by econom

There appears to be increasing concern on the part share received by people in the lower income groups o from research at international centers. Given the dram Colombian rice sector, it was felt that efforts should b the size and the distribution of the benefits of this tec will devote more effort to the distribution of the net b magnitude only as a "by-product." An existing study that the investment in rice research in Colombia up ur return of between 60 and 80 percent, leaving little do

We will consider three groups of people:

1. Upland rice producers
2. Irrigated rice producers
3. Rice consumers.

In measuring the incidence of the net benefits, we v for each group and subtract their share of the costs of a true indicator of the incidence of net benefits of res based on both the return and the costs borne by differ only dividing the total gross benefits between produce pe (e.g., Ardila, 1973; Akino and Hayami, 1975;

producers into upland and irrigated categories because the relative benefits accruing to both groups from was developed specifically for irrigated culture. We or analyzing the differential impact of new agricul- o limited ecological adaptability, favor certain

e a graphical representation of the model; this is tatement. The model used is an extension of that (1972) for the case of cotton in the state of Sao volves dividing the total supply of Colombian rice duced under upland conditions (SUR) and that or (SIR), where

s (expressed as a function of the expected price of gether with the supply curves S'IR and S'TR. The he irrigated sector when only traditional varieties oonding total supply, so that

displaced k percent to the left of SIR and STR, parameter, determined by the difference in yield ieties and the proportion of the total area planted neters for SIR and STR are denoted k_I and k_T res-

y DR is a declining funtion of the current price of rice e supply of rice is postulated to depend on the previous

tant assumptions:

ombia is effectively closed; i.e., the foreign trade in rice, action of total production, is ignored.

et operates free from direct Government intervention; n 4.6) from 1950-1969, the proportion purchased by he assumption does more violence since 1970. Be- difference between the actual prices and quantities in ch would have resulted in the absence of Government

intervention have been estimated as 7 and 2.3 perc
and Hertford, 1974).

3. Rice from both sectors is taken to be of identical q

4. The entire analysis will be conducted at the farm le
of benefits to consumers strictly requires the use of
rather than the derived farm level demand curve. H
ing margin (the difference between farm and retail
great violence is done. The problem of marketing m
detail in a subsequent section.

In Figure 6, P_1 is the expected price which calls forth
that clear the market at a price of P_2, while P_3 is the pri
vailed in the absence of sowings to HYV's.

First we consider only the total benefits (TB) and the
fits to the development of the new rice varieties (in any
comparing the difference between total consumer utility
of rice production, with and without the new varieties. I
Figure 6, we can write

$$TB = (OABC - OAD) - (OEFC - OEG)$$

These total benefits are divided between changes in
plus (ΔCS and ΔPS), so that

$$TB = \Delta CS + \Delta PS$$

$$\Delta CS = P_2BC - P_3FC = P_2BFP_3$$

$$\Delta PS = (OABP_2 - OAD) - (OEFP_3 - OEG)$$

Equation (5.6) only gives the global change in produc
examine the impact on two groups of producers, we now
change in upland and irrigated producer surplus (ΔUPS a

$$\Delta PS = \Delta UPS + \Delta IPS$$

$$\Delta UPS = -P_2\,UVP_3$$

$$\Delta IPS = (OKJP_2 - OKH) - (OLNP_3 - OLR)$$

The loss in producer surplus in the upland sector, whe
took place, is simply the loss in gross revenue they suffe

---

*Where possible we have maintained the same notation as Aye
comparison.

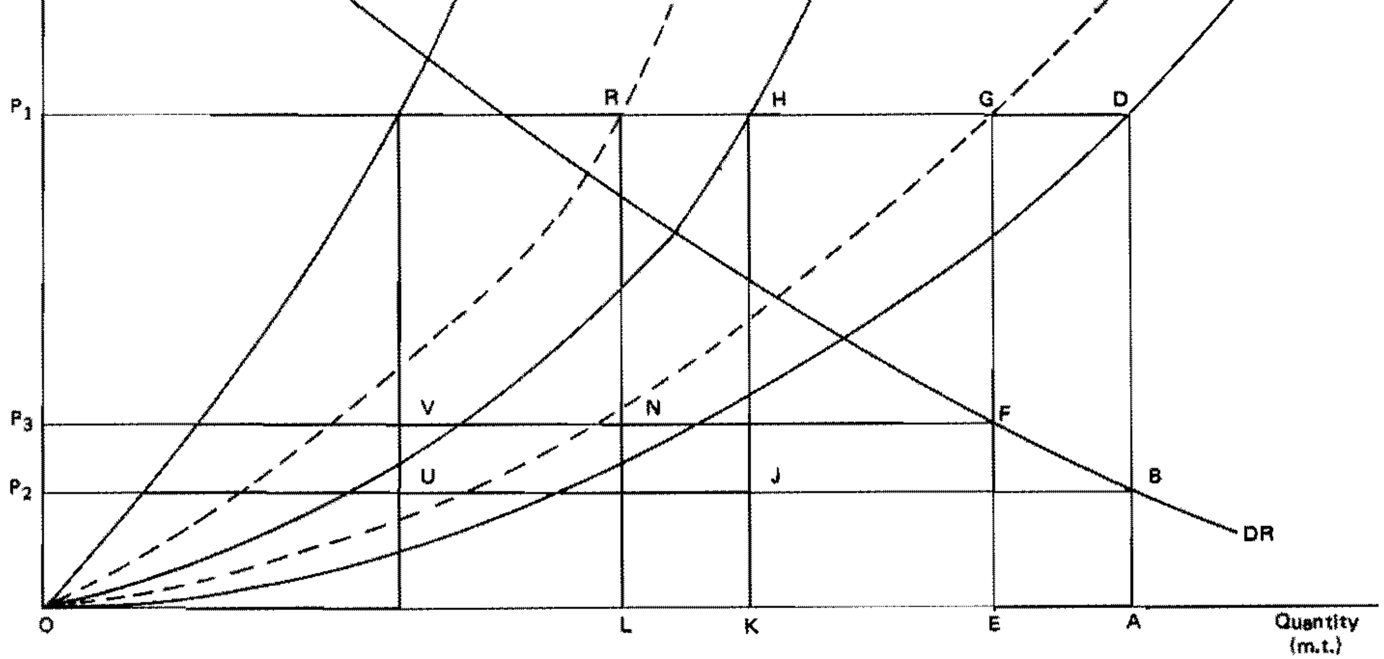


Figure 6. Graphical representation of the model for estimating the distribution of gross benefits from the introduction of HYV's of rice.

(P_3 instead of P_2* which would have prevailed if the expa
taken place in the irrigated sector). As the change in cons
can note that P_2UVP_3 is simply a transfer from upland ri
i.e., of the benefits accruing to consumers; the part shown
the expense of upland producers.

In summary, the consumers gained, some of this gain l
ducers; upland producers suffered a net loss, all of which
Whether or not irrigated producers had an overall gain wi
magnitudes of the supply and demand elasticities for rice

5.2 Mathematical representation

The formal representation of the model in terms of th
equations is as follows:

$$\text{DR:} \quad P_t = \alpha\, Q_{T,t}^{1/\eta}$$

$$\text{SIR:} \quad Q_{I,t} = \beta P_{t-1}^{\epsilon_I}$$

$$\text{SUR:} \quad Q_{U,t} = \gamma P_{t-1}^{\epsilon_U}$$

$$\text{STR:} \quad Q_{T,t} = \delta\, P_{t-1}^{\epsilon}$$

$$\text{S}'\text{IR:} \quad Q'_{I,t} = (1 - k_{I,t})\, P_{t-1}^{\epsilon_I}$$

$$\text{S}'\text{TR:} \quad Q'_{T,t} = (1 - k_{T,t})\, P_{t-1}^{\epsilon_U}$$

with η and ϵ representing the demand and supply elastici
senting all the variables and parameters which affect supp
plicitly included in the model.

Once we have established the magnitude of the supply
we can derive (5.14) and (5.15) directly from SIR and S
equations (5.10) to (5.13) and eight unknowns: (α, β, γ
In the following section we discuss the estimation of the

*Implicitly, we are assuming the elasticity of demand for rice is

; parameter

taken the yield superiority of new varieties under ex-
proxy for their superiority under farm conditions (f),

$_{T,t})^f$ (5.16)

on arises simply because we generally lack farm level
sis) for determining the yield superiority of the im-
traditionals ($Y_{T,t}$).

nd Martin, 1965) that experimental yields are gener-
result of the more timely control of the cultural
n given to small plots, etc. The implicit assumption
nder experimental conditions might both overstate
ould approximate the unknown farm level difference
re of the new varieties (Kawano et al., 1974) is often
ly more to fertilizer, water and superior cultural
reasonable to assume that the difference at the expe-
or the farm level differences. In the case of the Co-
ults based on a small number of observations suffer
mental error which may not reflect overall farm

dopted an alternative approach. However, we first
regional trial data comparing improved and tradi-
ds to unacceptable results.

(5.17)

area of improved varieties (taken together)

area of the traditional variety

n and area.*

---

me subcript, t.

$$\frac{Q_I}{H_I + H_T} + \frac{Q_T}{H_I + H_T} = \frac{Q}{H}$$

$$\frac{Q_I}{H_I} \cdot \frac{H_I}{H_I + H_T} + \frac{Q_T}{H_T} \cdot \frac{H_T}{H_I + H_T} = \frac{Q}{H}$$

or, $Y_I \cdot P + Y_T \cdot (1-P) = Y$

where

P = proportion of the total area sown to impro

Y_I = average weighted yield of improved varieti

Y_T = yield of the traditional variety

Y = overall observed yield.

If the experimental values for Y_I and Y_T are in fact ponding farm level values, we should be able to derive tion [derived by rearranging (5.20)],

$$P_t = \frac{(Y_t - Y^e_{Tt})}{(Y^e_{It} - Y^e_{Tt})} \cdot 100$$

where:

Y_t = observed yield in irrigated sector

$Y^e_{I,t}, Y^e_{T,t}$ = yields of improved and traditiona trial data of ICA.

The data and results are show in Table 28.

As shown, only 6 of the 17 results for P_t fall in the results are either greater than 100 percent or negative. of these data is when P_t is greater than 100 percent (a $Y_t > Y_{I,t}$; i.e., the observed yields are higher than the trials. As not all the observed yield is based on improv that the experimental data are understating the yields is negative (also nonsensical), it is almost always the ca

n of the area sown to HYV's, based on experimental yields
nal variety (1964-1974).

*	Experimental yields		Implied proportion sown to HYV's (P_t)
	HYV's (Y^e_{It})	Traditional ($Y^e_{T,t}$)	
	(kg/ha)		(%)
	5,166	4,336	− 149
	4,336	3,462	− 47
	3,645	1,590	+ 68
	2,690	2,893	− 283
	4,600	3,200	+ 73
	3,809	3,086	+ 139
	4,840	3,339	+ 107
	4,372	3,164	+ 157
	5,243	2,866	+ 97
	4,934	3,383	+ 125
	5,398	3,086	+ 91
		3,724	+ 55
	5,243	4,100	+ 70
		3,380	+ 129
		4,954	+ 3,200
	4,934	3,573	+ 131
		4,324	+ 274

yield under experimental conditions, indicating that traditional variety overstate the corresponding farm $_{T,t} > Y_{T,t}$, so that

$$_{T,f})^{f}$$

l margin of yield superiority is less than the farm

perimental data as a basis for estimating the superi- e farm level.* We have preferred to base our esti-

tion) argues that the regional trials are not specifically y; a wide range of other characteristics are also consi-

mates on observed farm level data; to do this we need
at the farm level. We took P_t from FEDEARROZ da
that:

1. Their sales of improved seed (over 50 percent o
   total pattern of sowings to improved varieties.*

2. All the improved seed was sown under irrigation
   case, but the evidence of the observed upland yi
   was no apparent impact due to new varieties in

Rearranging equation (5.20), we have

$$Y_{I,t} = \frac{Y_t - (1-P_t)\ Y_{T,t}}{P_t}$$

where:

Y_t = observed yield under irrigation in year t

$Y_{T,t}$ = the traditional yield that would have pre

We took the average of years 1964-66 when 88 p
sown to Bluebonnet-50 as the base period, giving a y
fitted the following equation:

$$Y_t = \alpha + \beta_1 P_t + \beta_2 t - \epsilon_t$$

obtaining

$$Y_t = 2{,}938 + 2{,}290\ P_t + 38t;\ R^2 = 0.93$$

We then assumed that the estimated residuals ($\hat{\epsilon}_t$
were due to climatic factors and that the traditional
in the same proportion.

Using

$$\hat{Y}_{T,t} = 3{,}048\ [(\hat{\epsilon}_t/Y_t) + 1]$$

we simulated the traditional yields for each year. Wi
equation (5.22), we obtained the results for $Y_{I,t}$ sho
estimated yield superiority was very slightly negativ
improved varieties was only 0.2 percent so we restri

**In 1974, 40,835 m.t. of certified seed were produced,
to sow all the irrigated area (ICA, 1974, p. 30).

th improved information about cultural practices ent fall took place gradually as the varieties spread age superiority of the improved varieties between .7 tons/ha. This compares with 2.1 tons/ha in the see Appendix Table 11). Rosero (1975) estimates r this period.

l be sufficient to allow us to proceed with the esti- $_t$ (for example, in the manner outlined by Ayer and eve that for the case of rice in Colombia this would of the HYV's. The reason for this is that it seems st part of the expansion in the irrigated area was **due** nce rather than attribute to the HYV's only the n, we also include all the production from the presence of HYV's. On this basis, the following d $k_{I,t}$ and $k_{T,t}$ respectively.

raditional and improved varieties: Colombia (1964-1974).

aditional Variety[2] ($\hat{Y}_{T,t}$)	Proportion sown to HYV's[3] (P)	Yield of improved varieties[4] ($Y_{I,t}$)
	(%)	(kg/ha)
3,092	5.1	3,248
3,007	5.0	3,847
3,023	0.2	—(5)
3,292	6.9	5,843
3,164	42.6	5,645
3,039	42.6	5,510
3,339	58.8	6,070
3,417	57.2	6,291
3,007	87.4	5,486
2,936	97.8	5,371
2,835	99.2	5,219

975)

ference between traditional and improved varieties was

nent-sponsored irrigation districts rose from 27,114 ha in the period of rapid expansion of the HYV's. The use of dwarfs ester of 1970 to about 80 percent in 1975 (all data are from his expansion in area reflects, in part, the relative profitability

$$k_{I,t} = \{P_t[(Y_{I,t} - Y_{T,t}) * A_{N,t} + Y_{I,t} \cdot A_{A,t}]$$

$$k_{T,t} = \{P_t[(Y_{I,t} - Y_{T,t}) * A_{N,t} + Y_{I,t} \cdot A_{A,t}]$$

where:

$A_{N,t}$ = area of irrigated land that would have be quirements in the absence of HYV's

$A_{A,t}$ = additional area sown due to presence of

$Q_{I,t}$ = total production from irrigated sector in

$Q_{T,t}$ = total rice production in year t.

