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	Perú	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.**

Ranking	Importers						Exporters					
	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).

	Exported by						
Importers	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 befôre 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.

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*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."

Table 7. **Estimated areas planted with HYV's in Latin America* (1974).**

Country	Area (ha)	Source
Mexico	108,420	CIAT survey, 1975
Cuba	145,600	Dalrymple, 1976
Dominican Republic	10,000	Dalrymple, 1974
MEXICO AND CARIBBEAN	264,020	
Guatemala	2,200	CIAT survey, 1975
El Salvador	11,130	CIAT survey, 1975
Nicaragua	20,700	Dalrymple, 1976
Costa Rica	64,173	CIAT survey, 1975
Panama	5,100	CIAT survey, 1975
CENTRAL AMERICA	165,303	
Colombia	270,221	
Surinam	38,237	CIAT survey, 1973
Venezuela	40,000	Dalrymple, 1974
Ecuador	61,900	Dalrymple, 1976
Peru	28,130	CIAT survey, 1975
SOUTH AMERICA	438,488	
LATIN AMERICA	807,811	

* Includes only those countries for which data was obtainable. It is understood that no HYV's are grown in Guyana or Chile.

in line 10 of Table 8 may reflect the fact that they have been sown on superior land with higher levels of complementary inputs. Of course, in the absence of improved genetic potential, the use of superior land and higher input levels may not have been justified. Finally, the estimates of the percentage contribution of HYV's (Table 8) is probably conservative. The total regional areas and outputs have been included in Table 8, but only the HYV area for the reporting countries is included. Provided the nonreporting countries have similar yield margins, then the additional production due to HYV's would be greater, 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	3.867
10. Yield margin (tons/ha)	0.825	1.349	2.365	2.125	1.827
11. Additional prod. ('000 m.t.)	217.8	142.0	1,037.1	574.2	1,475.9
12. Additional prod. (%)	27.1	43.0	39.7	67.9	40.3

Derivations:

5 = 1 - 4
6 = Average yield 1950-1964
7 = 5 · 6
8 = 2 - 7

10 = 9 - 6
11 = 10 · 4
12 = 11/2 - 11 · 100

4. RICE IN COLOMBIA: SOME ECONOMIC ASPECTS

4.1 Background

Rice has been grown in Colombia for almost 400 years and today is one of the nation's major agricultural products. Outside of Asia, Colombia ranked fifth in world rice output in 1975; including Asia, it ranked twentieth (U.S. Department of Agriculture, 1976, p. 4). In 1972 rice was the single most important source of calories in the urban Colombian diet, providing 13.6 percent of the calorific intake, or 286 calories per person per day. In addition, it was the second most important source of protein (after beef), providing 12.7 percent of the protein intake, or 6.3 g per person per day (Departamento Nacional de Planeación, 1974).

No attempt is made in this report to trace the total development of the Colombian rice industry; the existing literature contains a wealth of information. Historical aspects have been documented by Jennings (1961), the technical aspects by Rosero (1974), field problems by Cheaney and Jennings (1975), economic and institutional development until 1965 by Leurquin (1967), and finally a broad range of information is given in a mammoth study by López (1966). The present report cannot possibly do justice to all the detailed material documented in these references, and the interested reader is urged to consult them.

4.2 Research*

The Colombian rice research program began in 1957, with a national rice program within the Agricultural Ministry and the cooperation of the Rockefeller Foundation.

At that time, the tall U.S. variety Bluebonnet-50 was extensively grown; but in 1957 it was attacked by a virus disease, "hoja blanca," causing extensive losses. The research program was initiated with a primary objective of selection for resistance

*For a more complete discussion, see Hertford (1976) and Rosero (1974).

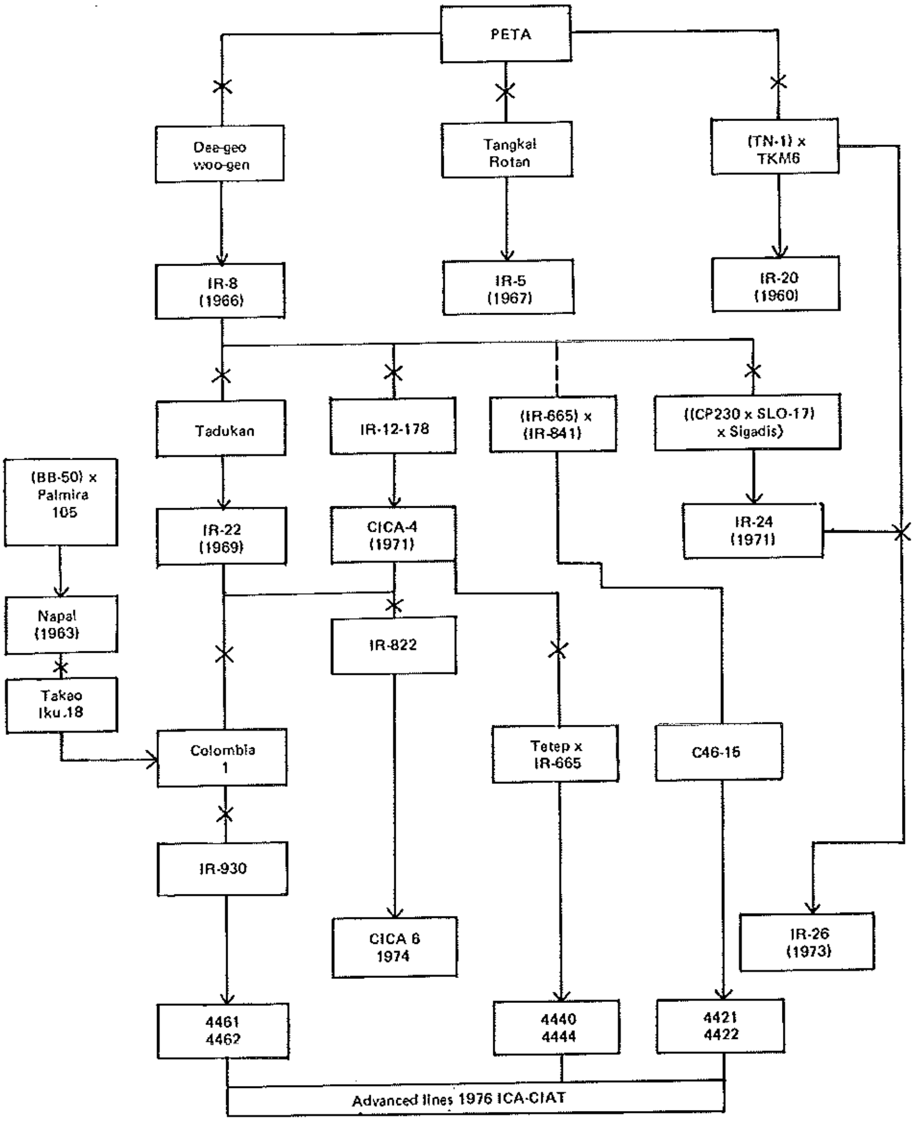

Figure 1. A simplified genealogy of IRRI and ICA-CIAT rice varieties.

to this virus. Meanwhile, in 1961, another U.S. variety showing some resistance (Gulfrose) was released.

By 1963 the program had selected Napal for release (see Figure 1), a cross between the long-grain Bluebonnet-50 and a selection (Palmira 105) for resistance. Napal's life was short due to its susceptibility to rice blast disease in an attack in 1965. Tapuripa, a Surinamese variety with partial resistance, was released in 1965.

In 1967 the newly formed Rice Program of CIAT joined in a collaborative effort with the Colombian program, and dwarf lines from IRRI were introduced into the breeding program. In 1968 IR-8 was released, which was resistant to hoja blanca, although of inferior grain quality. IR-22 was recommended in 1970. Two additional releases, ICA-3 and ICA-10, were never widely grown due to their lower yields compared with IR-8 and IR-22.

In 1971, the joint ICA-CIAT program released their first variety, CICA-4, which was more disease resistant and had better grain quality. This variety was followed by CICA-6 in 1974, and at present six advanced lines* (see Figure 1) are undergoing final testing prior to the naming and release of a further variety. In the regional tests conducted by ICA at 21 sites throughout Colombia in the first semester of 1975, these six lines yielded 6.9 tons/ha, compared with 5.8 tons/ha for the dwarf varieties presently used commercially. The principal problem facing the breeding program is that of blast resistance. The fungus readily adapts; and one or two years after planting, varieties resistant at the time of release become susceptible. The present strategy is to release a new variety every one or two years; a longer term strategy is the incorporation of stable resistance; multiline varieties incorporating a number of sources of resistance are a further possibility.

Table 9 summarizes some important characteristics of the varieties, and Table 10 presents the varietal distribution in Colombia based on the seed sales of FEDEARROZ, which sells over half the certified seed. The introduction of the dwarfs has been rapid and spectacular, virtually replacing the previously predominant Bluebonnet-50. Two additional points should be made: first, much of the new material has been directly transferred technology rather than locally developed; the remainder (Napal and CICA-4) was adapted locally, based on imported lines. This serves to underline the importance of international technology transfer, combined with strong national programs for adaptation and diffusion (Evenson, 1976). Second, Colombian rice producers had had a long experience with varietal changes; the introduction of dwarfs therefore presented no unusual problems of adoption, an aspect generally attracting much attention in the development and introduction of new agricultural technology. The rapid and widespread adoption of dwarf rices was, of course, largely due to their yield superiority, responsiveness to higher input levels and improved resistance, especially to hoja blanca.

Any discussion of Colombian rice research and the use of new varieties would be incomplete without references to the role of FEDEARROZ. With its strong network

*For details of the performance of 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			Others (%)
					IR-8 (%)	IR-22 (%)	CICA-4 (%)	
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
1970	36	—	26	—	29	—	—	9
1971	35	—	14	—	37	3	4	7
1972	12	—	—	—	27	30	30	1
1973	2	—	—	—	41	39	18	0
1974	1	—	—	—	31	33	27	8

Source: **FEDEARROZ (1973 and 1975)**

Table 10. **Characteristics of the principal rice varieties.**

Variety	Type[1]	Resistance[2] to			Quality			
		Blast	Hoja blanca	Sheath blight	Milling[3]	Cooking[4]	Grain appearance[5]	Grain length
Bluebonnet-50	Tall	S	S	S	EX	EX	EX	Long
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, publication of technical bulletins, data gathering services and collaboration with the National Rice Program of ICA in regional testing, FEDEARROZ has been an important factor in the development of the Colombian rice industry.