To apply equations (5.25) and (5.26) we must first sown ($A_{A,t}$) due to HYV's; $A_{N,t}$ is found by subtracti actually sown. The following steps summarize the pro

1. The area of upland rice which would have been sov yielding varieties was estimated.

2. Multiplying this by the actual yields of the upland from the upland sector.

3. The domestic demand was estimated by inflating th period 1964-67 by a factor of 6.636 percent yearly rate of 3 percent yearly, a real income growth rate income elasticity of demand of 0.538 (see Section

4. The difference between the domestic demand and sector was taken as the production which would ha ed sector.

5. Dividing this production by the yields in the irrigat area needed ($A_{N,t}$).

Two methods of estimating the upland area in the in order to test the sensitivity of the shift parameter

(A) First, the following equation for the area of up

$$A_{U,t} = 91{,}031 - \underset{(-1.77)}{202{,}534}\ P_t + \underset{(1.26)}{9{,}298} - \underset{(-0.3}{149}$$

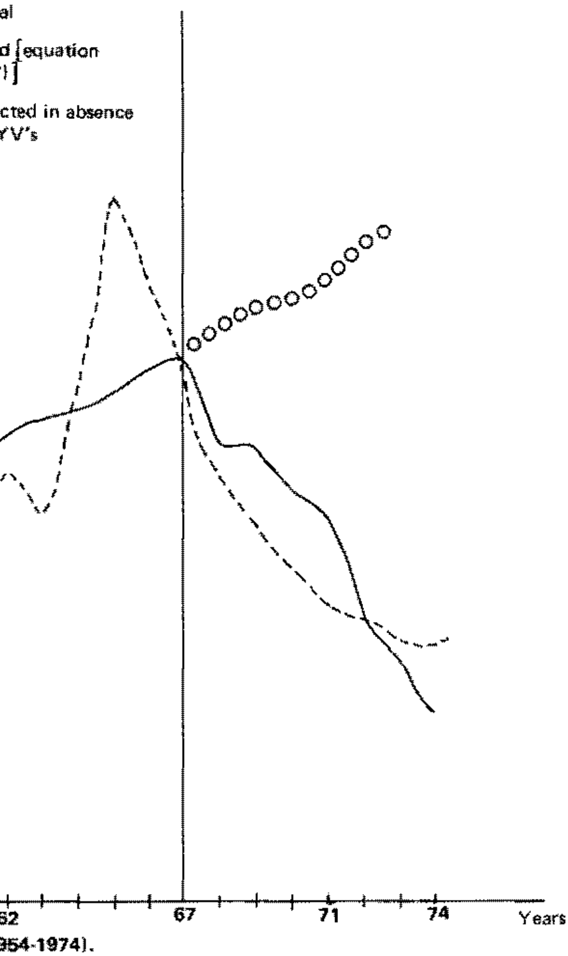
$n = 21;\ R^2 = 0.62;\ DW = 1.04$

where:

d rice in year t

igated sector sown to HYV's year t

d sector sown to HYV's (P_t) was included as an
that higher values of P_t would mean higher output
ational prices and hence less area sown to upland
nge took place).The actual areas sown to upland
her with the areas predicted by equations (5.27).
absence of HYV's, P_t was constrained to zero in
n (5.27). These values are also shown in Figure 7.



954-1974).

nated from this analysis as the proportion sown to HYV's
t any additional area sown due to the HYV's would have

Table 30. **Estimated area sown to upland rice in the absence [...] assumptions: Colombia (1969-1974).**

Year	Actual*	Area sown to up[...] (A) From equation (5.27)
		(ha)
1968	150,200	196,977
1969	134,570	201,656
1970	121,113	206,037
1971	109,130	209,822
1972	103,220	213,905
1973	98,840	217,392
1974	95,600	220,581

* From Table 11

(B) The second method of estimating the area of upl[...] was simply to take the historical area prior to the rise [...] this figure for the subsequent years.

The average area sown during the years 1954-196[...] was applied to the period 1968-1974.* In Table 30, t[...] the two different assumptions is given. The additiona[...] because of the presence of the HYV's under the two [...] shown in Appendix Tables 12 and 13, respectively.

All the data needed to estimate the shift paramete[...] available, and the results of applying equations (5.25[...] Table 31 for assumptions (A) and (B). Given the relat[...] shift parameters under the two sets of assumptions, o[...] are used in the subsequent analysis.

In conclusion it should be stressed that the meth[...] superiority employed above does not pretend to isol[...] potential from the use of improved cultural practice[...] possibly higher input levels. The view is taken that t[...] puts necessary for the expression of the yield poten[...] rieties. Without them, that potential may not have b[...] 1974); hence measuring the return to the genetic po[...] artificial exercise.

5.4 Estimation of the elasticities

Estimates of income elasticity of demand and th[...] and supply are required.

1964	385,000	156	0.26	0.17	0.26	0.17
1965	396,400	840	1.38	0.81	1.38	0.81
1966	341,400	0	0.00	0.00	0.00	0.00
1967	381,000	2,551	5.07	2.92	5.07	2.92
1968	535,700	2,481	35.03	23.87	36.75	25.00
1969	474,225	2,471	29.82	20.36	28.59	19.58
1970	554,347	2,731	39.56	29.16	33.92	24.94
1971	730,652	2,874	44.09	35.62	44.29	35.79
1972	882,724	2,479	59.96	50.75	55.27	46.84
1973	1,021.102	2,435	65.89	57.20	59.25	51.52
1974	1,420.110	2,348	73.68	66.65	68.94	62.11

* From Table 11

5.4.1 Income elasticity of demand (η_y)

Pinstrup-Andersen (unpublished data) provides an es
0.34. While we might accept this as indicative of the urb
population), it is likely that the rural sector would displ
other published studies for Latin American countries* g
the urban and rural income elasticities of demand:

	Income Elasticity of D
Country	Urban
Chile	0.20
Mexico	0.18
Peru	0.21
Venezuela	0.20
Simple average	0.1975

The implied average ratio of the rural to urban elastic
to the Cali estimate, to give 0.779 (= 0.34 x 2.29) fo
and urban figures were then weighted by the proportion
in each sector.

$$\eta_y = 0.45\,(0.779) + 0.55\quad(0.34)$$

$$\eta_y = 0.538$$

The resulting national estimate of 0.538 is between 0.5,
FAO (1971) for Colombia, and 0.6, estimated by ECLA
and Ruiz (1967) estimated a value of 0.982, but this wa
and given rising real incomes, the current value is likely

5.4.2 Price elasticity of demand (η)

There are only two known estimates of the price elas
bian rice. The estimate of 1.372 presented by Gutiérrez
adopted for the following reasons:

1. It is considerably higher than one would intuitively
   commodity facing essentially a domestic market.

2. It was calculated from a time series regression usin
   than the retail prices (to which consumers would s
   would not do violence to the estimate of the price
   relation between the farm and retail price had beer
   later (see Chapter 8), this has not been the case.

*See Appendix Table 14.

estricted demand equation (where a value for the in-
d), whose R^2 value is inexplicably larger than that for
. 16).

the values of the price elasticity of demand for rice for regions; in all, 53 different estimates. While it is recog- come from widely varying social and economic circum- note that the maximum value is −0.65, while the sim- érrez and Hertford) is −0.309.

nstrup-Andersen's value for Cali of −0.354 as a proxy or. We calculated a value for the rural sector of −0.575, sing the proportions for the Venezuelan results (the untry reporting rural and urban values). Then by proportions, we obtained:

$$.55 \ (-0.345) \qquad (5.29)$$

d of deriving η, we felt that a sensitivity analysis would amined values of −0.300 and −0.754. The first is gen- ower income countries in Appendix Table 14; the le Schlesinger and Ruiz (1967) is taken as the upper

f supply (ϵ_{I}, ϵ_{II} and ϵ)

ve require estimates of the elasticities of supply nd total rice output. The only known estimate* tput, presented by Gutiérrez and Hertford (1974). uation incorporating an expected price, the price oduction, in the irrigated sector) and the area sown; Colombian output between 1950 and 1969 was is by accepting this value, as the short-run supply It is in keeping with the values from other country ble 14. However, we must now derive separate the irrigated and upland sectors.

bscripts T, I and U refer to total, irrigated and upland, nply shown that

---

by Cruz de Schlesinger and Ruiz (1967) contains only a trend

$$\epsilon = \alpha \ \epsilon_I + (1-\alpha)\epsilon_U$$

so that if we can find either ϵ_U or ϵ_I, given the other an
proportion of output from the irrigated sector), we can
unknown elasticity.

In an attempt to estimate ϵ_U, we fitted the following
upland sector:

$$Q_{U,t} = -1.47 + \underset{(10.5)}{0.99A_{U,t}} + \underset{(0.1),}{0.01PR_{(t-1)}} +$$

$$\underset{(-0.3)}{-0.04PY_{(t-1)}} + \underset{(0.1)}{0.02PS_{(t-1)}} - \underset{(-1.7)}{0.35PM_{(t-1)}}$$

$$n = 20; \ R^2 = 0.96; \ DW = 2.00$$

where:

Q_U = output of upland rice in Colombia

$A_{U,t}$ = area sown to upland rice in year t

$PR_{(t-1)}$ = price of rice in (t-1)

$PC_{(t-1),(t-3)}$ = average price of cattle in prece

$PY_{(t-1)}$ = price of cassava in year t-1

$PS_{(t-1)}$ = price of sesame in year t-1

$PM_{(t-1)}$ = price of maize in year t-1

Values in parentheses are the values of Student's "t"
are expressed in logarithmic form.

The level of variance of output explained is high, due
of area sown.However, this and the lagged price of cattle
variables. The lagged price of cattle carries a positive sign
comes from the North Coast and Piedmont areas of the
competes with upland rice for land.However, higher catt
demand for greater areas of pasture; and as rice is freque
in the clearing of land and establishment of pasture,then
between cattle prices and upland rice otuput is as expect

d negative signs, but the price of sesame has a positive, t.*

city of supply of upland rice (ϵ_U) is 0.01, but the ly different from zero. While we have preferred a more l below) to estimating (ϵ_U) and (ϵ_I), these results of upland rice supply is probably low and almost ticity of supply of irrigated output.

output coming from the irrigated sector changed from riod 1964-1974, three subperiods were selected and the each subperiod (Table 32). We now argue that

can derive the two boundary values of ϵ_I corresponding ch of the three subperiods. The midpoint of the possible itrarily chosen and the corresponding values of ϵ_U calcu- n Table 33 for the preferred estimate of $\epsilon = 0.235$, and 1.500. Appendix Table 15 presents the six sets of elas- n the sensitivity analysis.

duction from the irrigated sector: Colombia (1964-1974);

Av proportion of total output from the irrigated sector* (α)
0.58
0.73
0.87

found a similar result in their equation for total rice supply.

Table 33. **Values of supply elasticities for three subperiods:** ϵ =

Subperiod	α	Value of ϵ_I when $\epsilon_U = 0$	$\epsilon_U = \epsilon_I$
1964-1967	0.58	0.405	0.235
1968-1971	0.73	0.73	0.322
1972-1974	0.87	0.87	0.270

* From equation (5.30)

Table 34. **Values of supply elasticities for three subperiods:** ϵ =

Subperiod	α	Value of when $\epsilon_U =$ £0	$\epsilon_U = \epsilon_I$
1964-1967	0.58	2.586	1.500
1968-1971	0.73	2.055	1.500
1972-1974	0.87	1.724	1.500

* From equation (5.30)

EFITS, COSTS AND NET BENEFITS
HYV's IN COLOMBIA

ations (5.10) to (5.15) was estimated; and using this
from 1964 to 1974, the gross benefits to consumers
igated) were calculated using (5.3), (5.8) and (5.9),
r the quantities of rice are from Table 11, and for
d in 1964 pesos) from Table 14. The total gross
of consumer and producer (upland and irrigated)

ble 35 for the preferred elasticity estimates (η =
ts for the other five combinations of elasticities are

ur "most likely" estimates (for $\eta = -0.449$ and ϵ =
" estimates given by Ardila (1973, p. 132). Both sets
64. Despite a number of differences in the assumptions
e total gross benefits are remarkably similar. However,
umers and producers is markedly different in the two
of the elasticity of demand. Ardila used a value of
Hertford, 1974), while the "preferred" value in this
ence of this difference is that Ardila attributes 80 per-
to producers and 20 percent to consumers, while in
o producers are always negative, implying foregone
r benefits are positive because in the absence of
ching the domestic market would have been much
price (P_3 in Figure 6) would have been very much
the same reason, producers as a whole have foregone
and entrepreneurial skills). With the rapid expansion
HYV's, prices received by producers were much lower
the absence of HYV's. Both upland and irrigated pro-
s a result of the introduction of HYV's. This result

Table 35. **Gross benefits* to consumers and producers of r**
($\eta = -0.449$ and $\epsilon = 0.235$).

Year	Consumer gains	Foregone income to	
		Upland	Irrigated
		($m)	
1964	3.0	− 1.1	− 0.9
1965	19.4	− 8.0	− 4.4
1966	0.0	0.0	0.0
1967	63.0	− 27.1	− 14.6
1968	823.6	− 304.1	− 207.9
1969	495.0	− 177.2	− 140.5
1970	806.3	− 256.7	− 246.2
1971	1,228.0	− 302.2	− 453.2
1972	2,341.8	− 550.8	− 855.2
1973	3,826.1	− 850.6	− 1,377.6
1974	9,340.0	− 1,917.4	− 3,536.0

* Expressed in 1964 pesos

should in no way be construed as meaning that rice pr
to the introduction of HYV's. Obviously, if the produ
"profitable," their expansion to almost 100 percent o
have occurred. As noted in Section 4.5, real productio
introduction of HYV's. All we can legitimately conclu
HYV's, the price of rice in Colombia would have pres

Table 36. **Comparison of preferred estimates of total gross be**
Ardila (1973).

Year	Present study
1964	1.0
1965	7.0
1966	0.0
1967	21.3
1968	311.6
1969	177.3
1970	403.5
1971	472.6
Total	1,294.3

* Expressed in 1964 pesos

roducers would have been higher by the amount
e foregone income to producres, the gross benefits
rs plus consumers) have been positive and substan-

ty and gross value of additional rice due to

ally in Figure 6 can be simplified by considering
R and STR) and assuming equilibrium prices pre-

form where P_1 and Q_1, and P_0 and Q_0 refer to
ithout the new varieties, respectively. The quantity
6 and is the quantity produced without HYV's,
f interest is the quantity Q_0 which can be estimated

$$- (\epsilon/\eta)]^{-1} \qquad (6.1)$$

timates of 0.235 and −0.449 for ϵ and η, respec-
in Table 37; $Q_1 - Q_0$ is then the additional produc-
at the export prices received by Latin American
964-1974, and totalled \$(US)350m (in 1974 dollars).
mated value of additional production was \$(US)127
(US)100m for the same period made by Jennings

f the costs of rice research in Colombia are explained
on to these estimates which must be emphasized at
o include any costs incurred by the International
the development of IR-8 and IR-22, which occupied
ea sown to HYV's in Colombia. Hence for these
benefits, by allowing their contribution to produc-
ll costs. However, if the measurement of net bene-
andpoint, then it is valid to include only those costs
multiplying and releasing the IRRI materials.

xpenditures by three entities:

f ICA

ers through FEDEARROZ under Ley 101 of 1963,
omento Arrocera. This law authorizes the collec-
rs. All rice buyers are responsible for deducting it

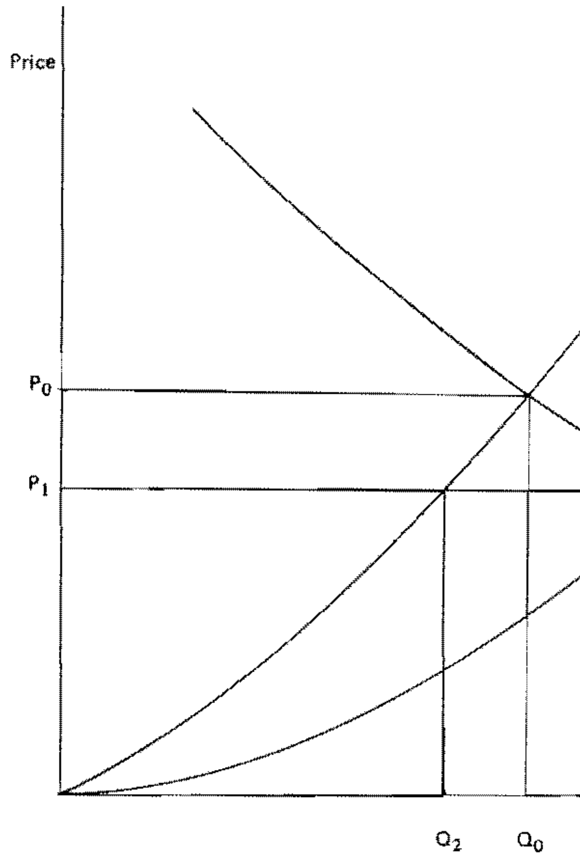


Figure 8. Simplified model showing impact of HYV's on equ

from growers' receipts. The law authorizes FEDE
and it is used for support of research, regional tes
tins, presenting training courses to field agronomi
Division of FEDEARROZ.

3. International Cooperation.*

The data for these three categories, respectively, w

*In including the costs of International Cooperation, we
argument that "only those costs incurred by Colombia" sho
however, that had those externally provided funds not gon
been available to Colombia for investment in other areas wi
have an opportunity cost for Colombia.

1964	600,000	599,019	599,353	421	142	0.06
1965	672,000	666,596	668,433	2,319	110	0.26
1966	680,000	680,000	680,000	0	149	0.00
1967	661,500	642,196	648,759	8,282	142	1.18
1968	786,300	588,623	655,833	84,804	138	11.70
1969	694,500	553,097	601,174	60,662	123	7.46
1970	752,595	533,167	607,773	94,134	94	8.85
1971	904,348	582,236	691,754	138,186	107	14.79
1972	1,043,284	513,888	693,883	227,111	164	37.25
1973	1,175,871	503,263	731,950	288,549	212	61.17
1974	1,569,940	523,563	879,331	448,896	333	149.48

1 Corresponds to OA in Figure 6 or Q_1 in Figure 8 and is from Table 11

2 Corresponds to OE in Figure 6 or Q_2 in Figure 8

3 Corresponds to Q_0 in Figure 8 and given by equation (6.1)

4 Corresponds to $Q_1 - Q_0$ in Figure 8 and converted to milled rice equivalent

1. From Ardila (1973), for 1957-1970, and converting instead of his $(Col.) 1958; for 1971-1974, unpubli by ICA*

2. Based on a constant collection rate of 45 percent (F period 1963-1974

3. Based on Ardila (1973) for the years 1958-1971 an CIAT Controller's Office for 1972-1974.

The costs for each of the three categories are shown interesting to note that the producer contributions (th at a time when new varieties were being released by IC production increases came from the new varieties.

Table 38. **Costs* of rice research program in Colombia 1957-1**

	Source		
Year	ICA	FEDEARROZ	I c
		($m)	
1957	0.03	0.00	
1958	0.11	0.00	
1959	0.20	0.00	
1960	0.31	0.00	
1961	0.69	0.00	
1962	0.62	0.00	
1963	0.28	2.91	
1964	0.61	2.70	
1965	0.79	2.83	
1966	0.82	2.45	
1967	1.33	2.21	
1968	1.49	2.44	
1969	2.67	2.02	
1970	2.78	2.05	
1971	1.69	2.20	
1972	1.58	2.23	
1973	1.38	2.06	
1974	1.31	2.19	

* Expressed in 1964 pesos

*Personal communication, División de Presupuesto y Finan Presupuestal, December 18, 1975.

arch per ton of irrigated paddy rice production in Colombia

Excluding international cooperation	Total
($/m.t.)	
0.14	0.14
0.47	1.64
0.83	1.90
1.18	2.13
2.52	3.08
1.75	1.93
9.28	9.45
0.60	8.76
9.14	9.29
9.58	9.76
9.30	9.45
7.34	7.45
9.89	12.53
8.72	13.37
5.32	11.73
4.32	8.73
3.37	5.98
2.46	4.16

ul view of the trends in investment in rice research,
wing the amount invested per ton of irrigated paddy
demonstrate the intensified program built up with
e 1960's. Recently, there has been a decline in the
ed to rice research per unit of rice output. The data
n per ton of irrigated paddy production show a marked
he intensive period of development of Colombian
total investment per unit output has fallen over the
area sown to new varieties reached saturation. Were
ying resistance to rice blast disease, then one might
ever decline further in the future.

s of return

of net benefits from 1957 to 1974, under each of the
ed. Net benefits were calculated by subtracting the
he corresponding flows of gross benefits (Table 35
net benefits are all negative until 1964, as we have

Table 40. **Costs, net benefits[1] and rates of return to rice research in Colombia for various elasticities of supply and demand (1957-1974).**

Year	Total costs[2]	Net benefits ($m.)					
		$\eta^3 = -0.300$		$\eta = -0.449$		$\eta = -0.754$	
		$\epsilon^4 = 0.235$	$\epsilon = 1.500$	$\epsilon = 0.235$	$\epsilon = 1.500$	$\epsilon = 0.235$	$\epsilon = 1.500$
1957	0.03	–0.03	–0.03	–0.03	–0.03	–0.03	–0.03
1958	0.38	–0.38	–0.38	–0.38	–0.38	–0.38	–0.38
1959	0.46	–0.46	–0.46	–0.46	–0.46	–0.46	–0.46
1960	0.56	–0.56	–0.56	–0.56	–0.56	–0.56	–0.56
1961	0.84	–0.84	–0.84	–0.84	–0.84	–0.84	–0.84
1962	0.68	–0.68	–0.68	–0.68	–0.68	–0.68	–0.68
1963	3.25	–3.25	–3.25	–3.25	–3.25	–3.25	–3.25
1964	3.37	–2.27	–2.87	–2.37	–2.87	–2.37	–2.87
1965	3.68	3.42	0.22	3.32	0.22	3.12	0.12
1966	3.33	–3.33	–3.33	–3.33	–3.33	–3.33	–3.33
1967	3.60	18.10	5.60	17.70	5.20	17.30	4.80
1968	3.99	272.01	260.81	307.61	195.51	263.51	151.31
1969	5.94	203.26	116.66	171.36	84.76	149.06	62.36
1970	7.41	380.59	267.89	295.99	183.09	241.99	129.39

l rice program of ICA since its inception in 1957.
; in research and training during those early years
development and spread of subsequently released

ave grown substantially, reaching almost $4,000m
elasticities. The analysis of the sensitivity of the
mates shows that the value used for the price elas-
y crucial. The two widely disparate values tested
1.5) only made a difference of 10 percent in net
rred demand elasticity (−0.449) was used. The
ges in the demand elasticity. Higher values reduce
umers. An infinitely elastic demand would result
sumers; such is the case for a crop that is totally

cy of the investment in rice research are also shown
f Return is that rate which reduces the present value
ro.* It is a measure of the profitability of the invest-
; in rice reserach. "An internal rate of return of 20
t, on average, each dollar invested returns 20 cents
ted until the cut off date" (Peterson, 1967, p. 664).

the Internal Rate of Return was 94 percent. Given
972, p. 155) that the social opportunity cost of
veen 10 and 11 percent, there is little doubt that
y efficient use of funds.

fit/cost ratio** as an alternative measure of the pro-

e Internal Rate of Return is that rate p which makes

$$\text{nefits})_i \ (1 + \rho)^{-i} = 0$$

han one sign change occurs in the net benefit stream (as
oblem of multiple solutions to this equation (Hirshleifer
streams of Table 40 theoretically have two Internal Rates
uation. However, in this case the perturbation below zero
(by reversing the signs for 1965 and 1966) makes no
Rates of Return shown in Table 40.

e 30-year period 1957-1986. The level of net benefits for
ghout the period 1975-1986. This simply implies that were
continued until 1986, they would continue to generate the
74. In fact, because the above equation involves discount-
e rates of return are all high, the results are very insensitive
future costs and benefits.

resent value of Gross Benefits to the present value of Re-
of 10 percent (Harberger, 1972, p. 155).

fitability of the program. Its value of 77 reinforces th
the social efficiency of this program. Finally, whiche
used and whichever combination of elasticities chose
program, in terms of efficient use of scarce resources
high.*

*These high returns are not uncommon in agricultural res
581) report an internal rate of return of 89 percent for cotto
Hayami (1975, p. 8) report values up to 75 percent for rice i
reports 20 to 30 percent for poultry in the U.S.A.; Barletta (
in Mexico; Griliches (1958) reports 35 percent for corn in th
to 82 percent for rice in Colombia up until 1971; and Monte
for soybeans in Colombia.

RIBUTION OF NET BENEFITS

s the question of the distribution of the net benefits; ply stated, we are asking which groups in society bene- nological change in the Colombian rice industry. In siderable limitations in the available data were encoun- rtant assumptions; these should be borne in mind in for this reason, the procedures are explained in some ved that this is the first study to address the distribu- onal basis, certainly with respect to income levels.

fits and costs by sectors

presented in Table 41, which gives a summary of the search program and the net benefits for various groups oss benefits are based on the benefits shown in Table lasticity estimates. The values in Table 41 are the sum 1964-1974, expressed in $(Col.) m. 1970, compounding and discounting back the years 1971-1974, both using rcent for the real rate of return on capital in Colombia

osts of the research from the three sources (ICA, FE- l Cooperation) from Table 38 were summed and are of the ICA program were assumed to come from gen- between consumers and producers on the basis of urban l tax revenues in 1970 (Jallade, 1974, Tables 3.4 and r contribution was further broken down between rs on the basis of the production coming from each ions from FEDEARROZ were distributed between the assuming a 45 percent collection rate of one centavo per that no contributions were assumed for upland pro-

Table 41. **Size and distribution of benefits and costs* of HYV's in Colombia: (1957-1974).**

Item	Producers			Consumers	Total Colombia	International cooperation
	Upland	Irrigated	Total			
	$m					
Gross benefits	– 3,542.1	– 5,292.9	– 8,835.0	14,939.3	6,104.3	—
Research costs:						
FEDEARROZ	8.4	29.9	38.3	—	38.3	—
ICA	0.7	1.7	2.4	22.1	24.5	—
Total	9.1	31.6	40.7	22.1	62.8	18.8
Net benefits	– 3,551.2	– 5,324.5	– 8,875.7	14,917.2	6,041.5	—

oressed in 1970 pesos, \$(Col.) 81.6 m. were devoted
nd 1974. The contributions were made in the follow-

	%
onsumers:	27
Producers:	50
Irrigated:	39
Upland:	11
ernational:	23
Total:	100

ucers' incomes would have been higher in the absence ge, it is pertinent to inquire why 50 percent of the oducers themselves. Were they simply contributing to nd if so, does this not imply irrational behavior on part at least, with the discussion of the "agricultural n 4.5. Colombian rice production is dominated by ucers (see Section 4.10), who founded and continue ngst these producers are undoubtedly a high porpor- in, at least temporarily, from the rapid adoption of ne extensive network of technical advisors that is an important source of information to members, s but also with respect to a wide range of cultural ARROZ, these growers have rapid access to the latest rice production, and the continually evolving and ogy means that they can repeatedly be amongst the cing technologies. Hence given that there are con- e rapid adoption of both varieties and, equally im- ctices, financial support of FEDEARROZ is not an oducer. The rapid postwar growth of private, grower- ubs in the U.K., Australia and New Zealand, is a

rough tax-financed support of public research) are dominated body politik, which captures the benefits lower wages in the manufacturing sector (as dis-

ts and costs by income level

al impacts of the technological change, the gross bene- ogram and the consequent net benefits were distri- consumers, and upland and irrigated producers. In pact (benefits and costs) for 1970 was estimated. The of the gross benefits or costs expressed in 1970 pesos number of years.

Gross benefits to consumers were assumed to be dir
quantity of rice consumed. The research costs (paid th
sumers were distributed on the basis of the proportion
each income strata in the urban sector. The results, sho
sumers by income level, are shown in Table 42.

The distribution of gross benefits to producers (in t
each size group was calculated by assuming the forego
to total production in each group. The results together
"losses" per farm are shown in Table 43. The costs of
ducers, by size group, are shown in Table 44. The ICA
basis of the proportion of production from each size g
butions were proportional to output. The distribution
has already been discussed. Table 44 also shows the an
Combining the results for gross benefits per farm (Tab
farm (Table 44) gives the distribution of net benefits b

One further step is required in order to estimate the
nefits" in relation to producer income. Ideally, income
upland and irrigated rice producers by size of farm. As
exist, resort was made to a distribution of rural income
(Berry, 1974, p. 610). The income data were inflated t
Index shown in Table 14. We have no basis for knowin
would have higher or lower incomes than the rural ave
However, our principal interest is in the relative distrib
level, rather than in the absolute income levels. Table 4
"net producer benefits" (negative) as a percentage of t
sponding to each size group.

The consumer net benefits shown in Table 42 (last
per household basis, by dividing the number of househ
(Jallande, 1974, p. 22). Both rural and urban househol
sector is also a rice consumer.* The average annual net
(first column, Table 47) were then expressed as a perce
income for each income group (second column, Table

The net benefits to consumers were positive for all
annual average net benefits tend to decline at higher in
peak in the second-to-lowest income group. As a perce
the net benefits accrued most significantly to the lowe
that the technological change in rice favored the lowes
absolutely and relatively. The relative distribution of c
level is shown in Figure 9. In Figure 10, the cumulativ

*This assumes that the rice consumption patterns in the ru
data shown in Table 42.

One study of rural food consumption reports that in a non
of calories and proteins in the average family diet came from
These data are only slightly below the urban figures reported
areas and traditional consuming areas such as the Atlantic Coa
levels of rice consumption.

costs and net benefits to consumers by level of income (1970).

$^{0}/_{0}$ of total taxes paid***	Gross benefits	Research costs	Net benefits
($^{0}/_{0}$)	($m)	($)	($m)
–	4.1	–	4.1
0 02	13.6	245	13.6
0 03	34.0	368	34.0
0.04	51.6	491	51.6
0.10	142.6	1,227	142 6
0.65	182 0	7,980	182 1
0.48	141.2	5,893	141.3
0.35	112.7	4,297	112.7
1.42	88.3	17,434	88.3
1.35	91.0	16,574	91.1
0.78	54.3	9,576	54.3
2.07	48.9	25,414	48.9
3.27	82 8	40,148	82 8
5 28	67.9	64,826	67 9
2.86	29.9	35 114	29.9
3.20	46.2	39,288	46.2
2 02	25.8	24,801	25 8
3.34	44.8	41,007	44.8
8 33	29.9	102,273	29.9
4.50	12 2	55,249	12.2
4.36	17.7	53,531	17 7
55.55	36.6	682,031	35.6
100 00	1,358 1	1,227,777	1,356.9

cuesta de Hogares (household survey)

Table 43. **Distribution of foregone producer income by farm size: upland and irrigated sectors,**

Farm size (ha)		Upland sector		Irrigated sector	
		Distribution of foregone income	Per farm per year	Distribution of foregone income	per farm per year
		($m)	($)	($m)	($)
0 —	1	— 21.0	— 876	— 0.5	— 842
1 —	2	— 72.7	— 1,943	— 7.7	— 1,406
2 —	3	— 95.9	— 3,221	— 6.3	— 1,342
3 —	4	— 93.4	— 4,652	— 7.2	— 2,470
4 —	5	— 88.5	— 5,518	— 12.6	— 3,910
5 —	10	— 287.2	— 6,136	— 42.9	— 4,407
10 —	20	— 361.0	— 7,503	— 110.3	— 7,363
20 —	30	— 215.1	— 7,729	— 91.4	— 9,032
30 —	40	— 171.2	— 8,123	— 99.2	— 11,052

research costs borne by producers by farm size: total and per farm

verage annual earch costs ($)		Average annual total costs per farm ($)		
Irrigated	Total	Upland	Irrigated	Total
527	729	*	3	a
2,633	3,240	*	5	1
2,107	2,916	1	5	1
2,282	3,040	1	9	1
4,213	4,971	1	14	3
14,220	16,546	1	16	3
36,516	81,157	10	27	14
30,371	69,248	15	33	20
32,829	63,769	16	40	23
33,707	61,513	17	47	26
129,384	227,310	21	63	33
330,045	416.343	35	129	83
353,393	434,939	40	332	140
251,396	296,239	118	716	405
262,280	287,912	196	950	707
269,653	291,240	322	1,964	1,421
,755,556	2,261,112	14	137	46

Table 45. **Distribution of annual average net benefits per far**

Farm size (ha)		Upland	Ir
		($)	
0 –	1	– 876	
1 –	2	– 1,943	–
2 –	3	– 3,222	–
3 –	4	– 4,653	–
4 –	5	– 5,519	–
5 –	10	– 6,137	–
10 –	20	– 7,513	–
20 –	30	– 7,744	–
30 –	40	– 8,139	–
40 –	50	– 8,492	–
50 –	100	– 10,413	–
100 –	200	– 17,518	–
200 –	500	– 20,209	–
500 –	1,000	– 59,519	– 1
1,000 –	2,500	– 98,887	– 2
2,500 –	+	– 162,872	– 5
Totals		– 8,915	–

with respect to the cumulative percentage of househol income distribution. In this type of graphical analysis above or below the 45° line show an unequal distribut distance from the line of perfect equality, the greater t tion. The graph can be interpreted as follows: 25 perc point marked on the graph) received 4 percent of the i tured 28 percent of the net benefits due to new rice va marked) is that 50 percent of the households received captured 64 percent of the benefits.