4.3 Production and disappearance

The basic data on area, production and yields for the irrigated and upland sectors are given in Table 11. Colombia produces rice under three systems (Leurquin, 1967, n. 1, p. 221):

1. In leveed fields with controlled water supply (the majority)

2. Swamp rice planted on river banks and "irrigated" by floods

3. Upland rice which depends on rainfall.

The classification used by FEDEARROZ (and throughout this study) is irrigated (the first category, together with that part of the third category that is mechanized),), and upland (the remainder).

The upland sector is now relatively unimportant; while in 1966, 50 percent of the production came from this sector, it produced only 9 percent in 1975. This swing has in part been due to the introduction of new varieties. In fact, in 1967 when the first impact on yields was felt, the upland area started a steady decline. New varieties suited to irrigated culture gave a comparative advantage to the irrigated sector and upland production with its static yields commenced to decline.

In the irrigated sector, where yields had averaged 3.0 tons/ha for many years, production rose until 1970, due solely to higher yields. Then, as rice became a profitable crop relative to irrigated alternatives, the irrigated area doubled in the next five years. Total production more than doubled between 1970 and 1974. In 1975 the national average yield was 4.4 tons/ha. This was only 0.4 tons/ha less than the yield of irrigated commercial checks in ICA's regional trial network during the first semester of 1975. This remarkable closeness of farm and experimental yields contrasts sharply with the gap between potential and actual yields of 6.3 tons/ha reported for the Philippines (Herdt and Wickham, 1975, p. 167).

Table 12 sets out a summary of the annual flows of milled rice. The basic data are all from FEDEARROZ (1975). The reliability of the data for human and industrial use is probably questionable; certainly wide variance exists between sources. Based on U.S. Agricultural Attaché reports, Gislason (1975) reports 768,000 m.t. for human and industrial use in 1974, compared with 712,000 m.t. in Table 12, and closing stocks of 287,000 m.t. compared with the present estimate of 423,000 m.t. Rice is used for livestock feed, for beer and breadmaking, but the quantities are not known with any certainty. However, the important point of Table 12 is that there

Table 11. Area, production and yields of paddy rice by sector: Colombia (1954-1975).

	Upland sector			Irrigated sector			Total			Production	
Year*	Area (ha)	Prod. (m.t.)	Yield (kg/ha)	Area (ha)	Prod. (m.t.)	Yield (kg/ha)	Area (ha)	Prod (m.t.)	Yield (kg/ha)	Irrigated (o/o)	Upland (o/o)
1954	111,580	123,600	1,105	63,420	171,200	2,700	175,000	294,800	1,685	58	42
1955	103,920	124,328	1,196	84,070	195,872	2,330	188,000	320,200	1,703	61	39
1956	119,960	130,210	1,085	70,040	212,290	3,021	190,000	342,500	1,803	62	38
1957	110,250	130,042	1,180	79,750	220,158	2,761	190,000	350,200	1,843	63	37
1958	124,800	147,779	1,184	71,200	232,621	3,267	196,000	380,400	1,941	61	39
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 13 years to 1974. Hence, outside of some recent rises in stocks, all of the expanded production has been consumed on the domestic market; whether this consumption was as rice, or indirectly in bread, beer, pork, poultry or eggs, need not concern us greatly at this stage.[2]

4.4 Regional shifts in production[3]

In the last forty years, the regional pattern of rice production in Colombia has changed markedly. The production of upland and swamp rice on the North Coast to serve the major consumption centers of Barranquilla, Cartagena and Santa Marta represented over 50 percent of Colombian output in 1934 (Table 13). With the decline in importance of upland rice, production became more concentrated in the middle Magdalena Valley; the states of Huila and Tolima accounted for 38 percent of the national output in 1974. With greater use of machinery and herbicides, production has spread rapidly in the Llanos, and the state of Meta is now the second most important area in Colombia (Figure 2). The Cauca Valley has continued to decline in importance as the area of sugar cane has expanded. In 1948 half the irrigated area of the country was in the Cauca Valley (Leurquin, 1967), but in 1974 only 5 percent of the irrigated area was in this region (FEDEARROZ, 1975, p. 29). The trends toward greater regional specialization were already apparent before the introduction of HYV's; it is probable these have been reinforced by the presence of HYV's, which have increased the comparative advantage of the irrigated rice areas, as well as the consequent decline in upland production.

4.5 Prices

Nominal and real prices for rice in Colombia are shown in Table 14. The nominal prices are affected so greatly by inflation that attention is focused on the deflated prices. Farm prices averaged $1,437 per ton[4] in 1965-1969 and $1,037 per ton in 1970-1974, a fall of 28 percent during the period of significant impact of the HYV's.

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[1] The question of exports in 1974 is far from clear. A landslide blocked the road from the Llanos cutting off a major rice-producing area from the Bogotá market. Rice was apparently exported to Venezuela during this period. The official export figures of the Banco de la República show 1,000 tons of rice exported in 1974. The U.S. Department of Agriculture (1975b, p. 34) reports 176,000 tons of exports in 1974 and alternatively no exports (U.S. Department of Agriculture, 1975c, p. 5).

[2] When considering the distribution of benefits of the expanded production to consumers, the form in which rice is consumed is of obvious importance. If large amounts were processed and entered the market as high-income livestock products, then the pattern of consumer benefits would be markedly affected. However, while sketchy, the data seem to indicate that the total amount used outside direct human consumption is small. Table 11 shows the FEDEARROZ figure of 64,000 tons (net of seed) and the Ministerio de Agricultura (1975, p. 28) reports 81,000 tons.

[3] Leurquin (1967) presents a detailed analysis of historical forces which shaped the geographical pattern of rice production.

[4] All monetary data in this report are in Colombian pesos, unless otherwise noted.

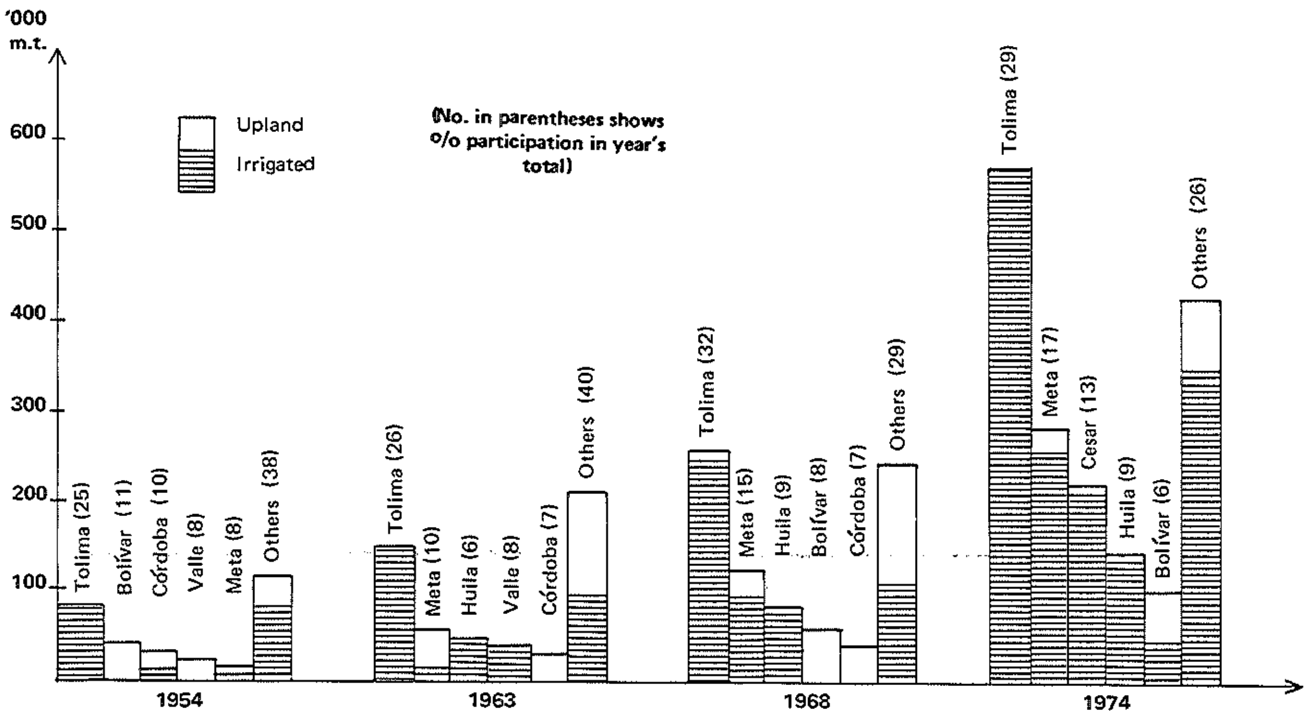

Figure 2. **Regional distribution of rice production by principal states: selected years.**

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)
1971	567	(–15)	552	503	–	20	–	523	29
1972	655	29	684	551	2	24	5	482	102
1973	738	102	840	608	20	26	–	654	186
1974	985	186	1,171	648	1	35	64	748	423

* From FEDEARROZ (1975)

Table 13. **Regional shifts in Colombian rice production (1934-1974).**

Region	States	1934	1949	1959	1963	1967	1974
		(%)					
Northern Colombia	Antioquia, Córdoba, Bolívar, 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 Cesar 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			Real prices[1]			Price[2] index
	Farm[3]	Wholesale[4]	Retail[4]	Farm	Wholesale	Retail	
	($/m.t)			($/m.t.)			
1950	350	976	1,020	1,207	3,366	3,517	29
1951	465	944	1,060	1,453	2,950	3,313	32
1952	345	728	920	1,113	2,348	2,967	31
1953	400	1,128	1,240	1,176	3,318	3,647	34
1954	470	1,032	1,160	1,270	2,789	3,135	37
1955	475	928	1,160	1,284	2,508	3,135	37
1956	485	1,048	1,180	1,244	2,687	3,026	39
1957	615	1,472	1,700	1,337	3,200	3,696	46
1958	750	1,480	1,800	1,471	2,902	3,529	51
1959	770	1,456	1,720	1,375	2,600	3,071	56
1960	883	1,936	2,180	1,497	3,281	3,695	59
1961	954	1,864	2,360	1,490	2,913	3,688	64
1962	919	1,728	2,360	1,372	2,579	3,522	67
1963	1,040	2,232	2,569	1,321	2,626	3,012	85
1964	1,347	2,928	3,480	1,347	2,928	3,480	100
1965	1,703	3,616	4,120	1,592	3,379	3,850	107
1966	1,884	3,824	4,460	1,507	3,059	3,568	125
1967	1,914	3,848	4,400	1,418	2,850	3,259	135
1968	2,106	4,032	4,520	1,452	2,780	3,117	145
1969	1,887	3,744	4,460	1,217	2,415	2,877	155
1970	1,850	4,200	4,500	1,121	2,545	2,727	165
1971	1,931	4,272	5,060	1,044	2,309	2,735	185
1972	1,884	4,408	5,260	893	2,089	2,493	211
1973	2,514	7,080	8,000	978	2,755	3,113	257
1974	3,694	8,960	10,660	1,151	2,783	3,311	322

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 1950-1953
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 data)

The retail price of first grade rice in Bogotá fell from $3,334 per ton to $2,876, a decline of 14 percent over the same period.*

A frequent source of confusion is the apparent inconsistency of a falling farm price and expanded rice production. If the farm price fell, why did national output continue to rise so strongly? The simple answer is that with the new technology, rice production costs per ton fell, making expanded output profitable even at the lower prices. Based on data from Gislason (1975), the real cost of irrigated rice production in 1964 pesos was $1,494 per ton, $1,401 per ton and $976 per ton, for 1961-1964, 1965-1969 and 1970-1974, respectively.

*A detailed examination of the marketing margins is made in Chapter 8.

Between the last two periods real production costs per ton fell by 30 percent (Gislason, 1975), or by almost exactly the same amount as the fall in the farm price.The continued adoption of new technology in the face of falling farm prices is a phenomenon that has been widely documented. Cochrane (1958, pp.106-107), referring to the U.S.A., notes that the farmer "reasons 'I can't influence price, but I can influence my own costs. I can get my costs down . . .thus the farmer is always on the lookout for new cost-reducing technologies. Built into the market organization of agriculture, then, is a powerful incentive for adopting new technologies. . .. The peacetime tendency for aggregate supply to outpace aggregate demand keeps farm prices relatively low." Cochrane refers to this as the "agricultural treadmill." We have no reason to doubt that a similar effect has been operative in the Colombian rice industry. Early adopters (be they larger, better informed or better serviced farmers) test cost-reducing (i.e., yield-increasing) technologies. Their additional output initially has little effect on price,thus generating temporary abnormal profits. Further adoption is then stimulated; but as output expands, farm prices fall, so that the remaining nonadopters are forced to either follow suit or withdraw. The data in Table 9 are dramatic evidence of the almost total varietal change in Colombia's irrigated sector.

Not only did the real price of rice fall as a result of the new varieties, but rice also became cheaper relative to other major food items (Table 15). For example, in 1959, one kilogram of beans purchased 1.67 kg of rice; but by 1974, it purchased 3.47 kg of rice. The period 1970-1974, corresponding to the major impact of the HYV's, saw a significant change in the prices of major foodstuffs relative to rice (Figure 3). Between 1950 and 1970, there had been no clear change in the relative price of rice, except with respect to cassava. But in the final period (1970-1974), rice became 45 percent cheaper relative to the other commodities.

Table 15. **Number of kilograms of rice that could be purchased with one kilogram of other selected products in the Bogotá wholesale market: selected years.**

Year	Kg of rice purchased with 1 kg of				
	Beans	Cassava	Maize	Potatoes	Beef
1950	1.67	0.31	0.49	0.63	1.43
1955	2.59	0.29	0.41	0.45	2.60
1960	1.99	0.16	0.36	0.37	2.18
1965	1.82	0.34	0.36	0.37	1.88
1970	2.38	0.48	0.45	0.29	2.64
1974	3.47	0.79	0.51	0.55	2.95
Fall in relative price of rice between 1970-1974 (%)	–46%	–65%	–13%	–90%	–12%

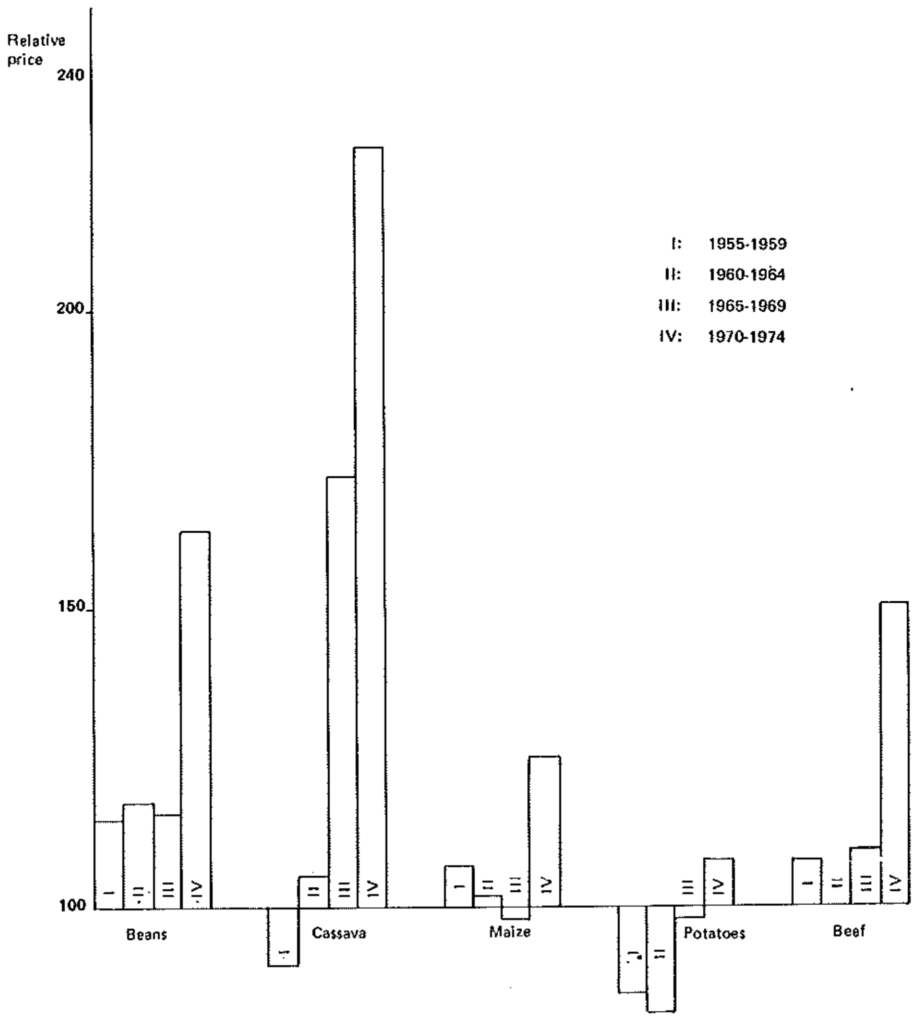

Figure 3. **Changes in the relative price of five commodities to rice: Bogotá wholesale market (1950-1954 = 100).**

The increased proportion of new varieties, some with poorer milling and cooking qualities than the traditional variety (Bluebonnet-50), has altered the proportions of the various grades of rice entering the market. While no data on the relative quantities are available, Table 16 shows that first grade rice has become more expensive relative to second and third grade rice; in the case of second grade rice, the change has been most marked in the period 1970-1974

4.6 Government price support scheme

Since 1944, the Government has operated a price support scheme for rice, initially through the Instituto Nacional de Abastecimiento (INA) and latterly through its successor, the Instituto de Mercadeo Agropecuario (IDEMA).

Table 16. **Relative price of rice by grade: Bogotá wholesale market (selected years).**

Year	Price of first grade rice relative to	
	Second grade	Third grade
1956	1.07	1.32
1960	1.04	1.57
1965	1.02	1.66
1970	1.04	1.73
1974*	1.11	1.79

* For the month of October; all other years, for December.

Source: Boletín Mensual de Estadísticas, DANE (various issues),

At present there are 24 separate support prices based on the type of rice, humidity, grain quality and impurities. The maximum and minimum prices are shown in Table 17, deflated to 1964 pesos, together with the average price paid by IDEMA for all rice purchased. The stated role of IDEMA has been to stablize the producer price of rice, although it is doubtful whether it has had either "the financial resources or the storage capacity to influence price levels significantly" (Leurquin, 1967, p.233). Gutiérrez and Hertford (1974, p.23) estimated that between 1950 and 1969, IDEMA 's actions reduced the coefficient of variation

Table 17. **Real support prices* for rice (1965-1974).**

Year	Support prices		Av prices paid by IDEMA**	Av farm price***
	Maximum	Minimum		
	($/m.t.)		($/m.t.)	($/m.t.)
1965	1,178	692	n.a.	1,592
1966	1,376	932	1,115	1,507
1967	1,519	1,048	1,536	1,418
1968	1,414	903	1,246	1,452
1969	1,290	742	1,029	1,217
1970	1,364	751	963	1,121
1971	1,216	670	790	1,044
1972	1,066	588	842	893
1973	1,078	440	n.a.	978
1974	1,250	704	1,097	1,151

* Expressed in 1964 pesos

** Calculated from unpublished data supplied by the Unidad de Estadística, Oficina de Planeación, IDEMA

*** From Table 14

of farm prices by 13 percent although simultaneously the average price received was slightly lower due to state intervention. The data in Table 17 show that the average price paid by IDEMA was generally lower than the average farm price, reflecting the orientation of IDEMA to the low-income consumer, by dealing in lower quality rice.

Table 18 shows various measures of the intensity of IDEMA's activities in the rice market. Between 1950 and 1965, IDEMA purchased a very small proportion of the rice crop, averaging 2 percent per year (Gutiérrez and Hertford , 1974 p. 11). Since 1965, the purchases have been increased, and the real quantity of funds invested by IDEMA in rice has grown (Table 18). In the five-year period 1970-1974 IDEMA purchased an average of 10 percent of the rice crop. The average price paid by IDEMA during 1966-1969 and 1970-1974 was 12 percent below the average farm price in both periods. This suggests that there was little change in IDEMA's purchasing strategy in terms of the quality mix as a result of the introduction of HYV's.