Turning to producers, the group most severely affe income) upland producers. For these producers, the a through lower rice prices (and no compensating techn a high proportion of their assumed 1970 income, to th incomes had been below the rural sector average, this i more pronounced. On the other hand, the foregone in varied more erratically depending on the size group, w producers as a percentage of 1970 income by sector.

*	Av annual net losses as a °/o of 1970 income (°/o)		
	Upland	Irrigated	Total
1,500**	58	56	41
3,647	53	39	37
5,330	60	25	39
6,508	71	38	47
7,406	75	53	52
0,295	60	43	42
5,652	48	47	38
3,934	41	48	35
3,394	35	47	33
3,620	30	45	30
5,904	29	48	31
6,759	26	53	41
5,398	18	79	41
7,513	21	69	47
2,389	19	49	45
0,199	11	36	32

to 1970

Table 47 . **Annual average net benefits to consumers by inc**

Income group* ($)	Av annual net benefits
1. 0 – 6,000	385
2. 6,001 – 12,000	642
3. 12,001 – 18,000	530
4. 18,001 – 24,000	333
5. 24,001 – 30,000	348
6. 30,001 – 36,000	353
7. 36,001 – 48,000	342
8. 48,001 – 60,000	200
9. 60,001 – 72,000	128
10. 72,001 – 84,000	232
11. 84,000 – +	135

* The distribution shown in Table 42 had to be reduced t
no. of households per income group was not available f

falling on the 200-1,000 hectares group. However, t
overstated if irrigated producers had incomes above
income earners. Figure 11 shows the distributional i

In conclusion, the positive benefits of the techno
sumers, with the lowest income households receivin
relatively. The foregone income to producers appea
small upland producers. Even if the average annual c
as benefits to upland producers, the small upland pr
severely affected.

7.4 Foreign trade, technological change and

It has been demonstrated that the net benefits of
tured by Colombian consumers, with a disparate sha
sumers.

net benefits to consumers by level of income.

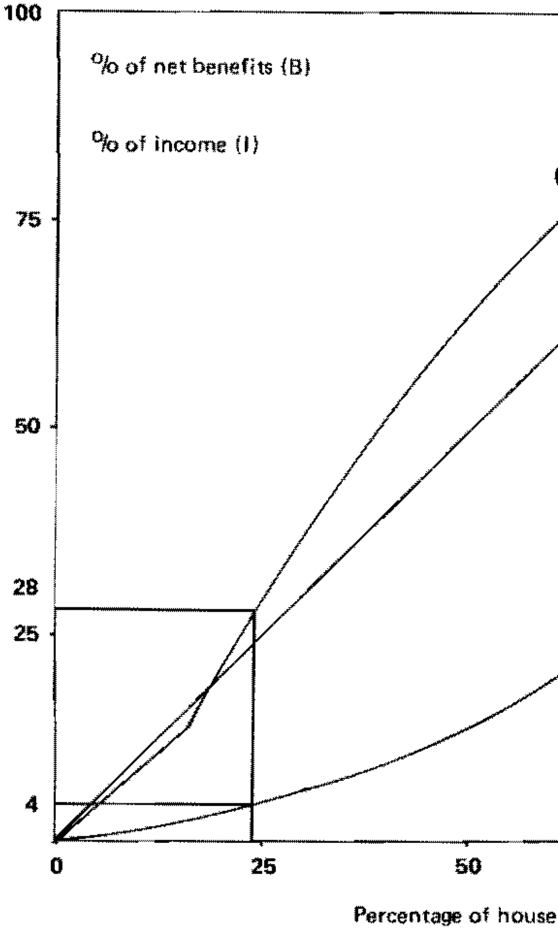
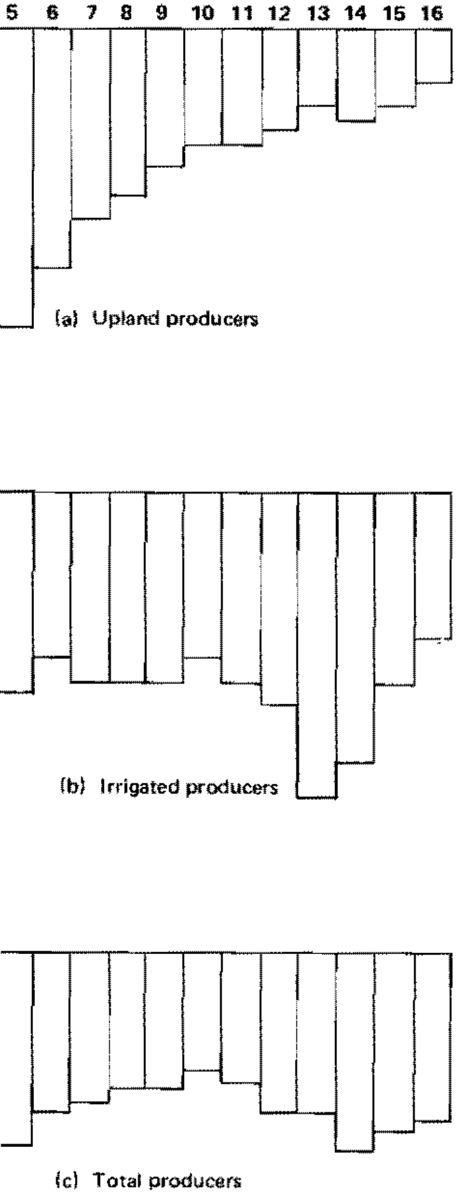


Figure 10. **Distribution of income and net consumer**

The net income of rice producers would have bee
HYV's. It is of interest to inquire why this pattrrn of
result of a deliberate policy to use agricultural resear
income distribution in favor of low-income consume
lar set of economic policies in operation at that time
connected to rice production and consumption? The
in the hope of shedding some light on these question
be of importance to those concerned with the planni

* This result assumes that no imports would have occurred
prices that would have prevailed in the absence of HYV's.



ge net losses to producers by level of income.

and international agricultural research programs, whe
for establishing research priorities.[1] .

The basic premise adopted here is that the distribu
technology in Colombia was principally a result of th
at the national level, not directly related to the rice se
that Colombia's industrial protection policy, through t
ed manufactured goods, has a three-pronged bias agai
cluding, of course, the rice-production sector. In the f
factured inputs used by agriculture are raised. Second
manufacturing are augmented by the tariff barriers, e
resources to flow into the industrial sector. Their avai
by reduced, or alternatively, their prices are inflated,
agricultural sector less competitive. Finally, and most
context, the price of foreign exchange could be maint
plying that agricultural exports are less attractive. Thi
sector has been widely noted. Little et al. (1970, pp.
of manufacturing produces a bias against agriculture,
available for agricultural investment, as well as reduc
and sell, especially as far as exports are concerned. . ..
been excessive; that in several of the countries[3] the ef
has been damaging, and that agricultural exports earn
done in most countries."

It is believed that the Colombian case conforms to
virtually no rice was exported[4] during the period of
(1968-1974) which accompanied the introduction of
this lack of exports was due to the relatively unattrac
potential rice exporters, as a result of the industrial p
be noted that for an eight-month period ending May
ban on rice exports; this could be interpreted as a del
cy.[5]

The set of general economic policies (including ta
price of foreign exchange), together with the particul

---

[1] Ardila and Valderrama (1975) report that the equitabl
employed within ICA for selecting projects. Lopes Neto (197
ed "in the definition of priorities and resource allocation fo

[2] For a model relating the level of industrial protection t
Scobie and Johnson (1974).

[3] Their study includes three Latin American countries: B

[4] Some of the production in 1974 was carried over as sto
recommence exporting rice.

[5] At the same time it should be noted that prior to 1974
45-55 percent against imported rice for consumption, indica
consumer-orientated and a producer-orientated rice policy t
tervention (Leurquin, 1967).

re a product of continually evolving economic and
ften opposed, reflecting the interests of different
typically concerned with presenting cases for
noting exports. On the other hand, manufacturing
and overvalued exchange rates, which have the
cheap domestic food supplies (especially in the
ange in agriculture), hence lowering the price of
ing the price of labor to the manufacturing sec-
) notes, rapid urbanization (together with growth
ncial sectors) has increased the political weight of
ral interests. So that while FEDEARROZ has
s of rice growers since its inception (Leurquin,
won concessions favoring rice producers, its
y national economic strategies promoted by an
rial class whose political power base lies less and
, 1967). The net result of these forces has been
arieties were captured by consumers, as a result of
consistent with, and complementary to, protection

rice of foreign exchange, the expanded production
domestic market. As Harberger (1970, pp. 1007-
ere, of course, is that each new restriction on
change rate relative to the internal price level, thus
ing the export trade." With a moderately inelastic
rices fell, resulting in the capture of the net

comparative advantage that Colombia would have
e favorable exchange rate policy, Table 48 was
foreign exchange which reflects the real value of
mbia has been somewhat arbitrarily taken as 50
ge rates prevailing between 1968 and 1974. This
on very sketchy information. Dudley and Sandi-
40 percent for the period 1963 to 1971*; they
e period 1950-1970, which proposed shadow rates
minal buying rate for dollars. The average tariff pro-
975 was 31 percent (Departamento de Planeación
rally believed to have been substantially reduced

ble 48 is that at a more attractive exchange rate,
compete favorably in external markets with other

ilar value of the level of effective protection given to
ason to assume that effective protection rate measures
r (1972), p.125.

Table 48. **Competitive position of Colombia as a rice exporter (1958-1974).**

Year	Price in Colombia[1] (f.o.b.) (1)	Shadow exchange rate[2] (2)	Price in Colombia (f.o.b.) (3)	Export price of competitors[3] (f.o.b.) (4)	Competitive margin of Colombia[4] (5)	Milled rice exports from Colombia
	($Col)	($Col/$US)	($US)	($US)	(%)	('000 m.t)
1968	3,440	25.43	135	138	+ 2	0
1969	3,153	26.90	117	123	+ 5	24
1970	3,146	28.76	109	94	− 16	5
1971	3,320	31.50	105	107	+ 2	0

ever, starting in 1975, the domestic price of rice has
porting attractive, and it is probable that Colombia
ce exporter. This will mean that future benefits of
tured by producers and foreign consumers, rather
as has been the case.

8. AN ANALYSIS OF THE MARKETIN
RICE IN COLOMBI

8.1 Implications of marketing margins

The role and efficiency of the marketing sector is a raised in the context of developing economies. Freque denounced either as speculators or performing no real ernment agricultural marketing policies are then aimed supposedly avoiding speculation and lowering the pric following analysis is aimed at examining changes in the Colombia and asking to what extent such changes cou result of normal competitive economic forces, rather t competitive structure in the marketing sector, which m intervention.

In Chapter 7, the distribution of benefits to produc lyzed. However, there is an additonal link in the produ not addressed to this point. The production and distrib transport, storage, insurance, milling, packaging, whole refer to the totality of these operations as belonging to sector can be regarded as simply another production st product, **milled rice**, in the hands of the eventual consu truct a model to analyze the producer returns at differ marketing sequence.*** Because of insufficient data o each stage and over time, we will restrict the following of the farm-to-retail marketing margin. We are concerne

*The authors are indebted to Bruce L. Gardner of the P Advisors, Washington, D.C., for his guidance and insights in th

**Indicative of the "anti-intermediary" sentiment is the f of rice cannot use warehouse receipts as collateral for bank lo

***As suggested by Carlson (1969, p. 161) and attempted

troduction of the new varieties. Specifically, we are
enefits of the new farm technology have been cap-
ather than being passed on to the final consumers of

expressed in 1964 pesos) for rice at three levels of
in Table 14. A summary (Table 49) shows that in
e spread has been constant for twenty-five years,
t fall in the absolute price levels at all points in the

ns why one might have expected the real costs of the

total rice crop is now produced nearer the main con-
presumably lowering the total transport costs (see

duced the per unit costs of transport.

in the milling process may have lowered unit costs
drying to machine drying with a consequent reduc-
quin, 1967, p. 259).

e in the proportion of the total crop coming from
uality due to breakages in the grain (Table 10), the
e may have been expected to rise. But if on balance
re expected to fall, then their apparent failure to
ections in the marketing sector.

rice milling

retail marketing margin remained constant, it did
of the introduction of new varieties and the asso-
This rise is especially marked when the margin is
farm price (Table 50), increasing from a record low
rd high in 1973 of 218 percent.

e 50 show the annual changes in the farm-to-retail
average of these changes. The moving average was
nnual changes, in an attempt to reveal any under-
ented in Figure 12, where a striking cyclical pattern

illing sector is proposed as a possible explanation of
. At the troughs of the cycle, installed milling capa-

Table 49. **Real rice prices* and marketing margins for selected periods: Colombia (1950-1974).**

Average de	Real Price			Marketing Margins			Retail farm prices (P_r/P_f)
	Farm (P_f)	Whole-sale	Retail (P_r)	Farm to whole-sale	Wholesale to retail	Farm to retail	
1950-52	1,258	2,888	3,266	1,630	378	2,008	2.60
1957-59	1,394	2,901	3,432	1,507	531	2,038	2.46
1965-67	1,506	[illegible]	3,559	1,590	[illegible]	2,053	2.36

ts in margins being driven up as production increases
incentives to invest in expanded milling, storage and
because of some overcapacity, results in a lowering
othesis, the rising trend in the farm-to-retail margin
nore than a cyclical upswing in the margins, which
er a 22-year period.

data on installed capacity in the milling sector are
investment cycle hypothesis. However, the observa-
with the explanation proposed for the cyclical

acity was reported to be double the production of
on existed among millers to obtain paddy rice
967, p. 34). Data for the years 1964 and 1967 in-
rise between those two years, as the cyclical model
, 1967, p. 257 and FEDEARROZ, unpublished data).
that in 1968 the state of Valle had 15 rice
percent of capacity, although this is partly a local-
ining rice production in the region.

proposed to explain the pattern of changes in
ds in part on the argument that the milling sector
d capacity, approximately every 5 to 6 years. One
rinvestment would be if the investment had to be
is is rejected, however, as rice milling is not subject
in 1964 there were 340 rice mills in the country
3 in 1967 (FEDEARROZ, unpublished data).
s that there is no learning process on the part of the
heir ability to predict the demand for their services
ing in view of the fact that the larger millers them-
also obtain paddy rice by contracts with indepen-
should result in a more predictable throughput of
he explanation of the cycle, it does strongly suggest
varieties was not necessarily accompanied by an
g structure, capturing abnormal profits.

dicted change in the farm-to-retail

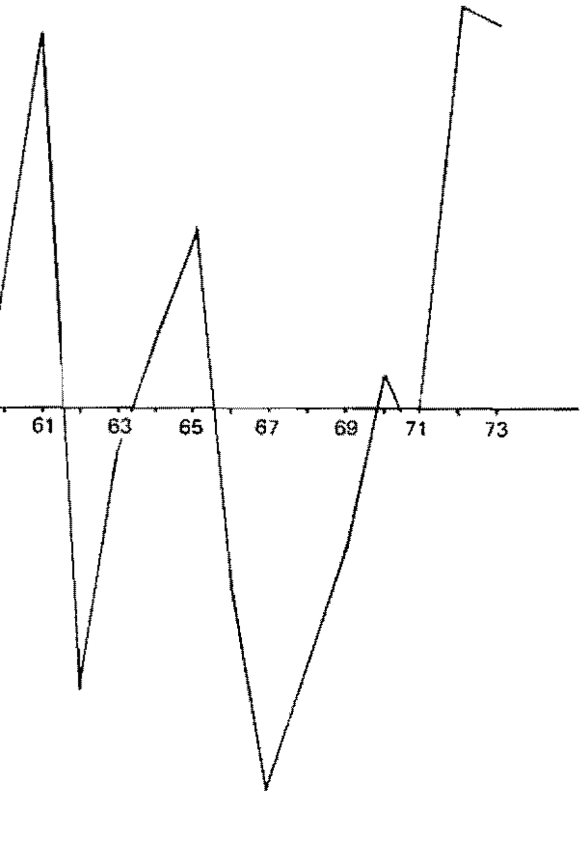
e question: by how much could the farm-to-retail
ange due to the introduction of the HYV's and
f paddy rice?

an analytical framework which allows this question

cites evidence of similar price competition among Louisiana
8) note the existence of excess rice milling capacity in the
razil.

Table 50. **Marketing margins for Colombian rice (1950-1974).**

Year	Farm to wholesale		Wholesale to retail		Farm to retail		Annual change in farm-to-retail margin	Three-year moving av of the annual changes in farm-to-retail margin
	Absolute*	Relative**	Absolute	relative	Absolute	relative		
	($)	(%)	($)	(%)	($)	(%)	($)	($)
1950	2,159	179	151	4	2,310	191	–	–
1951	1,497	103	363	12	1,860	128	–450	–
1952	1,235	111	619	26	1,854	167	–6	54
1953	2,142	182	329	10	2,471	210	617	2
1954	1,519	120	346	12	1,865	147	–606	–1
1955	1,224	105	627	25	1,851	144	–14	–247
1956	1,443	116	339	13	1,728	143	–123	165
1957	1,863	139	496	16	2,359	176	631	69
1958	1,431	97	627	22	2,058	140	–301	–11
1959	1,225	89	471	18	1,696	123	–362	–54
1960	1,784	119	414	13	2,198	147	502	47
1961	1,423	96	775	27	2,198	148	0	151
1962	1,207	88	943	37	2,150	157	–48	–139
1963	1,395	113	386	15	1,781	147	–369	–22



**of the annual changes in the farm-to-retail marketing
973).**

to be addressed. When there is a technical improvemen
function, both the farm price and the retail price can b
in Table 49). But for the marketing sector to produce,
more polished rice will require more of the other inpu
milling machinery, storage and transport services, pack
creased demand for these inputs will raise their prices
supply are not infinite. This will raise the cost of nonf
sector relative to the price of paddy rice, hence increa
the farm price (as shown in the last column of Table 4

Let the marketing sector's production function be:

$$MR = f(PR, O)$$

i.e., the sector produces (and distributes) milled ric
paddy rice purchased from growers (PR) and other ma

The demand by final consumers of milled rice is c
P_r and other factors (population, income, etc.), N, whi

$$MR = D(P_r, N)$$

To these equations are added the supply and demar
inputs PR and O. The milling sector is assumed to dem
ties of PR and O, so that in both cases the value margi
be equated to its price:

$$P_0 = P_r \, f_0$$

$$P_f = P_r \cdot f_{MR}$$

where the physical marginal products are represented b
derivatives of (8.1) with respect to 0 and MR, respecti
paddy rice and other inputs to the milling industry are

$$P_f = F(PR, W)$$

$$P_0 = G(P_0, T)$$

where W and T are shifters of the respective supply cu
relationship of interest is the elasticity (E_W) of the rat
supply curve shifter (W) of paddy rice; i.e.,

$$E_W = \frac{\%\Delta(P_r/P_f)}{\%\Delta W}$$

Based on the competitive model outlined above, Ga
rived the expression for this elasticity, which is given b

$$\overline{\sigma) + \epsilon_{PR}\epsilon_0 + \sigma(S_{PR}\epsilon_{PR} + S_0\epsilon_0)} \quad (8.8)$$

ly of the marketing inputs; viz., paddy rice (PR)

or milled rice

dy rice and other inputs; e.g., S_{PR} = (PR). P_f/
– S_{PR}

tution of paddy rice for other marketing inputs
illed rice

th respect to W; this is set equal to 1 so that E_W
of (P_r/P_f) with respect to a change in W, sufficient
paddy rice by 1 percent.

(8.8) would be inappropriate as it was derived
or milled rice. This assumption is patently violated
extending over an eleven-year period. Ideally, one
, in which shifts in the demand for milled rice are
ated (and analytically simpler) approach is adopted
milled rice can be expected to reduce the market-
supply of paddy rice would tend to widen the

margin with respect to a shift in the demand curve
y:

(8.9)

nd for milled rice with respect to N, and D is the

ange between 1965-1967 and 1972-1974. The ver-
calculated by evaluating the 1972-1974 total supply
for 1965-1967 (see Figure 13). The percentage
s [100(66–1506)]/1506 = -95.6 percent.

ption that the elasticity of supply of paddy rice is less
nputs to the marketing sector (Gardner, 1975, p. 406).

ge of equation (5.13) evaluated for each year from 1972

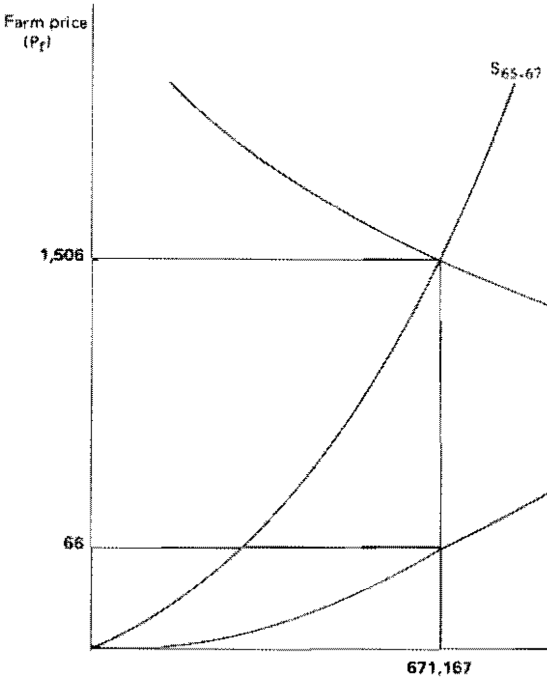


Figure 13. **Vertical shift in the supply curve of paddy rice.**

To estimate the horizontal shift in the demand c
was evaluated at the average retail price in 1972-19
ing percentage change in N evaluated as [100(1,263
percent.

The following values of the parameters were use

$$\eta = -0.449$$

$$\eta_N, \epsilon_W = 1$$

$$\epsilon_{PR} = 0.235$$

$$\epsilon_0 = 0.4$$

To estimate the value share of paddy rice (S_{PR})

$$S_{PR} = \frac{P_f}{P_r} \cdot \frac{PR}{MR}$$

The assumed milling ratio gives:

1 ton (PR) = 0.65 tons (MR)

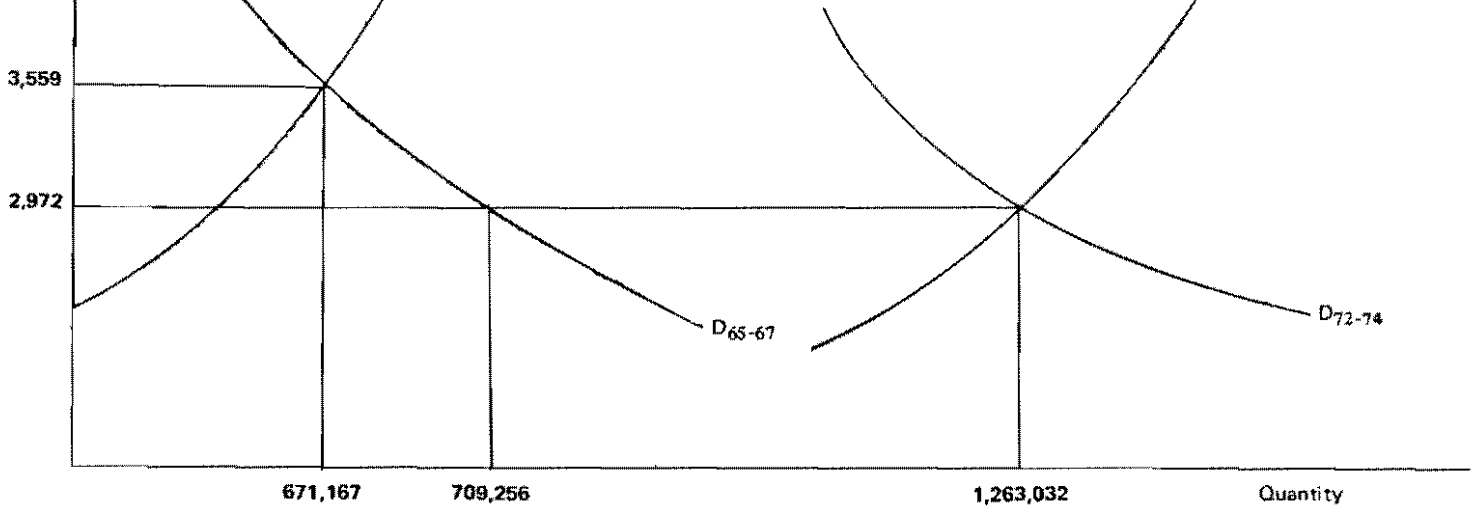


Figure 14. **Horizontal shift in the demand curve for rice.**

or $$\frac{PR}{MR} = 0.65$$

The average ratio of (P_f/P_r) for the two periods
this results in a value for S_{PR} of 0.24 from (8.10).

It is likely that the substitution possibilities betw
in the production of milled rice are limited, imply
(1975, p. 406) suggests a method whereby an appro

$$\sigma \simeq \frac{\%\Delta S_{PR}}{\%\Delta (P_r/P_f)} + 1$$

Using equations (8.10) and (8.11) and superscri
1967 and 1972-1974, respectively,

$$\sigma \simeq \frac{[0.65\,(P_f/P_r)^1 - 0.65\,(P_f/P_r)^0]/0.65\,(P_f/P_r)^0}{[(P_r/P_f)^1 - (P_r/P_f)^0]/(P_r/P_f)^0}$$

This estimate of σ agrees with the intuitive reasonin
would be low. Using these values, E_W and E_N were
respectively.

$$\%\Delta (P_r/P_f)\,|_{dN=0} = E_W\,(\%\Delta W) = (-0.4)\,(96.$$

and

$$\%\Delta (P_r/P_f)\,|_{dW=0} = E_N\,(\%\Delta N) = (-0.33)\,(7$$

giving a total "net" effect of (38-26) or 12 percent;
had behaved in accord with the competitive pricing
tions and had been fully adjusted to the change in
would have expected a 12 percent increase in the m
margin rose from 2.36 to 2.95 (see Table 40), or by
gested in conclusion that this result, rather than nec
ly competitive marketing sector, merely reflects the
outlined above. The normal cyclical pattern of rises
were occurring. The marketing margin widened som
petitive forces following the rapid increase in paddy
of the observed rise being due to the cyclical investr

8.5 Formation of rice prices

In an attempt to partially explain the formation
Bogotá, a model presented by Timmer (1974) was t
built on the following identity:

(8.16)

of rice, respectively

marketing charges, if $\alpha = 1$, then there are no pro-

arges

to equation (8.16), the model can be fitted using
nificantly greater than zero, then there is evidence
, the costs of marketing are independent of the per
of α/c is much less than an expected milling ratio
ice of proportional charges; i.e., costs varying with

imated:

(8.17)

= 25.

rentheses. The estimate of A is significantly great-
the farm price coefficient is 0.69, close to an ex-
e of proportional charges. Hence we conclude that
e rather than proportional, confirmed by the cons-
ble 49. An additional run of equation (8.17) gave a
riable, reflecting the proportion of the crop coming
upport to the hypothesis that there were no abnor-
associated with the introduction of HYV's. In con-
pport the rather widely held contention that an
arketing sector exercised its market power to cap-
e introduction of new rice varieties.

CHAPTER 9

SUMMARY

The principal highlights of this report are:

1. Since 1950 rice production in Latin America ha rate of 3.6 percent, compared with 2.8 percent f

2. Latin America produced 3.6 percent of world ou lombia are the major producers, representing 56 spectively, of Latin American production in 197

3. Until the mid-sixties, yields were constant, but r percent of the increase in production between 1

4. Only the Caribbean is a net importing region wit for half the region's total.

5. In 1970 over 75 percent of Latin American expo gion. Future expansion in exports will likely dep and Africa.

6. In 1974 at least 800,000 hectares (or 12 percent dwarf varieties.

7. In 1974 Latin American output was 14.5 percen been in the absence of HYV's; excluding Brazil, In 1972-1973 Asian production was estimated t to the presence of HYV's.

8. In Colombia the introduction of new varieties c of an expanded program of rice research in ICA boration of CIAT.

rapid and widespread; they now occupy virtually

risen from 1.8tons/ha in 1965 to 4.4tons/ha in

rs federation (FEDEARROZ) has undoubtedly
in output.

irrigated culture gave a comparative advantage to
g upland production. In 1966 upland production
output; in 1975 it was 9 percent.

) as a result of the expanded output. In the period
price was $1,437 per ton. In 1970-1974 it was
ercent. The costs of production per ton fell by
riod.

e to other major foodstuffs; in 1965 1 kg of beans
1974, it purchased 3.47 kg of rice.

s concentrated in large irrigated holdings. In 1970
) percent of the national output came from irrigat-

Colombian diet; in 1972 it was the most important
ent) and the second most important source of pro-

e of HYV's was a highly efficient use of public and
rogram was estimated to have generated an inter-
ent.

rice production between 1964 and 1974 was esti-

than they would have been in the absence of
nsumers were the beneficiaries of the research
d relatively, the greatest net benefits went to the
ifty percent of Colombian households received
ut captured 62 percent of the net benefits from

e received higher prices and had higher incomes in
ties. Small upland producers were the most severe-
they are a minor group (about 6,000 in 1970).

the marketing sector captured abnormal profits
V's.