Table 18 also gives the percentage of IDEMA's purchases coming from the irrigated sector, together with the proportion of the national output originating in that sector. If IDEMA were to be following a neutral policy with respect to its source of purchases (rather than say favoring smaller upland producers or for political reasons, favoring the larger irrigated producers), then we would expect IDEMA's purchases to follow the observed national trend in the distribution of output. In fact, a Chi-square test provided no evidence to reject the hypothesis that IDEMA was in fact merely shifting its purchases in line with the national production trends from the irrigated and upland sectors. Apparently, there was no deliberate policy of favoring one sector or another. Had IDEMA been following a policy of supporting farm incomes, then we would have expected a greater proportion of its purchases to have come from the upland sector, which was comparatively disadvantaged due to the introduction of new irrigated technology.

4.7 Credit

Limited data on the public sources of credit available for rice production (Table 19) indicate that there was no apparent rise in the real amount of credit per hectare made available publicly during the period of adoption of the new varieties.

4.8 Chemical inputs

Attempts to examine whether the use of chemical products per unit of output rose with the introduction of HYV's meet with severe data limitations. The available data (Table 20) for fertilizers, while incomplete, show little increase in the total quantity applied, implying a perhaps surprising decrease from 84 kg of fertilizer per ton of total rice production in 1971 to 51 kg per ton in 1974.

A very crude approximation to the input of herbicides, insecticides and fungicides suggested that their use per unit of rice production rose by 20 percent between

Table 18. **Measures of the intensity of the public marketing sector (1966-1974).**

Year	°/o of crop purchased by IDEMA based on		Real value of IDEMA's Purchases[2]	°/o of IDEMA's purchases from the irrigated sector[3]	°/o of national output from irrigated sector[4]
	Output	Value[1]			
	(°/o)	(°/o)	($m)	(°/o)	(°/o)
1966	2.4	1.8	18.3	n.a.	50
1967	1.8	2.0	18.4	49	58
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**	Total	Credit per hectare
		($m)		($)
1968	161	108	269	971
1969	161	87	248	960
1970	179	72	251	1,076
1971	197	81	278	1,097
1972	176	111	287	1,048
1973	114	157	271	932
1974	183	229	412	1,118

* Expressed in 1964 pesos
** Fondo Financiero Agrario

1965-1967 and 1971-1973, suggesting that the introduction of HYV s was accompanied by some intensified use of these products.

The standard commentaries on the green revolution invariably stress the notion that improved genetic potential of seed is only expressed under farm conditions when applied as a "package" with high levels of chemical inputs (and better water control). Sketchy as they are, the Colombian data do not appear to lend strong support to this notion, at least in the case of chemical inputs. Total fertilizer applications were constant* during a period of rapid and widespread extension of HYV's (implying a lower fertilizer use per unit of output), and the average level of other chemical products per unit of output rose very moderately.

4.9 Labor usage

In Table 21, an estimate of the total labor usage in rice production is shown. In the period since the introduction of new varieties (1965-1975), the total labor usage has apparently declined by 33 percent. The availability of new varieties gave a comparative advantage to mechanized irrigated production,which uses only 30 percent of the man-days per hectare of the upland manual system for labor in rice production. However, it is almost certain that labor usage in the milling, packing and distribution sector rose as a result of the large increases in production. In addition, the expanded demand for farm inputs would have increased the demand for labor for their provision, especially where the products are domestically produced.

Finally, there are two indirect effects of expanded rice output on employment.

*Fertilizer prices rose during this period, which undoubtedly accounts for some restraint in their use and perhaps a slower increase in yields than would have occurred had fertilizer prices been constant.

Table 20. Use of chemical inputs in rice production (1965-1974).

Year	Fertilizers*	Insecticides	Herbicides	Fungicides
	('000 m.t.)	('000 liters or kg of active ingredient)		
1965	n.a.	547	424	19
1966	n.a.	954	740	38
1967	n.a.	962	680	25
1968	n.a.	1,344	457	103
1969	n.a.	1,430	374	120
1970	n.d.	1,650	394	129
1971	76.2	1,773	400	144
1972	74.9	1,673	675	270
1973	76.7	2,304	960	384
1974	80.1	n.a.	1,082	303

* Urea and mixed fertilizers
Sources: Fertilizer data and other products for 1972-1974 from the Ministerio de Agricultura (1972-1974); the remaining data from ICA (1973)

One is the "multiplier effect"; due to increased incomes of rice producers, their demand for nonfarm goods and service increases. Secondly, if the price of rice is low to urban consumers, then the pressure for increased industrial wages is diminished (Crisostomo et al.,1971, p. 142). This has the effect of cheapening the cost of labor relative to other inputs and hence stimulating the demand for labor in the industrial sector. The strength of this effect depends on the proportion of total family expenditures spent on rice. These data for five major Colombian cities are shown in Table 22 and indicate that especially among the lower income groups, rice forms an important part of the total household expenditures. Between 1963 and 1970 nominal wages in the industrial sector rose by 104 percent while

Table 21. Estimate of labor usage in Colombian rice production: selected years.

Year	Sector: Irrigated*	Sector: Upland**	Total
	('000 man-days)		
1955	2,942	9,976	12,918
1959	1,827	14,593	16,420
1965	4,550	23,251	27,801
1969	4,056	12,919	16,975
1975	9,578	9,120	18,698

* Based on 35 man-days / ha (Ministerio de Agricultura, 1973, p.30)
** Based on 96 man-days / ha (Ministerio de Agricultura, 1973, p. 30)

Table 22. **Proportion of household expenditures spent on rice by income level for five major Colombian cities (1970).**

City	Income level ($'000/year)				
	0-18	18-42	42-72	72-120	120 or more
	(%)				
Bogotá	3.0	2.1	1.5	1.0	0.6
Cali	5.1	4.0	2.5	1.9	1.2
Bucaramanga	2.3	1.7	1.0	1.0	0.6
Barranquilla	5.2	4.3	3.6	2.6	1.7
Pasto	4.8	3.6	2.2	2.5	0.8

Source: DANE: Boletín Mensual de Estadisticas No. 264-265, July-August 1973, pp.25-31

the retail price of first grade rice in Bogotá rose only by 75 percent, indicating that as a wage good, rice represented a dampening effect on the rise in industrial wages.

In conclusion, despite the apparent decline in on-farm labor usage in rice production, it would be presumptuous to conclude that HYV's have been a net labor-saving technological change. Indirect expansion of the demand for off-farm labor following the large increases in rice production due to HYV's could well have offset the decline in on-farm labor usage.

4.10 Distribution of rice farms, area and production by farm size

In this section we present a review of the structure of the rice-producing industry by farm size categories and indicate how this has been changing over time. The principal purpose of this somewhat detailed section is to generate distributions of rice production by farm size for both the upland and irrigated sectors in 1970. This information will be needed subsequently as a basis for determining the distribution of costs and benefits of the new rice varieties.

The analysis is based on unpublished census data provided by DANE for 1959 and 1970 and on a special tabulation by DANE for 1966 (Atkinson, 1970, p. 25). Unfortunately no data exist for years subsequent to 1970, so that the full impact of the introduction of HYV's on the structure of the rice-producing industry cannot be assessed. However, some clear trends were already evident by 1970, and there is no reason to believe that the pattern of change which was evolving up to 1970 has not continued.

The census data for 1959 and 1970 were available by states. The first step was to classify these as either "Upland" or "Irrigated," on the basis of the percentage of the production from each system. Fortunately, in almost all cases, these geopolitical boundaries correspond remarkably closely to the two types of rice-production systems. The classification, based on FEDEARROZ data for 1963 (the closest year corresponding to 1959 for which state production data were available (Leurquin, 1967, p. 299) and 1970, is presented in Appendix Table 2. The data show a high concentration of production system by states. The only low value of concern is the 1970 figure of 57 percent of production from the irrigated sector in Meta; this implies we have incorrectly classified the remaining 43 percent upland as irrigated production.

The only low value of concern is the 1970 figure of 57 percent of production from the irrigated sector in Meta; this implies we have incorrectly classified the remaining 43 percent upland as irrigated production.

On the basis of this classification, Appendix Tables 3, 4 and 5 were constructed for 1959 and Appendix Table 7 for 1970. The data for 1966 are shown in Appendix Table 6; for this year the breakdown by states was not available. The 1959 and 1970 census data refer to farms that reported rice as the principal crop, whereas the 1966 data refer to all rice-producing farms.

The most striking feature revealed by these data is the concentration of rice production in large holdings. In 1959, farms of greater than 100 ha represented 15 percent of the farms where rice was the principal crop, yet they sowed 53 percent of the total area of rice in Colombia. In 1966, 32 percent of the farms were over 50 ha and produced 72 percent of the total rice output, 42 percent coming from farms of over 200 ha.

As shown in Table 23, there has been some tendency for the concentration to increase over time, with the small- and medium-size groups declining relative to the proportion of large farms (50 ha and over). This trend was particularly marked in the irrigated sector where farms over 50 ha accounted for 59 percent of all farms where rice was the principal crop in 1959 and 50 percent in 1970 (Table 24). The only known data for yields by farm size are shown for 1966 in Appendix Table 6; overall they indicate no real differences, except for the largest size group (over 500 ha), which did appear to have higher yields.

At the same time as rice production has become more concentrated in the larger farms, the total number of farms declined substantially between 1959 and 1970 (Table 25). Most of this fall was in the upland sector and evenly distributed across all size groups. In the irrigated sector, the number of small and medium producers declined substantially, while the number of large producers increased. In 1970, the irrigated sector had 26 percent of the farms, yet produced 74 percent of the national rice output.

Attention is now given to estimating the distribution of production in 1970 by farm size group, for both the upland and irrigated sectors.

Figure 4 shows the method of estimating the number of farms in each time period on the basis of available data (the data not in parentheses). A constant annual rate

Table 23. **Percentage distribution of rice farms by three categories of farm size: Colombia (selected years).**

Size group (ha)	1959	1966	1970
		(%)	
Small (0–5)	30	25	27
Medium (5–50)	43	43	41
Large (50 +)	27	32	32
Total	100	100	100

of change between 1959 and 1970 was assumed and the number of "principal" producers for 1966 estimated as 35,721. The relation between principal and total producers for 1959 and 1970 was assumed to be the same as for 1966.* The numbers of the total irrigated and upland producers for 1959 and 1970 were estimated on the basis of the known proportions of principal producers in these two years.

For the upland sector the area sown by the i-th size group in 1970 ($A_{70,i}$) was based on the area sown in 1959 ($A_{59,i}$) adjusting upward for the total number of producers in 1959 and downward for the decline in upland area.