22. The net benefits were highly skewed toward t
most all the additional output was sold on the

23. Protection given to the manufacturing sector
tain an overvalued exchange rate which has di
ports.

24. The domestic price has now fallen to the poin
ble.

25. If Colombia becomes a consistent rice export
benefits from new rice technology will accrue t
ers rather than to Colombian consumers, as h

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Belize	1	3	3.0	0	1	— 1
Costa Rica	34	53	1.5	0	2	— 2
El Salvador	11	22	2.0	0	0	0
Guatemala	8	8	1.0	0	1	— 1
Honduras	11	17	1.5	0	0	0
Nicaragua	16	23	1.4	2	0	2
Panama	67	85	1.2	0	0	0
CENTRAL AMERICA	149	211	1.4	2	4	— 2
Argentina	47	141	3.0	0	0	0
Bolivia	16	18	1.1	0	8	— 8
Brazil	1,967	3,182	1.6	95	0	95
Chile	23	40	1.7	12	0	12
Colombia	133	291	2.1	0	1	— 1
Ecuador	52	113	2.1	62	0	62
Fr. Guiana	0	0	0	0	1	— 1
Guyana	46	112	2.4	30	0	30
Paraguay	12	19	1.5	0	0	0
Peru	51	207	4.0	0	26	— 26
Surinam	18	50	2.7	4	0	4
Uruguay	12	37	3.0	11	0	11
Venezuela	36	39	1.0	0	28	— 28
SOUTH AMERICA	2,413	4,249	1.7	214	64	150
LATIN AMERICA	2,819	4,865	1.7	244	415	—171

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1951).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	104	177	1.7	1	0	1
Cuba	74	116	1.5	0	291	291
Other Caribbean	88	123	1.3	0	62	— 62
CARIBBEAN	162	239	1.4	0	353	—353
Belize	0	1		0	1	— 1
Costa Rica	28	36	1.3	0	0	0
El Salvador	15	31	2.0	0	2	— 2
Guatemala	9	11	1.2	0	1	— 1
Honduras	11	18	1.6	0	0	0
Nicaragua	19	26	1.3	8	0	8
Panama	66	86	1.3	0	4	— 4
CENTRAL AMERICA	148	211	1.4	8	8	0
Argentina	56	174	3.1	0	0	0
Bolivia	16	18	1.1	0	9	— 9
[illegible]	[illegible]	[illegible]	1.5	[illegible]	0	[illegible]

Costa Rica	29	41	1.4	0	0	0
El Salvador	16	27	1.6	0	0	0
Guatemala	8	10	1.2	0	0	0
Honduras	10	17	1.7	0	0	0
Nicaragua	24	31	1.2	5	0	5
Panama	67	92	1.3	0	3	— 3
CENTRAL AMERICA	155	219	1.4	5	4	1
Argentina	61	194	3.1	2	0	2
Bolivia	15	24	1.6	0	0	0
Brazil	2,072	3,072	1.4	172	0	172
Chile	32	93	2.9	0	4	— 4
Colombia	150	320	2.1	8	0	8
Ecuador	85	126	1.4	57	0	57
Fr. Guiana	0	0	0	0	1	— 1
Guyana	62	194	3.1	28	0	28
Paraguay	7	16	2.2	0	0	0
Peru	66	277	4.1	0	15	— 15
Surinam	20	54	2.7	9	0	9
Uruguay	15	53	3.5	13	0	13
Venezuela	40	49	1.2	0	3	— 3
SOUTH AMERICA	2,625	4,472	1.7	289	23	266
LATIN AMERICA	3,019	5,138	1.7	296	298	— 2

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1953).**

Country	Area	Prod.	Yield	Exports	Imports	**Net exports**
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	94	151	1.6	0	0	0
Cuba	85	180	2.1	0	255	–255
Other Caribbean	93	133	1.4	2	66	– 64
CARIBBEAN	178	313	1.7	2	321	–319
Belize	1	1	1.0	0	1	– 1
Costa Rica	37	48	1.2	0	0	0
El Salvador	14	23	1.6	0	0	0
Guatemala	10	11	1.1	0	0	0
Honduras	11	18	1.6	1	0	1
Nicaragua	34	50	1.4	18	0	18
Panama	79	111	1.4	0	0	0
CENTRAL AMERICA	186	262	1.4	19	1	18
Argentina	73	212	2.9	14	0	14

Costa Rica	34	38	1.1	0	0	0
El Salvador	12	24	2.0	2	7	— 5
Guatemala	8	10	1.2	0	1	— 1
Honduras	10	17	1.7	0	2	— 2
Nicaragua	18	25	1.3	10	0	10
Panama	83	99	1.1	0	0	0
CENTRAL AMERICA	166	214	1.2	12	12	0
Argentina	55	172	3.1	36	0	36
Bolivia	18	29	1.6	0	0	0
Brazil	2,512	3,737	1.4	0	0	0
Chile	30	93	3.1	1	0	1
Colombia	175	294	1.6	0	31	—31
Ecuador	63	154	2.4	20	0	—20
Fr. Guiana	0	0	0	0	1	— 1
Guyana	59	147	2.4	37	0	37
Paraguay	10	18	1.8	0	–	0
Peru	62	249	4.0	21	0	21
Surinam	22	77	3.5	6	0	6
Uruguay	20	68	3.4	28	0	28
Venezuela	62	102	1.6	0	2	— 2
SOUTH AMERICA	3,088	5,140	1.6	148	34	114
LATIN AMERICA	3,564	5,919	1.6	160	290	—130

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1955).**

Country	Area	Prod.	Yield	Exports	Imports	**Net exports**
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	96	210	2.1	0	0	0
Cuba	134	318	2.3	0	108	–108
Other Caribbean	128	150	1.1	0	65	– 65
CARIBE	262	468	1.7	0	173	–173
Belize	1	1	1.0	0	1	– 1
Costa Rica	36	34	0.9	0	6	– 6
El Salvador	10	20	2.0	1	6	– 5
Guatemala	8	9	1.1	0	2	– 2
Honduras	11	18	1.6	0	2	– 2
Nicaragua	19	22	1.1	0	1	– 1
Panama	87	98	1.1	0	0	0
CENTRAL AMERICA	172	202	1.1	1	18	–17
Argentina	54	164	3.0	32	0	32

Belize	1	1	1.0	0	2	— 2
Costa Rica	53	56	1.0	0	0	0
El Salvador	11	19	1.7	1	4	— 3
Guatemala	10	14	1.4	0	0	0
Honduras	4	7	1.7	1	2	— 1
Nicaragua	21	34	1.6	1	0	1
Panama	89	97	1.0		1	— 1
CENTRAL AMERICA	189	228	1.2	3	9	— 6
Argentina	46	149	3.2	5	1	4
Bolivia	28	59	2.1	0	2	— 2
Brazil	2,966	4,795	1.6	0	0	0
Chile	40	109	2.7	0	16	— 16
Colombia	227	450	1.9	0	0	0
Ecuador	76	175	2.3	27	0	27
Fr. Guiana	0	0	0	0	0	0
Guyana	89	197	2.2	65	0	65
Paraguay	15	32	2.1	0	0	0
Peru	87	358	4.1	0	26	— 26
Surinam	30	81	2.7	23	0	23
Uruguay	14	53	3.7	6	0	6
Venezuela	42	72	1.7	0	27	— 27
SOUTH AMERICA	3,660	6,530	1.7	126	72	54
LATIN AMERICA	4,289	7,581	1.7	131	347	–216

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1961).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	146	333	2.2	3	0	3
Cuba	150	213	1.4	0	185	–185
Other Caribbean	132	173	1.3	9	80	– 71
CARIBBEAN	282	386	1.3	9	265	–256
Belize	1	1	1.0	0	1	– 1
Costa Rica	54	61	1.1	0	0	0
El Salvador	9	17	1.8	2	2	0
Guatemala	9	13	1.4	0	0	0
Honduras	4	7	1.7	0	2	– 2
Nicaragua	24	39	1.6	0	6	– 6
Panama	100	110	1.1	0	1	– 1
CENTRAL AMERICA	201	248	1.2	2	12	–10
Argentina	53	182	3.4	10	0	9
Bolivia	30	60	2.0	0	4	– 4
Brazil	3 174	5 513	1.7	151	0	151

Belize	1	1	1.0	0	0	0
Costa Rica	50	62	1.2	0	0	0
El Salvador	11	24	2.1	1	4	— 3
Guatemala	10	16	1.6	0	0	0
Honduras	5	7	1.4	1	1	0
Nicaragua	23	37	1.6	4	3	1
Panama	100	111	1.1	0	4	4
CENTRAL AMERICA	200	258	1.2	5	12	— 7
Argentina	52	178	3.4	38	0	38
Bolivia	30	62	2.0	0	8	— 8
Brazil	3,350	5,443	1.6	44	0	44
Chile	33	84	2.5	25	6	19
Colombia	280	585	2.0	4	3	1
Ecuador	110	209	1.9	5	0	5
Fr. Guiana	0	0	0	0	1	— 1
Guyana	100	203	2.0	80	0	80
Paraguay	16	37	2.3	0	1	— 1
Peru	87	374	4.2	0	1	— 1
Surinam	27	79	2.9	21	0	21
Uruguay	18	61	3.3	25	0	25
Venezuela	69	103	1.4	0	4	— 4
SOUTH AMERICA	4,172	7,418	1.7	242	24	218
LATIN AMERICA	4,802	8,366	1.7	310	283	27

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1963).**

Country	Area	Prod.	Yield	Exports	Imports	**Net exports**
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	135	296	2.1	0	2	— 2
Cuba	85	140	1.6	0	104	—104
Other Caribbean	60	118	1.9	0	83	— 83
CARIBE	145	258	1.7	0	4	—187
Belize	0	0	0	0	4	— 4
Costa Rica	54	64	1.1	0	0	0
El Salvador	9	20	2.2	2	2	0
Guatemala	11	18	1.6	0	0	0
Honduras	4	6	1.5	0	0	0
Nicaragua	21	29	1.3	1	10	— 9
Panama	103	111	1.0	0	4	— 4
CENTRAL AMERICA	202	248	1.2	3	20	—17
Argentina	54	190	3.5	14	0	14
Bolivia	32	65	2.0	0	0	0

Belize				0	2	– 2
Costa Rica	55	70	1.2	0	0	0
El Salvador	15	31	2.0	2	1	1
Guatemala	11	20	1.8	1	–	1
Honduras	6	8	1.3	0	2	– 2
Nicaragua	23	43	1.8	1	9	– 8
Panama	121	128	1.0	0	5	– 5
CENTRAL AMERICA	231	300	1.2	4	19	–15
Argentina	68	268	3.9	6	0	6
Bolivia	28	63	2.2	0	0	0
Brazil	4,182	6,114	1.4	12	0	12
Chile	31	92	2.9	0	13	– 13
Colombia	302	600	1.9	0	0	0
Ecuador	110	164	1.4	11	0	11
Fr. Guiana	0	0	0	0	1	– 1
Guyana	126	244	1.9	79	0	79
Paraguay	16	37	2.3	0	0	0
Peru	82	351	4.2	0	49	– 49
Surinam	30	88	2.9	14	0	14
Uruguay	21	47	2.2	26	0	26
Venezuela	91	166	1.8	0	2	– 2
SOUTH AMERICA	5,087	8,234	1.6	148	65	83
LATIN AMERICA	5,600	9,073	1.6	152	352	–200

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1965).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	153	287	1.8	0	24	– 24
Cuba	38	55	1.4	0	258	–258
Other Caribbean	72	167	2.3	0	85	– 85
CARIBBEAN	110	222	2.0	0	343	–343
Belize	–	–		0	1	– 1
Costa Rica	56	74	1.3	0	5	– 5
El Salvador	13	32	2.4	5	3	2
Guatemala	10	17	1.7	3	0	3
Honduras	8	9	1.1	2	2	0
Nicaragua	25	48	1.9	2	9	– 7
Panamá	133	152	1.1	0	0	0
CENTRAL AMERICA	245	332	1.3	12	20	– 8
Argentina	47	165	3.5	35	0	35
Bolivia	27	42	1.5	0	0	0

Costa Rica	37	50	1.3	0	6	— 6
El Salvador	16	27	1.6	0	4	— 4
Guatemala	8	10	1.2	0	6	— 6
Honduras	12	20	1.6	0	0	0
Nicaragua	25	30	1.2	0	5	— 5
Panama	85	96	1.1	0	1	— 1
CENTRAL AMERICA	184	235	1.2	0	23	—23
Argentina	57	193	3.3	37	0	37
Bolivia	17	27	1.5	0	6	— 6
Brazil	2,525	4,072	1.6	103	0	103
Chile	24	64	2.6	0	0	0
Colombia	190	342	1.8	0	0	
Ecuador	50	126	2.5	12	0	12
Fr. Guiana	0	0	0	0	1	— 1
Guyana	54	134	2.4	42	0	42
Paraguay	10	23	2.3	0	0	0
Peru	60	246	4.1	0	0	0
Surinam	25	71	2.8	15	1	14
Uruguay	9	57	6.3	35	0	35
Venezuela	40	47	1.1	0	0	0
SOUTH AMERICA	3,061	5,402	1.7	244	8	236
LATIN AMERICA	3,651	6,399	1.7	245	228	17

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1957).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	117	240	2.0	6	0	6
Cuba	109	261	2.3	0	191	–191
Other Caribbean	129	75	0.5	0	78	–178
CARIBBEAN	238	336	1.4	0	269	–269
Belize	1	2	2.0	0	1	– 1
Costa Rica	37	34	0.9	0	4	– 4
El Salvador	16	27	1.6	1	1	0
Guatemala	9	11	1.2	0	4	– 4
Honduras	13	21	1.6	0	1	– 1
Nicaragua	24	33	1.3	2	1	1
Panama	89	86	0.9	0	2	– 2
CENTRAL AMERICA	189	214	1.1	3	14	– 11
Argentina	60	217	3.6	24	0	24

El Salvador	13	20	1.5	1	1	0
Guatemala	10	12	1.2	0	3	— 3
Honduras	11	18	1.6	0	3	— 3
Nicaragua	23	33	1.4	1	3	— 2
Panama	95	114	1.2	0	1	— 1
CENTRAL AMERICA	198	256	1.2	2	17	— 15
Argentina	52	162	3.1	37	0	37
Bolivia	13	21	1.6	0	11	— 11
Brazil	2,683	4,101	1.5	52	0	52
Chile	41	83	2.0	0	4	— 4
Colombia	196	380	1.9	0	0	0
Ecuador	84	155	1.8	28	0	28
Fr. Guiana	0	0	0	0	1	— 1
Guyana	74	152	2.0	18	0	18
Paraguay	7	16	2.2	0	0	0
Peru	70	249	3.5	0	45	— 45
Surinam	31	85	2.7	15	2	13
Uruguay	18	49	2.7	9	0	9
Venezuela	12	19	1.5	0	40	— 40
SOUTH AMERICA	3,281	5,472	1.6	159	103	56
LATIN AMERICA	3,841	6,412	1.6	168	397	–229

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1959).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	127	261	2.0	10	0	10
Cuba	168	326	1.9	0	203	–203
Other Caribbean	127	176	1.3	0	77	– 77
CARIBBEAN	295	502	1.7	0	280	–280
Belize	1	1	1.0	0	2	– 2
Costa Rica	58	55	0.9	0	8	– 8
El Salvador	9	19	2.1	1	4	– 3
Guatemala	11	15	1.3	0	1	– 1
Honduras	13	21	1.6	0	1	– 1
Nicaragua	21	32	1.5	2	1	1
Panama	97	119	1.2	0	1	– 1
CENTRAL AMERICA	210	262	1.2	3	18	– 15
Argentina	56	190	3.3	9	3	6

Belize	2	1	0.5	0	1	— 1
Costa Rica	56	82	1.4	0	6	— 6
El Salvador	20	47	2.3	7	6	1
Guatemala	12	18	1.5	0	4	— 4
Honduras	5	5	1.0	0	7	— 7
Nicaragua	24	56	2,3	2	13	11
Panama	131	140	1,0	0	0	0
CENTRAL AMERICA	250	349	1,3	9	37	—28
Argentina	62	217	3.5	46	0	46
Bolivia	28	47	1.6	0	2	— 2
Brazil	4,291	5,050	1.1	278	0	278
Chile	29	89	3.0	0	32	— 32
Colombia	350	680	1.9	0	0	0
Ecuador	100	204	2.0	23	0	23
Fr. Guiana	0	0	0	0	1	— 1
Guyana	125	249	1.9	109	0	109
Paraguay	17	38	2.2	0	0	0
Peru	96	374	3.8	0	58	—58
Surinam	29	98	3.3	20	0	20
Uruguay	32	107	3.3	45	0	45
Venezuela	104	210	2.0	50	4	46
SOUTH AMERICA	5,263	7,363	1.3	571	97	474
LATIN AMERICA	5,826	8,403	1.4	580	369	211

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1967).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	167	430	2.5	0	0	0
Cuba	44	94	2.1	0	31	– 31
Other Caribbean	130	195	1.5	0	101	–101
CARIBBEAN	174	289	1.6	0	132	–132
Belize	2	3	1.5	0	1	– 1
Costa Rica	60	86	1.4	1	6	– 5
El Salvador	28	72	2.5	14	1	13
Guatemala	13	20	1.5	0	2	– 2
Honduras	7	8	1.1	0	7	– 7
Nicaragua	26	64	2.4	0	10	–10
Panama	129	151	1.1	0	0	0
CENTRAL AMERICA	265	404	1.5	15	27	–12
Argentina	71	283	3.9	34	0	34
Bolivia	38	66	1.7	0	0	0
Brazil	4,558	5,600	1.2	32	0	32

El Salvador	27	74	2.7	23	20	3
Guatemala	14	24	1.7	2	3	– 1
Honduras	6	7	1.1	2	7	– 5
Nicaragua	32	67	2.0	2	12	–14
Panama	129	157	1.2	0	0	0
CENTRAL AMERICA	245	387	1.5	30	47	– 17
Argentina	88	345	3.9	41	0	41
Bolivia	35	68	1.9	0	0	0
Brazil	4,553	5,300	1.1	143	0	143
Chile	16	37	2.3	0	14	–14
Colombia	277	786	2;8	0	0	0
Ecuador	60	127	2.1	0	4	– 4
Fr. Guiana	0	0	0	0	0	0
Guyana	127	214	1.6	96	0	96
Paraguay	16	47	2.9	0	0	0
Peru	76	286	3.7	0	29	– 29
Surinam	35	116	3.3	30	0	30
Uruguay	31	104	3.3	19	0	19
Venezuela	115	245	2.1	33	5	28
SOUTH AMERICA	5,429	7,675	1.4	362	52	310
LATIN AMERICA	6,049	8,750	1.4	438	366	72

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1969).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	167	361	2.1	0	5	– 5
Cuba	146	205	1.4	0	155	–155
Other Caribbean	145	244	1;6	0	105	–105
CARIBBEAN	291	449	1.5	0	260	–260
Belize	2	2	1.0	0	0	0
Costa Rica	36	62	1.7	5	0	5
El Salvador	22	33	1.5	12	6	14
Guatemala	14	25	1.7	1	3	2
Honduras	5	6	1.2	0	1	– 1
Nicaragua	39	67	1.7	6	0	6
Panama	126	164	1.3	0	0	0
CENTRAL AMERICA	243	359	1.4	24	10	14
Argentina	102	407	3.9	74	0	74

Costa Rica	36	66	1.8	0	0	0
El Salvador	27	41	1.5	3	0	3
Guatemala	14	26	1.8	2	2	0
Honduras	5	6	1.2	0	0	0
Nicaragua	43	68	1.5	20	0	20
Panama	122	155	1.2	0	0	0
CENTRAL AMERICA	249	365	1.4	25	4	21
Argentina	77	288	3.7	91	0	91
Bolivia	37	62	1.8	0	0	0
Brazil	4,125	6,315	1.5	95	0	95
Chile	26	73	2.8	0	17	– 17
Colombia	233	752	3.2	5	0	5
Ecuador	85	184	2.1	0	1	1
Fr. Guiana	0	0	0	0	1	– 1
Guyana	119	222	1.8	67	0	67
Paraguay	20	58	2.9	0	0	0
Peru	133	601	4.5	0	6	– 6
Surinam	36	120	3.3	20	0	20
Uruguay	37	140	3.7	42	0	42
Venezuela	110	244	2.2	60	5	55
SOUTH AMERICA	5,038	9,059	1.7	380	30	350
LATIN AMERICA	5,766	10,347	1.7	405	296	–109

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1971).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	169	338	2.0	0	1	– 1
Cuba	130	330	2.5	0	284	–284
Other Caribbean	183	312	1.7	0	114	–114
CARIBBEAN	313	642	2.0	0	398	–398
Belize	2	3	1.5	0	2	– 2
Costa Rica	40	74	1.8	0	16	– 16
El Salvador	28	43	1.5	3	4	– 1
Guatemala	14	26	1.8	0	2	– 2
Honduras	7	6		0	3	– 3
Nicaragua	45	72	1.6	8	0	8
Panama	125	165	1.3	0	23	– 23
CENTRAL AMERICA	261	389	1.4	11	50	– 39
Argentina	93	315	3.3	82	0	82
Bolivia	38	77	2.0	0	0	0

Belize	2	4	2.0	0	2	– 2
Costa Rica	32	89	2.7	0	2	– 2
El Salvador	11	36	3.2	0	1	– 1
Guatemala	16	38	2.3	0	2	– 2
Honduras	15	16	1.0	0	5	– 5
Nicaragua	26	74	2.8	5	0	5
Panama	105	125	1.1	0	6	– 6
CENTRAL AMERICA	207	382	1.8	5	18	–13
Argentina	83	294	3.5	8	0	8
Bolivia	46	76	1.6	1	0	1
Brazil	4,821	7,100	1.4	1	9	– 8
Chile	26	86	3.3	0	55	–55
Colombia	273	1,043	3.8	3	0	3
Ecuador	61	171	2.8	0	0	0
Fr. Guiana	0	0	0	33	1	32
Guyana	80	147	1.8	71	0	71
Paraguay	22	39	1.7	0	0	0
Peru	131	552	4.2	0	0	0
Surinam	40	130	3.2	33	0	33
Uruguay	31	128	4.1	45	0	45
Venezuela	65	165	2.5	0	2	– 2
SOUTH AMERICA	5,679	9,931	1.7	195	67	128
LATIN AMERICA	6,368	11,377	1.7	216	480	–264

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1973).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	170	408	2.4	12	38	–26
Cuba	150	375	2.5	0	220	–220
Other Caribbean	146	271	1.8	0	140	–140
CARIBBEAN	296	646	2.1	0	360	–360
Belize	2	4	2.0	0	2	– 2
Costa Rica	32	90	2.8	0	1	– 1
El Salvador	7	26	3.7	0	1	– 1
Guatemala	19	38	2.0	0	2	– 2
Honduras	16	17	1.0	0	5	– 5
Nicaragua	28	81	3.0	0	0	0
Panama	105	162	1,5	0	1	– 1
CENTRAL AMERICA	209	418	2.0	0	12	–12

Belize	2	4	2.0	0	2	− 2
Costa Rica	55	143	2.6	0	0	0
El Salvador	10	34	3.4	0	0	0
Guatemala	21	67	3.1	0	0	0
Honduras	12	23	1.9	0	4	− 4
Nicaragua	27	73	2.7	27	0	27
Panama	115	159	1.3	0	0	0
CENTRAL AMERICA	242	503	2.1	27	6	21
Argentina	94	363	3.8	48	0	48
Bolivia	42	66	1.5	0	0	0
Brazil	5,075	6,510	1.2	20	0	20
Chile	28	62	2.2	0	22	− 22
Colombia	368	1,569	4.2	1	0	1
Ecuador	94	259	2.7	0	10	− 10
Fr. Guiana	0	0	0	0	1	− 1
Guyana	122	226	1.8	71	0	71
Paraguay	20	40	2.0	0	0	0
Peru	115	456	3.9	0	104	−104
Surinam	40	130	3.2	35	0	35
Uruguay	44	175	3.9	73	0	73
Venezuela	120	300	2.5	30	0	30
SOUTH AMERICA	6,112	10,156	1.6	278	137	141
LATIN AMERICA	6,806	11,681	1.7	305	623	−318

APPENDIX TABLE 1 (Cont.) RICE AREA, PRODUCTION, YIELD

Country	Area	Prod.	Yield
	('000 ha)	('000 m.t.)	(tons/ha)
MEXICO	175	435	2.5
Cuba	150	375	2.5
Other Caribbean**	147	323	2.2
CARIBBEAN	297	698	2.4
Belize*			
Costa Rica	55	143	2.6
El Salvador	12	33	2.8
Guatemala	22	64	2.9
Honduras	12	26	2.2
Nicaragua	29	89	3.1
Panama	115	175	1.5
CENTRAL AMERICA	245	530	2.2
Argentina	103	403	3.9
Bolivia	45	76	1.7
Brazil	5,200	6,500	1.3
Chile	24	77	3.2
Colombia	387	1,632	4.2
Ecuador	128	307	2.4
Fr. Guiana			
Guyana	122	305	2.5
Paraguay	20	40	2.0
Peru	117	456	3.9
Surinam	40	130	3.3
Uruguay	45	175	3.9
Venezuela	106	400	3.8
SOUTH AMERICA	6,337	10,500	1.7
LATIN AMERICA	7,054	12,163	1.7

* Not available
** Includes only Dominican Republic, Haiti, Jamaica and Dependenc
NOTE: Production is in '000 m.t. paddy; the trade data are in '00
Zero indicates no values recorded or less than 1,000 m.t.
Sources: 1. USDA: World agricultural situation, WAS. 7, ERS, Ju
2. USDA: The agricultural situation, WAS. 7, of the Wes
3. USDA: Review of world rice markets and major suppl
4. FAO: Production Yearbooks.
5. FAO: Trade Yearbooks.
6. FAO: World rice economy in figures: 1909-1963 Ro
7. All data for 1975 from USDA, Rice Marketing News Vo

State	% of Prod.	State	% of Prod.	State	% of Prod.	State	% of Prod.
Antioquia	88	Atlántico	56	Antioquia	98	Atlántico	100
Bolívar	94	Caldas	61	Bolívar	80	Caldas	92
Boyacá	85	Cauca	75	Boyacá	68	Cauca	98
Córdoba	91	Cundinamarca	86	Córdoba	91	Cesar	98
Meta	79	Huila	100	Nariño	100	Cundinamarca	97
Nariño	100	Magdalena	91	Santander	63	Huila	100
Santander	77	N. de Santander	80	Sucre	93	La Guajira	95
		Tolima	99			Magdalena	95
		Valle	100			Meta	57
						N. de Santander	74
						Tolima	100
						Valle	100

Appendix Table 3. **Distribution of farms and rice area where rice is the principal crop: upland sector* of Colombia, by farm size (1959).**

Farm size (ha)	No. of farms	Area of rice (ha)	Area/ farm (ha)	Percentage of: Upland total area (%)	Percentage of: Total area (%)	Percentage of: Upland farms (%)	Percentage of: Total farms (%)	Cumulative percentage of: Upland area (%)	Cumulative percentage of: Total area (%)	Cumulative percentage of: Upland farms (%)	Cumulative percentage of: Total farms (%)
0 – 0.5	300	145	0.48	**	**	1	**	–	–	–	–
0.5 – 1	1,331	691	0.52	1	**	3	2	1	–	3	2
1 – 2	3,887	2,888	0.74	2	1	9	7	3	1	12	9
2 – 3	3,553	3,811	1.07	3	2	8	7	6	3	20	16
3 – 4	2,792	3,710	1.33	3	2	6	5	9	5	26	21
4 – 5	2,211	3,515	1.59	2	2	5	4	11	7	31	25
5 – 10	6,238	11,410	1.83	8	5	14	12	19	12	45	37
10 – 20	6,227	14,340	2.30	10	6	14	12	29	18	59	49
20 – 30	3,265	8,545	2.62	6	4	7	6	35	22	66	54
30 – 40	2,399	6,803	2.84	5	3	5	5	40	25	71	59
40 – 50	1,876	6,117	3.26	4	3	4	4	44	28	75	63
50 – 100	5,223	21,543	4.12	15	10	11	10	59	38	87	73

0	–	0.5	20	13	0.65	**	**	**	**	–	–	–	–
0.5	–	1	152	49	0.32	**	**	2	**	–	–	2	–
1	–	2	490	355	0.72	**	**	6	1	–	–	8	1
2	–	3	428	402	0.94	**	**	5	1	–	–	13	2
3	–	4	256	245	0.96	**	**	3	1	–	–	16	3
4	–	5	168	284	1.69	**	**	2	1	2	1	18	4
5	–	10	757	1,443	1.91	2	1	10	1	4	2	28	5
10	–	20	942	3,009	3.19	3	1	12	2	7	3	40	7
20	–	30	694	2,714	3.91	3	1	9	1	10	4	49	8
30	–	40	589	2,820	4.79	3	1	7	1	13	5	56	0
40	–	50	401	2,223	5.54	3	1	5	1	16	6	61	10
50	–	100	1,282	9,570	7.46	11	4	17	2	27	10	78	12
100	–	200	899	13,761	15.31	16	6	11	2	43	16	89	14
200	–	500	549	21,639	39.42	25	10	7	1	68	26	96	15
500	–	1,000	164	13,950	85.06	16	6	2	**	84	32	98	15
1,000	–	2,500	67	7,562	112.87	9	3	1	**	93	35	99	15
2,500	+		26	6,039	232.27	7	3	**	**	100	38	100	15
Totals			7,884	86,078	10.92	100	38	100	15	–	–	–	–

* States of Atlántico, Caldas, Cauca, Cundinamarca, Huila, Magdalena, Norte de Santander, Tolima and Valle.
** Less Than 0.5%

Appendix Table 5. **Distribution of farms and rice area where rice is the principal crop: Colombia, by farm size (1959).**

Farm size (ha)		No. of farms	Area of rice (ha)	Area farm (ha)	Percentage of		Cumulative percentage of		Percentage of farms with irrigation (%)
					Total area (%)	Total no. of farms (%)	Total area (%)	Total no. of farms (%)	
0 –	0.5	320	158	0.49	*	1	–	1	6
0.5 –	1	1,483	740	0.50	*	3	–	4	10
1 –	2	4,377	3,243	0.74	1	8	1	12	11
2 –	3	3,981	4,312	1.06	2	7	3	19	11
3 –	4	3,048	3,955	1.30	2	6	5	25	8
4 –	5	2,379	3,799	1.60	2	4	7	29	7
5 –	10	6,995	12,853	1.84	6	13	13	42	11
10 –	20	7,169	17,349	2.42	8	14	21	56	13
20 –	30	3,959	11,259	2.84	5	7	26	63	18
30 –	40	2,988	9,623	3.22	4	6	30	69	20
40 –	50	2,277	8,340	3.66	4	4	34	73	18

(ha)			(no.)	(ha)	farm (ha)	(kg/ ha)	(m.t.)	Farm (%)	Area (%)	**Prod. (%)**	**Farms (%)**	**Prod. (%)**
0	–	2	4,920	3,410	0.69	1,635	5,575	8	1	1	8	1
2	–	5	11,585	13,331	1.15	1,767	23,556	17	6	5	25	6
5	–	10	7,500	12,135	1.62	1,517	18,409	12	5	4	37	10
10	–	20	7,920	14,371	1.81	1,693	24,330	12	6	5	49	15
20	–	60	12,643	34,706	2.74	1,595	55,356	19	14	13	68	28
50	–	200	14,622	75,639	5.17	1,781	134,713	23	31	30	91	58
200	–	500	3,819	41,455	10.85	1,899	78,723	6	17	17	97	75
500	–	2,500	1,926	48,239	25.05	2,367	114,182	3	20	25	100	100
Totals			64,935	243,286	3.75	1,870	454,844	100	100	**100**	—	—

Source: Adapted from Atkinston (1970,p.25)

Appendix Table 7. **Distribution of farms where rice is the principal crop: upland and irrigated regions of Colombia, by farm size (1970).**

Farm size (ha)	No. of farms: Upland sector*	No. of farms: Irrigated sector**	No. of farms: Total no.	% of farms with irrigation (%)	% of total farms (%)	Cumulative % of total farms (%)
0 – 1	1,199	89	1,288	7	5	5
1 – 2	1,872	274	2,146	13	8	13
2 – 3	1,489	235	1,724	14	6	19
3 – 4	1,004	146	1,150	13	4	23
4 – 5	802	161	963	17	4	27
5 – 10	2,341	487	2,828	17	11	38
10 – 20	2,406	749	3,155	24	12	50
20 – 30	1,410	506	1,916	26	7	57
30 – 40	1,054	449	1,503	30	6	63
40 – 50	909	397	1,306	30	5	68
50 – 100	2,609	1,133	3,742	30	14	82
100 – 200	1,367	1,408	2,775	51	11	93

0 –	2	6,180	4,920	3,434	12	8	13
2 –	5	9,180	4,920	3,424	12	17	14
5 –	10	6,995	7,500	2,828	13	12	11
10 –	20	7,169	7,920	3,155	13	12	12
20 –	50	9,224	12,643	4,725	17	19	18
50 –	200	10,639	14,622	6,517	20	23	24
200 –	500	2,464	3,819	1,706	5	6	6
500 –	2,500	1,010	1,926	626	2	3	2
2,500 +		194	—	113	**	–	**
Totals		53,283	64,935	26,941	100	100	100

* For 1959 and 1970, the data relate to farms where rice is the principal crop; for 1966 to all farms producing rice.