This method assumes that changes in area were proportional across all size groups, an assumption supported by the evidence in Table 25. Also, it assumes that the distribution of area for nonprincipal growers was similar to that for principal growers (as supported by Appendix Table 8, where the inclusion of all growers in 1966 did not alter the distribution significantly).

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

	Upland sector		Irrigated sector	
Size group (ha)	1959	1970	1959	1970
		(%)		
Small (0–5)	32	31	18	12
Medium (5–50)	44	42	43	38
Large (50 +)	24	27	39	50
Total	100	100	100	100

*As shown in Appendix Table 8, the size distribution for 1966, which includes all producers, differed very little from that for the two end periods (1959 and 1970), based on principal producers.

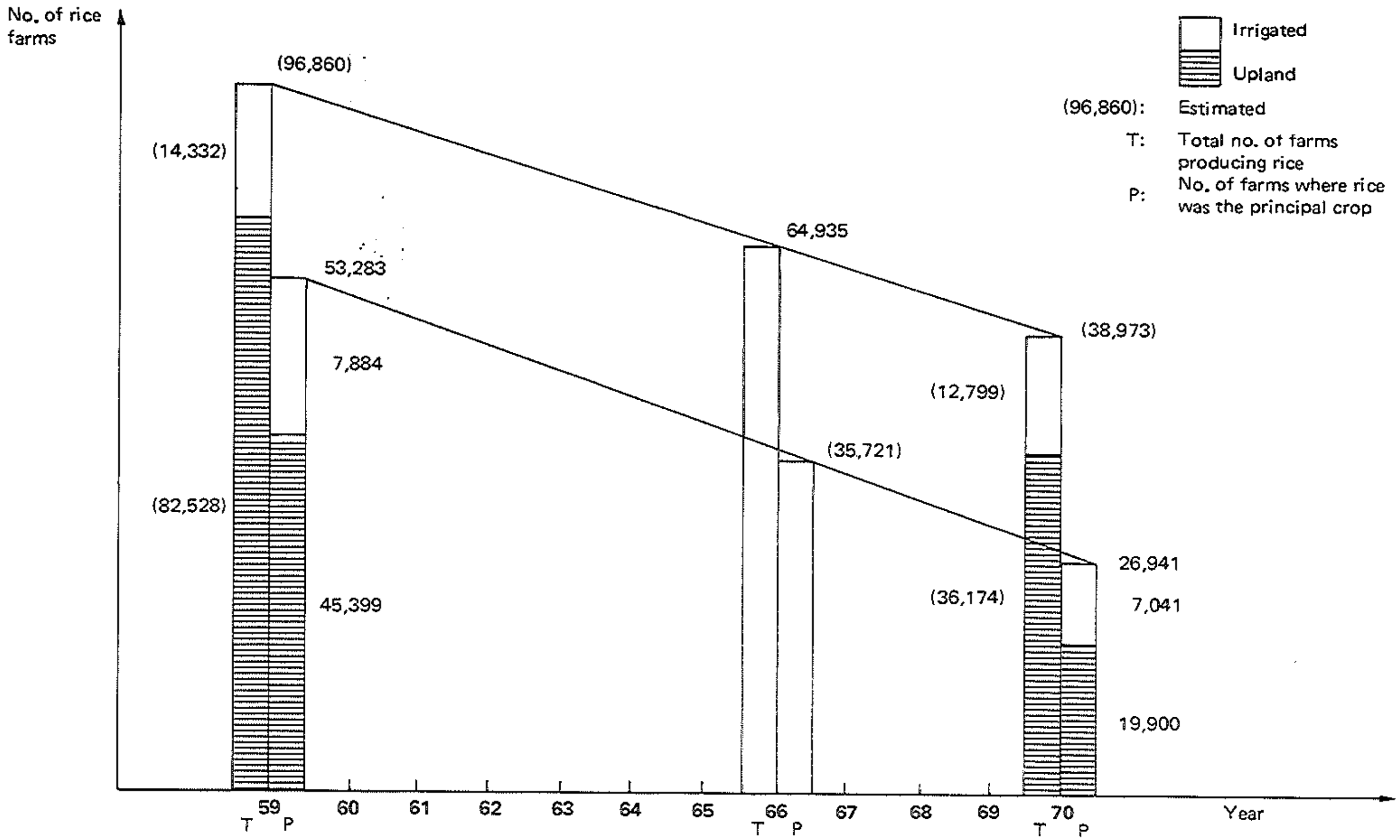

Figure 4. **Number of rice farms in Colombia in selected years.**

Table 25. **Changes in the number of farms between 1959 and 1970 where rice is the principal crop by three categories of farm size, by sector: Colombia.**

Size group (ha)	Upland sector		Irrigated sector		% of total farms in irrigated sector	
					1959	1970
	No.	(%)	No.	(%)	(%)	(%)
Small (0–5)	– 7,738	–55	–609	–40	4	12
Medium (5–50)	–11,885	–59	–795	–23	5	24
Large (50 +)	– 5,876	–52	+561	+19	6	40
Total	–25,499	–56	–843	–11	15	26

For the irrigated sector the above method could not be applied because:

1. The area reported by principal growers exceeded the total area reported for that year.
2. The change in total area was not evenly distributed across all farm sizes (Table 25).

The following procedure was therefore adopted:

1. The reported number of farms in each size group in 1959 was raised in ratio of 14,332/7,884 (see Figure 4), giving $NF_{59,i}$.
2. The reported area sown in each size group in 1959 was lowered by the ratio 52,190/86,078, or the reported total to the reported principal area sown in the irrigated sector, to give $A_{59,i}$.
3. The area per farm ($A_{59,i}/NF_{59,i}$) in 1959 was then assumed to hold in 1970 and multiplied by the number of farms in each size group in 1970, to give $A_{70,i}$. Each of these was then raised by the ratio of the actual area in 1970 in the irrigated sector to the estimated total ($\sum_i A_{70,i}$). As a check, the areas estimated for 1970 by size groups were compared with the reported data for 1966 (Appendix Table 9) and showed the expected increasing trend toward concentration among the larger size groups. Appendix Table 10 shows the number of principal producers in each size group for 1970, compared with the reported data for 1959.

Finally, the average reported yields in both sectors for 1970 were applied to these estimated areas by size group, to give the distribution of rice production by farm size for each sector in 1970 (Tables 26 and 27). It is this information which will subsequently be used to allocate the distribution of benefits to new rice varieties, by farm size.

The information in Tables 26 and 27 is summarized graphically in Figure 5. The much more unequal distribution of output in the irrigated compared to the upland sector in 1970 is evident. In that year, it is estimated that the lower 50 percent of the upland farms produced 25 percent of the upland output; in contrast, only 9 percent of the irrigated output came from the lower 50 percent of irrigated farms. These results have implications for the distributional impact of the benefits of the new varieties, as discussed in Chapter 7.

In conclusion, it should be reiterated that the structural changes noted in rice production were occurring prior to any possible significant influence of HYV's. The reasons for these changes have not been examined; such an inquiry would form a separate study.

Table 26. Estimated distribution of rice production by farm size: upland sector (1970).

Farm size (ha)	No. of farms	Area (ha)	Prod. (m.t.)*
0 – 1	2,180	719	1,177
1 – 2	3,402	486	4,069
2 – 3	2,707	3,280	5,368
3 – 4	1,825	3,193	5,226
4 – 5	1,458	3,025	4,951
5 – 10	4,255	9,821	16,076
10 – 20	4,374	12,342	20,202
20 – 30	2,563	7,355	12,039
30 – 40	1,916	5,855	9,583
40 – 50	1,652	5,265	8,618
50 – 100	4,743	18,543	30,354
100 – 200	2,485	16,338	26,745
200 – 500	2,036	15,444	25,281
500 – 1,000	380	8,491	13,899
1,000 – 2,500	131	4,861	7,957
2,500 +	67	4,095	6,703
Totals	36,174**	121,113***	198,248***

* Assuming a constant av yield of 1,637 kg/ha (Table 11)
** From Figure 4
*** From Table 11

Table 27. Estimated distribution of rice production by farm size: Irrigated sector: (1970).

Farm size (ha)	No. of farms	Area (ha)	Prod. (m.t.)*
0 – 1	162	32	158
1 – 2	498	164	811
2 – 3	427	133	658
3 – 4	265	151	747
4 – 5	293	266	1,315
5 – 10	885	908	4,490
10 – 20	1,362	2,336	11,553
20 – 30	920	1,934	9,565
30 – 40	816	2,100	10,386
40 – 50	721	2,147	10,618
50 – 100	2,060	8,262	40,857
100 – 200	2,560	21,071	104,197
200 – 500	1,065	22,569	111,605
500 – 1,000	351	16,049	79,363
1,000 – 2,500	276	16,747	82,815
2,500 +	138	17,231	85,209
Totals	12,799**	112,100***	554,347***

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

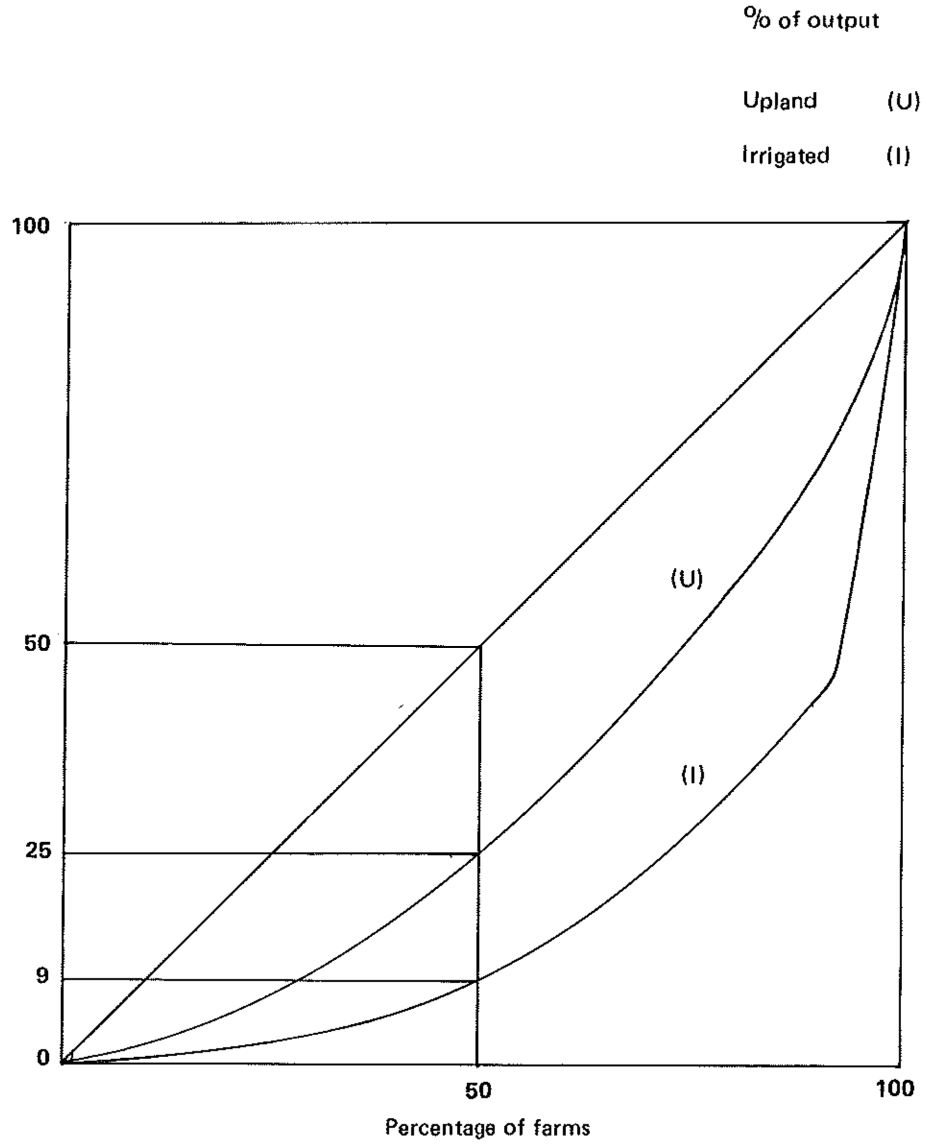

Figure 5. **Distribution of rice output in Colombia by sector (1970).**

5. AN ECONOMIC MODEL TO MEASURE THE GROSS BENEFITS OF HYV's IN COLOMBIA

The desirability of investment in any particular line of agricultural research can be judged using a wide variety of technical, social, economic and political criteria. In this study, we propose to examine the impact of investment in rice research in Colombia using two criteria: efficiency and equity (Akino and Hayami, 1975). By efficiency, we understand the social return on the scarce resources invested in rice research; i.e., was it a socially efficient way to invest those resources? By equity, we refer to the distribution of the net benefits by economic classes of the population.

There appears to be increasing concern on the part of donor agencies for the share received by people in the lower income groups of the net benefits stemming from research at international centers. Given the dramatic impact of HYV's on the Colombian rice sector, it was felt that efforts should be made to document both the size and the distribution of the benefits of this technological change. In fact, we will devote more effort to the distribution of the net benefits and measure their magnitude only as a "by-product." An existing study (Ardila, 1973) establishes that the investment in rice research in Colombia up until 1972 had a social rate of return of between 60 and 80 percent, leaving little doubt as to the efficiency issue.

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 will estimate the gross benefits for each group and subtract their share of the costs of the research. It is felt that a true indicator of the incidence of net benefits of research invesment must be based on both the return and the costs borne by different groups, rather than only dividing the total gross benefits between producers and consumers as is normally done in studies of this type (e.g., Ardila, 1973; Akino and Hayami, 1975; Ayer and Schuh, 1972).

We have chosen to separate producers into upland and irrigated categories because we are interested in examining the relative benefits accruing to both groups from a technological change which was developed specifically for irrigated culture. We developed a general approach for analyzing the differential impact of new agricultural technologies which, due to limited ecological adaptability, favor certain zones.

5.1 The general model

We first present and describe a graphical representation of the model; this is followed by its mathematical statement. The model used is an extension of that developed by Ayer and Schuh (1972) for the case of cotton in the state of Sao Paulo, Brazil. Our extension involves dividing the total supply of Colombian rice (STR) into two parts: that produced under upland conditions (SUR) and that coming from the irrigated sector (SIR), where

$$STR = SUR + SIR$$

These three supply relationships (expressed as a function of the expected price of rice) are shown in Figure 6, together with the supply curves S'IR and S'TR. The curve S'IR is the supply from the irrigated sector when only traditional varieties are sown, and S'TR the corresponding total supply, so that

$$S'TR = SUR + S'IR$$

The curves S'IR and S'TR are displaced k percent to the left of SIR and STR, respectively; k is thus the shift parameter, determined by the difference in yield between the dwarf and tall varieties and the proportion of the total area planted to dwarf rices. The shifts parameters for SIR and STR are denoted k_I and k_T respectively.

The demand curve shown by DR is a declining funtion of the current price of rice at the farm level. In contrast, the supply of rice is postulated to depend on the previous year's price.

There are four further important assumptions:

1. The rice economy for Colombia is effectively closed; i.e., the foreign trade in rice, which is a small, erratic fraction of total production, is ignored.
2. The Colombian rice market operates free from direct Government intervention; in fact (as noted in Section 4.6) from 1950-1969,the proportion purchased by IDEMA was very small; the assumption does more violence since 1970. Between 1950 and 1969 the difference between the actual prices and quantities in the market and those which would have resulted in the absence of Government

intervention have been estimated as 7 and 2.3 percent, respectively (Gutiérrez and Hertford, 1974).

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

4. The entire analysis will be conducted at the farm level. In fact, the measurement of benefits to consumers strictly requires the use of a retail level demand curve, rather than the derived farm level demand curve. However, provided the marketing margin (the difference between farm and retail prices) has not changed, no great violence is done. The problem of marketing margins is examined in more detail in a subsequent section.

In Figure 6, P_1 is the expected price which calls forth OA units of production that clear the market at a price of P_2, while P_3 is the price which would have prevailed in the absence of sowings to HYV's.

First we consider only the total benefits (TB) and their distribution.* Total benefits to the development of the new rice varieties (in any one year) are given by comparing the difference between total consumer utility and the real resource costs of rice production, with and without the new varieties. In terms of areas shown in Figure 6, we can write

$$TB = (OABC - OAD) - (OEFC - OEG) \tag{5.3}$$

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

$$TB = \Delta CS + \Delta PS \tag{5.4}$$

$$\Delta CS = P_2BC - P_3FC = P_2BFP_3 \tag{5.5}$$

$$\Delta PS = (OABP_2 - OAD) - (OEFP_3 - OEG) \tag{5.6}$$

Equation (5.6) only gives the global change in producer surplus. As we wish to examine the impact on two groups of producers, we now break down ΔPS into the change in upland and irrigated producer surplus (ΔUPS and ΔIPS), so that

$$\Delta PS = \Delta UPS + \Delta IPS \tag{5.7}$$

$$\Delta UPS = -P_2\,UVP_3 \tag{5.8}$$

$$\Delta IPS = (OKJP_2 - OKH) - (OLNP_3 - OLR) \tag{5.9}$$

The loss in producer surplus in the upland sector, where no technological change took place, is simply the loss in gross revenue they suffer by receiving a lower price

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*Where possible we have maintained the same notation as Ayer and Schuh (1972) to facilitate comparison.

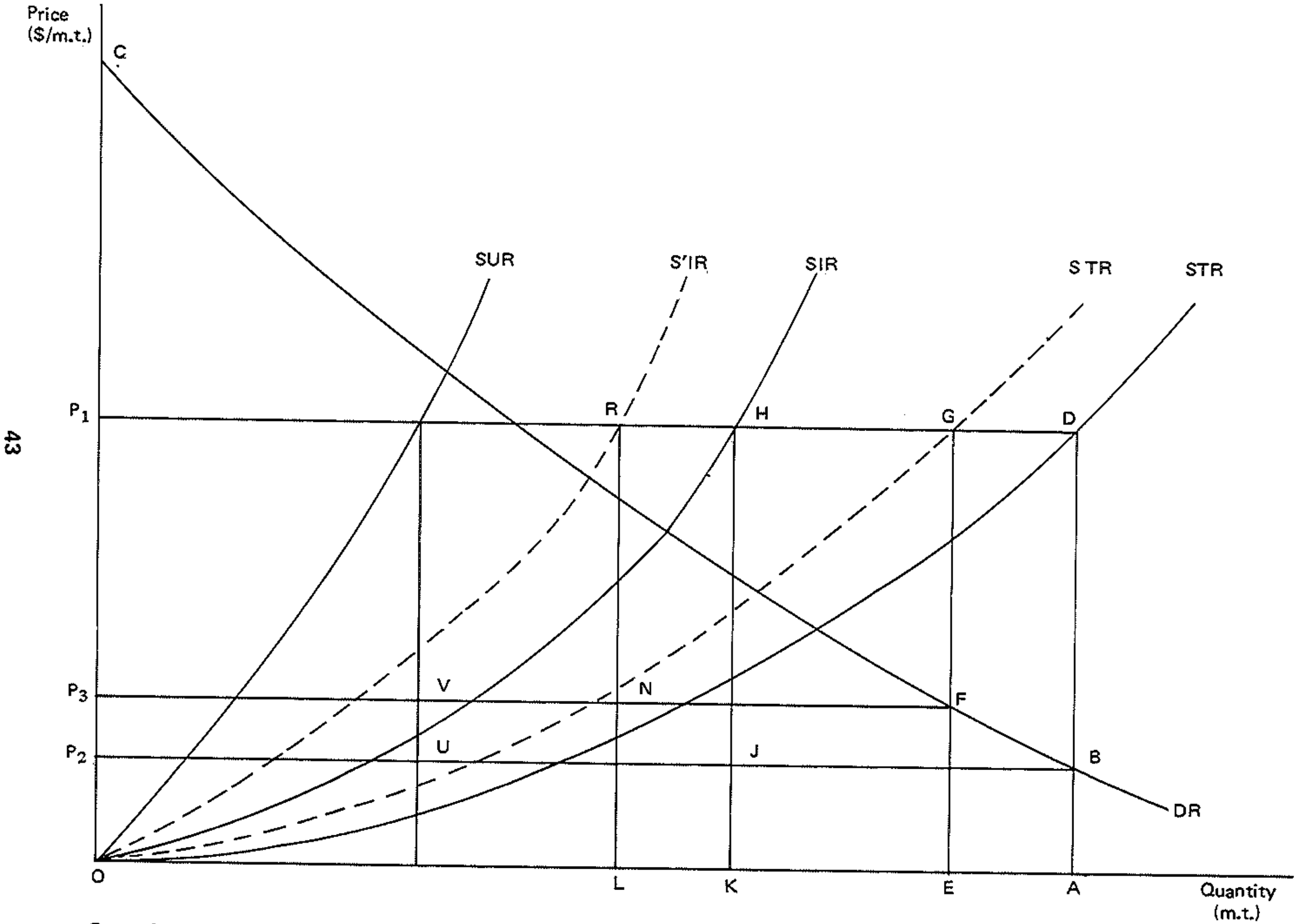

Figure 6. **Graphical representation of the model for estimating the distribution of gross benefits from the introduction of HYV's of rice.**

(P_3 instead of P_2* which would have prevailed if the expanded production had not taken place in the irrigated sector). As the change in consumer surplus is P_2BFP_3, we can note that P_2UVP_3 is simply a transfer from upland rice producers to consumers; i.e., of the benefits accruing to consumers; the part shown by P_2UVP_3 was gained at the expense of upland producers.