** Less than 0.5%

Appendix Table 9. **Distribution of Colombian rice farms and area (1966) and estimated values for 1970.**

Farm size (ha)	No. of farms		Area of rice (ha)		Percentage of			
					Farms (%)		Area (%)	
	1966	1970	1966	1970	1966	1970	1966	1970
0 – 2	4,920	6,242	3,410	3,401	8	13	1	2
2 – 5	11,585	6,975	13,331	10,048	17	14	6	4
5 – 10	7,500	5,140	**12,135**	10,729	12	11	5	5
10 – 20	7,920	5,736	14,371	14,678	12	12	6	6
20 – 50	12,643	8,588	34,706	24,656	19	18	14	11
50 – 200	14,622	11,848	75,639	64,214	23	24	31	27

5 – 10	6,238	2,341	14	12	757	487	10	7
10 – 20	6,227	2,406	14	12	942	749	12	11
20 – 30	3,265	1,410	7	7	694	506	9	7
30 – 40	2,399	1,054	5	6	589	449	7	7
40 – 50	1,876	909	4	5	401	397	5	6
50 – 100	5,223	2,609	11	13	1,282	1,133	17	16
100 – 200	3,235	1,367	7	7	899	1,408	11	20
200 – 500	1,915	1,120	4	6	549	586	7	8
500 – 1,000	528	209	1	1	164	193	2	3
1,000 – 2,500	251	72	1	*	67	152	1	2
2,500 +	168	37	*	*	26	76	*	1
Totals	45,399	19,900	100	100	7,884	7,041	100	100

* Less than 0.5%

Appendix Table 11. **Yields of rice in irrigation districts of INCORA* by variety (1970-1974).**

Variety	1970**	1971	1972	1973	1974	**Annual av**
	(m.t./ha)					
Starbonnet	—	5.9	5.4	—	—	5.7
Bluebonnet-50	4.6	3.5	5.0	—	—	4.4
Bluebelle	5.0	4.8	—	—	—	4.9
Group av	4.8	4.8	5.2	—	—	5.0
Surinam	6.2	—	—	—	—	6.2
Tapuripa	7.0	6.5	5.4	—	—	6.3
Monteria	—	5.7	6.2	—	—	6.0
Tencali	5.2	—	—	—	—	5.2

1968	196,977	1,668	328,558	696,732	368,174	4,221	87,224	126,925	39,701
1969	201,656	1,637	330,111	742,968	412,857	4,092	100,894	115,890	14,996
1970	206,037	1,637	337,282	792,272	454,990	4,945	92,010	112,100	20,090
1971	209,822	1,590	333,617	844,847	511,230	5,061	101,014	144,380	43,366
1972	213,905	1,555	332,622	900,911	568,289	5,174	109,836	170,620	60,784
1973	217,392	1,556	338,262	960,695	622,433	5,318	117,043	192,020	74,977
1974	220,581	1,570	346,312	1,024,447	678,134	5,200	130,410	272,950	142,540

* From Figure 7
** From Table 11

Appendix Table 13. **Estimates of the additional irrigated area sown due to the presence of HYV's: Colombia (1968-1974); assumption (B).**

Year	Upland sector: Area in absence of HYV's (B) (ha)	Upland sector: Yield* (kg/ha)	Upland sector: Prod. (m.t.)	National demand (m.t.)	Irrigated sector: Prod. needed (m.t.)	Irrigated sector: Yield* (kg/ha)	Irrigated sector: Area (ha) Required $(A_{N,t})$	Irrigated sector: Area (ha) Actual $(A_{I,t})$	Irrigated sector: Area (ha) Additional $(A_{A,t})$
1968	130,925	1,668	218,383	696,732	478,349	4,221	113,326	126,925	13,599
1969	130,925	1,637	214,324	742,968	528,644	4,092	129,190	115,890	0
1970	130,925	1,637	214,324	792,272	577,948	4,945	116,875	112,100	0
1971	130,925	1,590	208,171	844,847	626,676	5,061	[illegible]	[illegible]	[illegible]

Algeria			0.4	FAO (1971)
Angola			1.0	FAO (1971)
Argentina	0.4	–0.3		USDA (1971)
Argentina			0.1	FAO (1971)
Argentina		–0.435	0.536	de Janvry et al. (1972)
Asia and Far East			0.3	FAO (1971)
Australia			0.0	FAO (1971)
Australia and New Zealand	0.3	–0.3		USDA (1971)
Austria			0.3	FAO (1971)
Bangladesh	0.13 (SR)[1] 0.19 (LR)[2]	–0.1805		Cummings (1974)
Belgium Luxemburg			0.2	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity: Supply	Price elasticity: Demand	Income elasticity		Source
Bolivia			0.5		FAO (1971)
Brazil			0.2		FAO (1971)
Brazil			Rural	Urban	
Northeast			0.53	0.53	Getulio Vargas Foundation (1968)
East			0.30	0.19	
South			0.21	0.14	
Total			0.33	0.21	
Brazil	0.31 (SR)				Pastore (1971a)
	1.17 (LR)				
Brazil	0.31 (SR)	–0.10			Pariago (1969)

Burundi			0.8	FAO (1971)
Cameroon			1.2	FAO (1971)
Canada		–0.3		USDA (1971)
Canada			0.2	FAO (1971)
Caribbean			0.29	FAO (1971)
Central Africa			0.75	FAO (1971)
Central Africa Rep.			1.3	FAO (1971)
Central America			0.27	FAO (1971)
Central America and Mexico	0.4	–0.5		USDA (1971)
Ceylon			0.4	FAO (1971)
Chad			1.1	FAO (1971)
Chile			0.4 (H)	Universidad Católica (1969)
China (P.R.)			0.4	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Colombia			0.5	FAO (1971)
Colombia		–0.754	0.982	Cruz de Schlesinger and Ruiz (1967)
Colombia	0.235	–1.372		Gutiérrez and Hertford (1974)
Colombia			0.6	ECLA (1969)
Colombia (Cali)			0.48 (L)[3] 0.27 (M)[4] 0.04 (H)[5]	Molta (1969)
Colombia (Cali)		–0.426 (VL)[6]	0.41 (VL)	P. Pinstrup-Andersen

Dahomey			1.2	FAO (1971)
Denmark			0.3	FAO (1971)
Dominican Republic			0.6	FAO (1971)
El Salvador			0.5	Battelle Mem. Inst. (1969)
El Salvador			0.6	FAO (1971)
Ecuador			0.5	FAO (1971)
Ethiopia			0.6	FAO (1971)
Eastern S. Am.	0.4	–0.3		USDA (1971)
East Africa	0.2	–0.3		USDA (1971)
East Africa			0.17	FAO (1971)
East Asia and Pacific	0.3	–0.3		USDA (1971)
Eastern Europe	0.3	–0.3		USDA (1971)
Eastern Europe			0.18	FAO (1971)
EEC	0.3	–0.3		USDA (1971)
EEC			0.11	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Finland			0.0	
France		−0.1		Centre de Recherches (1967)
France			0.2	FAO (1971)
Gabon			1.2	FAO (1971)
Gambia			0.2	FAO (1971)
Germany (D.R.)			0.1	FAO (1971)
Germany (West)			0.3	FAO (1971)
Ghana			0.8	FAO (1971)
Greece			0.3	FAO (1971)
Guatemala			0.6	FAO (1971)
Guinea			0.4	FAO (1971)

Israel			0.1	FAO (1971)
Italy		–0.2		FAO (1965)
Italy			0.0	FAO (1971)
Ivory Coast			0.5	FAO (1971)
Jamaica			0.4	FAO (1971)
Japan	0.4	–0.3		USDA (1971)
Japan	0.2	–0.2		Akino and Hayami (1975)
Japan			0.1	FAO (1971)
Japan	0.007 (SR)			Arromdee (1968)
	0.03 (LR)	–0.3	0.16	
Jordan			0.6	FAO (1971)
Kenya			0.7	FAO (1971)
Khmer Rep.			0.4	FAO (1971)
Korea (North)			0.4	FAO (1971)
Korea (Rep.)			0.3	FAO (1971)
Latin America			0.25	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Laos			0.4	FAO (1971)
Liberia			0.1	FAO (1971)
Libia			0.8	FAO (1971)
Lebanon			0.3	FAO (1971)
Madagascar			0.4	FAO (1971)
Malaysia			0.19	FAO (1917)
Malaysia	0.5	−0.3		Chew (1971)
Malawai			1.2	FAO (1971)
Mali			0.5	FAO (1971)
Malta			0.3	FAO (1971)

New Zealand			0.1	FAO (1971)
Nicaragua			0.4	FAO (1971)
Niger			1.0	FAO (1971)
Nigeria			0.9	FAO (1971)
North Africa	0.3	–0.5		USDA (1971)
Norway			0.4	FAO (1971)
Oceania			0.01	FAO (1971)
Other Western	0.3	–0.3		USDA (1971)
Europe			0.24	FAO (1971)
Pakistan		–0.529		Basit (1971)
Pakistan			0.3	FAO (1971)
Pakistan (Punjab)	0.31			Hussain (1964)
Panama			0.2	FAO (1971)
Paraguay			0.3	FAO (1971)
Peru	0.5	–0.1	1.40	Merrill(1967)
Peru			0.3	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Peru			0.3	Van de Wetering and Cureo (1966)
Peru			0.21 (U)	Universidad Agraria (1969)
			0.46 (R)	
			0.27 (AV)	
Philippines	0.09	–0.23		Barker (1966)
Philippines		–0.5	0.4	Mears and Barker (1966)
Philippines		–0.3		Nasol (1971)
Philippines	0.3 (SR)			Mangahas et al. (1966)
	0.5 (LR)		0.2	FAO (1971)
[illegible]			[illegible]	[illegible]

South Africa	0.1	–0.3		USDA (1971)
South Africa			0.5	FAO (1971)
South America				
South Asia	0.3	–0.3		USDA (1971)
South Asia				
Southeast Asia	0.3	–0.1		USDA (1971)
Spain			0.1	FAO (1971)
Sudan			1.2	FAO (1971)
Surinam				
Sweden			0.0	FAO (1971)
Switzerland			0.1	FAO (1971)
Taiwan			0.3	FAO (1971)
Tanzania			0.5	FAO (1971)
Thailand	0.5	–0.65	0.2	Arromdee (1968)
Thailand	0.18 (SR)			Behrman (1968)
	0.31 (LR)			

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Thailand			0.2	FAO (1971)
Togo			0.8	FAO (1971)
Trinidad Tobago			0.1	FAO (1971)
Tunisia			0.4	FAO (1971)
Turkey			0.4	FAO (1971)
Uganda			1.0	FAO (1971)
Upper Volta			0.9	FAO (1971)
United Arab. Rep.			0.3	FAO (1971)
United Kingdom		–0.4		USDA (1971)
United Kingdom			0.0	FAO (1971)
USA	0.2	–0.2		USDA (1971)

		–0.21 (U-N)	0.11 (U-H)	
			0.3	FAO (1971)
Vietnam (North)			0.5	FAO (1971)
			0.5	FAO (1971)
Vietnam (Rep.)			0.4	FAO (1971)
West Africa	0.1	–0.4		USDA (1971)
West Africa			0.67	FAO (1971)
West Asia	0.25	–0.3		USDA (1971)
West Malaysia	0.23 (SR)	–0.35	0.4	Arromdee (1968)
	1.35 (LR)			
			0.2	FAO (1971)
Western Europe			0.16	FAO (1971)
World			0.23	FAO (1971)
Western Am.	0.3	–0.3		FAO (1971)
Yemen (P.D.R.)			0.7	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Yemen (Arab Rep.)			1.0	FAO (1971)
Yugoslavia			0.2	FAO (1971)
Zambia			1.0	FAO (1971)

1 Short run

1966	0.118	0.32	0.750	2.043
1967	0.118	0.32	0.750	2.043
1968	0.116	0.279	0.748	1.778
1969	0.116	0.279	0.748	1.778
1970	0.116	0.279	0.748	1.778
1971	0.116	0.279	0.748	1.779
1972	0.115	0.253	0.750	1.612
1973	0.115	0.253	0.750	1.612

* Each set of supply elasticities was run with three demand elasticities (- 0.3. -0.449 and -0.754) to give six sets of results.

Appendix Table 16. **Gross benefits* to consumers and producers of new rice varieties in Colombia (η = -0.300 and ϵ = 0.235).**

Year	Consumer gains	Foregone income to producers: Upland	Irrigated	Total	Total gross benefits
	($m)				
1964	4.6	-1.6	-1.9	-3.5	1.1
1965	29.3	-12.0	-10.2	-22.2	7.1
1966	0.0	0.0	0.0	0.0	0.0
1967	95.9	-41.3	-32.9	-74.2	21.7
1968	1,450.9	-339.3	-534.6	-1,073.9	377.0
1969	847.5	304.9	333.4	638.3	209.2

1965	29.2	-12.0	-13.3	-25.3	3.9
1966	0.0	0.0	0.0	0.0	0.0
1967	95.9	-41.3	-45.4	-86.7	9.2
1968	1,450.9	-539.3	-646.8	-1,186.1	264.8
1969	847.6	-304.9	-420.1	-725.0	122.6
1970	1,488.9	-479.0	-734.6	-1,213.6	275.3
1971	2,419.9	-605.7	-1,319.3	-1,925.0	494.9
1972	5,617.8	-1,376.2	-2,900.0	-4,276.2	1,341.6
1973	10,257.5	-2,410.4	-5,137.2	-7,547.6	2,709.9
1974	30,886.3	-6,531.8	-15,721.8	-22,253.6	8,632.7

Appendix Table 16 (Cont.). **Gross benefits to consumers and producers of new rice varieties in Colombia ($\eta = -0.449$ and $\epsilon_t = 1.500$).**

Year	Consumer gains	Foregone income to producers			Total gross benefits
		Upland	Irrigated	Total	
	($m)				
1964	3.0	-1.1	-1.4	-2.5	0.5
1965	19.5	-8.0	-7.6	-15.6	3.9
1966	0.0	0.0	0.0	0.0	0.0
1967	63.0	-27.1	-27.1	-54.2	8.8
1968	823.6	-304.0	-320.1	-624.1	199.5
1969	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1965	11.6	-4.7	-0.1	-4.8	6.8
1966	0.0	0.0	0.0	0.0	0.0
1967	37.0	-15.9	-0.2	-16.1	20.9
1968	431.9	-158.6	-5.8	-164.4	267.5
1969	265.2	-94.6	-15.6	-110.2	155.0
1970	408.3	-128.8	-30.1	-158.9	249.4
1971	593.0	-143.9	-80.8	-224.7	368.3
1972	984.6	-223.4	-131.3	-354.7	629.9
1973	1,491.2	-315.1	-172.4	-487.3	1,003.7
1974	3,164.8	-567.4	-417.9	-985.3	2,179.5

Appendix Table 16 (Cont.). **Gross benefits to consumers and producers of new rice varieties in Colombia (η = -0.754 and ϵ_t = 1.500).**

Year	Consumer gains	Foregone income to producers			Total gross benefits
		Upland	Irrigated	Total	
	($m)				
1964	1.8	-0.7	-0.6	-1.3	0.5
1965	11.6	-4.8	-3.0	-7.8	3.8
1966	0.0	0.0	0.0	0.0	0.0
1967	37.0	-15.9	-12.7	-28.6	8.4
1968	431.9	-158.6	-118.0	-276.6	155.3
1969	265.2	-94.6	-102.3	-196.9	68.3

GLOSSARY

:ional de Agricultura Tropical

Administrativo Nacional de Estadística

nission for Latin America

ional de Arroceros

biano Agropecuario

rcadeo Agropecuario

biano de Reforma Agraria

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