In summary, the consumers gained, some of this gain being a transfer from producers; upland producers suffered a net loss, all of which was a transfer to consumers. Whether or not irrigated producers had an overall gain will depend on the relative magnitudes of the supply and demand elasticities for rice.

5.2 Mathematical representation

The formal representation of the model in terms of the demand and supply equations is as follows:

$$\text{DR:} \quad P_t = \alpha\, Q_{T,t}^{1/\eta} \tag{5.10}$$

$$\text{SIR:} \quad Q_{I,t} = \beta P_{t-1}^{\epsilon_I} \tag{5.11}$$

$$\text{SUR:} \quad Q_{U,t} = \gamma P_{t-1}^{\epsilon_U} \tag{5.12}$$

$$\text{STR:} \quad Q_{T,t} = \delta\, P_{t-1}^{\epsilon} \tag{5.13}$$

$$\text{S}'\text{IR:} \quad Q'_{I,t} = (1-k_{I,t})\, P_{t-1}^{\epsilon_I} \tag{5.14}$$

$$\text{S}'\text{TR:} \quad Q'_{T,t} = (1-k_{T,t})\, P_{t-1}^{\epsilon_U} \tag{5.15}$$

with η and ϵ representing the demand and supply elasticities and α, β, γ and δ representing all the variables and parameters which affect supply and demand but not explicitly included in the model.

Once we have established the magnitude of the supply shifter (k_t) for each year, we can derive (5.14) and (5.15) directly from SIR and STR. This leaves a set of four equations (5.10) to (5.13) and eight unknowns: (α, β, γ and δ) and ($\eta, \epsilon_I, \epsilon_U$ and ϵ). In the following section we discuss the estimation of the shift parameter, k_t.

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

5.3 Estimation of the shift parameter

Frequently, researchers have taken the yield superiority of new varieties under experimental conditions (e) as the proxy for their superiority under farm conditions (f), or

$$(Y_{I,t} - Y_{T,t})^e \simeq (Y_{I,t} - Y_{T,t})^f \quad (5.16)$$

The need for this approximation arises simply because we generally lack farm level data (at least on a national basis) for determining the yield superiority of the improved varities ($Y_{I,t}$) over the traditionals ($Y_{T,t}$).

It is recognized (Davidson and Martin, 1965) that experimental yields are generally higher than farm yields as a result of the more timely control of the cultural operations, the greater attention given to small plots, etc. The implicit assumption is that although $Y_{I,t}$ and $Y_{T,t}$ under experimental conditions might both overstate the farm yields, the difference would approximate the unknown farm level difference in yields. However, the very nature of the new varieties (Kawano et al., 1974) is often such that they respond relatively more to fertilizer, water and superior cultural practices; hence it may not be reasonable to assume that the difference at the experimental level is a good proxy for the farm level differences. In the case of the Colombian data, experimental results based on a small number of observations suffer from fluctuations due to experimental error which may not reflect overall farm results.

For these reasons we have adopted an alternative approach. However, we first demonstrate that the use of the regional trial data comparing improved and traditional varieties in Colombia leads to unacceptable results.

We start with the identity

$$\frac{Q_I + Q_T}{H_I + H_T} = \frac{Q}{H} \quad (5.17)$$

where:

Q_I, H_I = production and area of improved varieties (taken together)

Q_T, H_T = production and area of the traditional variety

Q, H = total production and area.*

We can write (5.17) as

*For clarity, we have omitted the time subcript, t.

$$\frac{Q_I}{H_I + H_T} + \frac{Q_T}{H_I + H_T} = \frac{Q}{H} \qquad (5.18)$$

$$\frac{Q_I}{H_I} \cdot \frac{H_I}{H_I + H_T} + \frac{Q_T}{H_T} \cdot \frac{H_T}{H_I + H_T} = \frac{Q}{H} \qquad (5.19)$$

or, $Y_I \cdot P + Y_T \cdot (1-P) = Y$ (5.20)

where

P = proportion of the total area sown to improved varieties

Y_I = average weighted yield of improved varieties

Y_T = yield of the traditional variety

Y = overall observed yield.

If the experimental values for Y_I and Y_T are in fact good proxies for the corresponding farm level values, we should be able to derive P_t from the following equation [derived by rearranging (5.20)],

$$P_t = \frac{(Y_t - Y^e_{Tt})}{(Y^e_{It} - Y^e_{Tt})} \cdot 100 \qquad (5.21)$$

where:

Y_t = observed yield in irrigated sector in year t

$Y^e_{I,t}, Y^e_{T,t}$ = yields of improved and traditional varieties based on the regional 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 range $0 \leq P_t \leq 100$. The results are either greater than 100 percent or negative. The strongest indictment of these data is when P_t is greater than 100 percent (a nonsensical result), implying $Y_t > Y_{I,t}$; i.e., the observed yields are higher than the improved varieties in regional trials. As not all the observed yield is based on improved varieties, this establishes that the experimental data are understating the yields achieved on farms. When P is negative (also nonsensical), it is almost always the case that the observed irrigated

Table 28. **Estimates of the proportion of the area sown to HYV's, based on experimental yields for HYV's and the traditional variety (1964-1974).**

	Observed irrigated yield* (Y_t)	Experimental yields HYV's (Y^e_{It})	Experimental yields Traditional ($Y^e_{T,t}$)	Implied proportion sown to HYV's (P_t)
	(kg/ha)			(%)
1964	3,100	5,166	4,336	−149
1965	3,049	4,336	3,462	− 47
1966	2,995	3,645	1,590	+ 68
1967	3,468	2,690	2,893	−283
1968	4,221	4,600	3,200	+ 73
1969	4,092	3,809	3,086	+139
1970	4,945	4,840	3,339	+107
1971	5,061	4,372	3,164	+157
1972	5,174	5,243	2,866	+ 97
1973	5,318	4,934	3,383	+125
1974	5,200	5,398	3,086	+ 91
1972 Valle	4,560		3,724	+ 55
Huila	4,890	5,243	4,100	+ 70
Total	5,780		3,380	+ 129
1973 Valle	4,310		4,954	+3,200
Huila	5,350	4,934	3,573	+ 131
Total	6,000		4,324	+ 274

* From Table 11

yield is less than the traditional yield under experimental conditions, indicating that the experimental results for the traditional variety overstate the corresponding farm yields. Hence $Y^e_{I,t} < Y^f_{I,t}$ and $Y^e_{T,t} > Y_{T,t}$, so that

$$(Y_{I,t} - Y_{T,t})^e < (Y_{I,t} - Y_{T,t})^f$$

In other words, the experimental margin of yield superiority is less than the farm level margin.

We have therefore rejected experimental data as a basis for estimating the superiority of improved varieties at the farm level.* We have preferred to base our esti-

*Jennings (personal communication) argues that the regional trials are not specifically designed to measure yield superiority; a wide range of other characteristics are also considered.

mates on observed farm level data; to do this we need estimates of $Y_{I,t}$ and $Y_{T,t}$ at the farm level. We took P_t from FEDEARROZ data (1973 and 1975), assuming that:

1. Their sales of improved seed (over 50 percent of total) are representative of the total pattern of sowings to improved varieties.**

2. All the improved seed was sown under irrigation. [This was apparently not the case, but the evidence of the observed upland yields (Table 11) shows that there was no apparent impact due to new varieties in those areas.]

Rearranging equation (5.20), we have

$$Y_{I,t} = \frac{Y_t - (1-P_t)\ Y_{T,t}}{P_t} \qquad (5.22)$$

where:

Y_t = observed yield under irrigation in year t

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

We took the average of years 1964-66 when 88 percent of the irrigated area was sown to Bluebonnet-50 as the base period, giving a yield of 3,048 kg/ha. We then fitted the following equation:

$$Y_t = \alpha + \beta_1 P_t + \beta_2 t - \epsilon_t \qquad (5.23)$$

obtaining

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

We then assumed that the estimated residuals ($\hat{\epsilon}_t = Y_t - \hat{Y}_t$) from this equation were due to climatic factors and that the traditional yields ($Y_{T,t}$) would have varied in the same proportion.

Using

$$\hat{Y}_{T,t} = 3{,}048\ [(\hat{\epsilon}_t/Y_t) + 1] \qquad (5.24)$$

we simulated the traditional yields for each year. With these data and by applying equation (5.22), we obtained the results for $Y_{I,t}$ shown in Table 29. In 1966, the estimated yield superiority was very slightly negative; however, the area sown to improved varieties was only 0.2 percent so we restricted the difference to zero. The

**In 1974, 40,835 m.t. of certified seed were produced, which at 150 kg/ha was sufficient to sow all the irrigated area (ICA, 1974, p. 30).

initial rise in $Y_{I,t}$ is consistent with improved information about cultural practices as experience grew; the subsequent fall took place gradually as the varieties spread to more marginal lands. The average superiority of the improved varieties between 1970 and 1972 is estimated at 2.7 tons/ha. This compares with 2.1 tons/ha in the irrigation districts of INCORA (see Appendix Table 11). Rosero (1975) estimates the superiority at 2.6 tons/ha for this period.

The results in Table 29 would be sufficient to allow us to proceed with the estimation of the shift parameter, k_t (for example, in the manner outlined by Ayer and Schuh, 1972). However, we believe that for the case of rice in Colombia this would understate the true contribution of the HYV's. The reason for this is that it seems reasonable to assume that at least part of the expansion in the irrigated area was due to the presence* of HYV's. Hence rather than attribute to the HYV's only the yield differential on all land sown, we also include all the production from the additional area sown due to the presence of HYV's. On this basis, the following equations were used to calculated $k_{I,t}$ and $k_{T,t}$ respectively.

Table 29. Estimates of the yields of traditional and improved varieties: Colombia (1964-1974).

Year	Observed yield[1] (Y_t)	Traditional Variety[2] ($Y_{T,t}$)	Proportion sown to HYV's[3] (P)	Yield of improved varieties[4] ($Y_{I,t}$)
	(kg/ha)		(%)	(kg/ha)
1964	3,100	3,092	5.1	3,248
1965	3,049	3,007	5.0	3,847
1966	2,995	3,023	0.2	–(5)
1967	3,468	3,292	6.9	5,843
1968	4,221	3,164	42.6	5,645
1969	4,092	3,039	42.6	5,510
1970	4,945	3,339	58.8	6,070
1971	5,061	3,417	57.2	6,291
1972	5,174	3,007	87.4	5,486
1973	5,318	2,936	97.8	5,371
1974	5,200	2,835	99.2	5,219

1 From Table 11
2 From equation (5.24)
3 From FEDEARROZ (1973 and 1975)
4 From equation (5.22)
5 No value was estimated as the difference between traditional and improved varieties was slightly negative.

*The area of rice sown in Government-sponsored irrigation districts rose from 27,114 ha in 1971 to 65,587 in 1974; i.e., during the period of rapid expansion of the HYV's. The use of dwarfs rose from 12 percent in the first semester of 1970 to about 80 percent in 1975 (all data are from unpublished sources of INCORA). This expansion in area reflects, in part, the relative profitability of rice growing with the new HYV's.

$$k_{I,t} = \left\{P_t \left[(Y_{I,t} - Y_{T,t}) * A_{N,t} + Y_{I,t} \cdot A_{A,t}\right]\right\} / Q_{I,t} \quad (5.25)$$

$$k_{T,t} = \left\{P_t \left[(Y_{I,t} - Y_{T,t}) * A_{N,t} + Y_{I,t} \cdot A_{A,t}\right]\right\} / Q_{T,t} \quad (5.26)$$

where:

$A_{N,t}$ = area of irrigated land that would have been sown to meet domestic requirements in the absence of HYV's

$A_{A,t}$ = additional area sown due to presence of HYV's

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

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

To apply equations (5.25) and (5.26) we must first determine the additonal area sown ($A_{A,t}$) due to HYV's; $A_{N,t}$ is found by subtracting $A_{A,t}$ from the total area actually sown. The following steps summarize the procedure used.

1. The area of upland rice which would have been sown in the absence of high-yielding varieties was estimated.

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

3. The domestic demand was estimated by inflating the domestic production for the period 1964-67 by a factor of 6.636 percent yearly based on a population growth rate of 3 percent yearly,a real income growth rate of 6.76 percent yearly, and an income elasticity of demand of 0.538 (see Section 5.4).

4. The difference between the domestic demand and the production from the upland sector was taken as the production which would have had to come from the irrigated sector.

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

Two methods of estimating the upland area in the absence of HYV's were used in order to test the sensitivity of the shift parameters to this factor.

(A) First, the following equation for the area of upland rice was fitted:

$$A_{U,t} = 91{,}031 - \underset{(-1.77)}{202{,}534}\ P_t + \underset{(1.26)}{9{,}298} - \underset{(-0.32)}{149}\ t^2 \quad (5.27)$$

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

where:

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

P_t = proportion of the irrigated sector sown to HYV's year t

t = time.

The proportion of the irrigated sector sown to HYV's (P_t) was included as an explanatory variable on the basis that higher values of P_t would mean higher output from the irrigated sector, lower national prices and hence less area sown to upland rice (where no technological change took place). The actual areas sown to upland rice are shown in Figure 7, together with the areas predicted by equations (5.27). To estimate the area sown in the absence of HYV's, P_t was constrained to zero in the values of $A_{U,t}$ predicted from (5.27). These values are also shown in Figure 7.

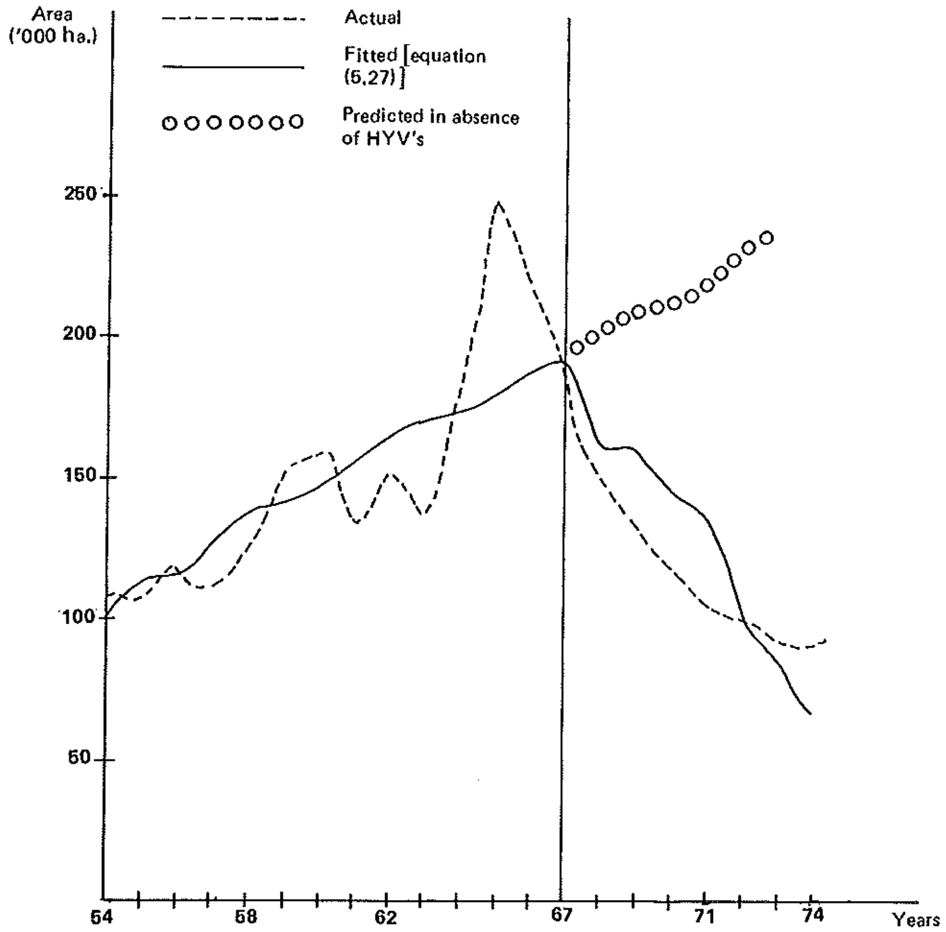

Figure 7. Area of upland rice (1954-1974).

*The years 1964-1967 were eliminated from this analysis as the proportion sown to HYV's was less than 5 percent, implying that any additional area sown due to the HYV's would have been negligible.

Table 30. **Estimated area sown to upland rice in the absence of HYV's under different assumptions: Colombia (1969-1974).**

Year	Area sown to upland rice		
		In absence of HYV's	
	Actual*	(A) From equation (5.27)	(B) Simple projection
		(ha)	
1968	150,200	196,977	130,925
1969	134,570	201,656	130,925
1970	121,113	206,037	130,925
1971	109,130	209,822	130,925
1972	103,220	213,905	130,925
1973	98,840	217,392	130,925
1974	95,600	220,581	130,925

* From Table 11

(B) The second method of estimating the area of upland rice in the absence of HYV's was simply to take the historical area prior to the rise in upland area in 1964 and use this figure for the subsequent years.

The average area sown during the years 1954-1963 was 130,925 ha. This figure was applied to the period 1968-1974.* In Table 30, the upland area sown under the two different assumptions is given. The additional areas of irrigated rice sown because of the presence of the HYV's under the two assumptions (A) and (B) are shown in Appendix Tables 12 and 13, respectively.

All the data needed to estimate the shift parameters ($k_{I,t}$ and $k_{T,t}$) are now available, and the results of applying equations (5.25) and (5.26) are shown in Table 31 for assumptions (A) and (B). Given the relatively minor differences in the shift parameters under the two sets of assumptions, only those relating to set (A) are used in the subsequent analysis.

In conclusion it should be stressed that the method of estimating the yield superiority employed above does not pretend to isolate the change in genetic potential from the use of improved cultural practices, better water control and possibly higher input levels. The view is taken that these are complementary inputs necessary for the expression of the yield potential embodied in the new varieties. Without them, that potential may not have been realized (Kawano et al., 1974); hence measuring the return to the genetic potential alone would be an artificial exercise.

5.4 Estimation of the elasticities

Estimates of income elasticity of demand and the price elasticities of demand and supply are required.

Table 31. **Estimates of the shift parameters due to HYV's: Colombia (1964-1974).**

Year	Irrigated production* ($A_{I,t}$)	Yield superiority** ($Y_{I,t}-\hat{Y}_{T,t}$)	Assumption (A)		Assumption (B)	
			$k_{I,t}$	$k_{T,t}$	$k_{I,t}$	$k_{T,t}$
	(m.t)	(kg/ha)				
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 estimate for the city of Cali of 0.34. While we might accept this as indicative of the urban sector (55 percent of the population), it is likely that the rural sector would display a higher value. Data from other published studies for Latin American countries* gave the following values for the urban and rural income elasticities of demand:

Income Elasticity of Demand

Country	Urban	Rural
Chile	0.20	0.40
Mexico	0.18	0.55
Peru	0.21	0.46
Venezuela	0.20	0.40
Simple average	0.1975	0.4525

The implied average ratio of the rural to urban elasticity (2.29:1), was applied to the Cali estimate, to give 0.779 (= 0.34 x 2.29) for rural Colombia.The rural and urban figures were then weighted by the proportions of the population in each sector.

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

$$\eta_y = 0.538$$

The resulting national estimate of 0.538 is between 0.5, the value estimated by FAO (1971) for Colombia, and 0.6, estimated by ECLA (1969). Cruz de Schlesinger and Ruiz (1967) estimated a value of 0.982, but this was for the period 1950-1963; and given rising real incomes, the current value is likely to be lower.

5.4.2 Price elasticity of demand (η)

There are only two known estimates of the price elasticity of demand for Colombian rice. The estimate of 1.372 presented by Gutiérrez and Hertford (1974) was not adopted for the following reasons:

1. It is considerably higher than one would intuitively expect for an agricultural commodity facing essentially a domestic market.
2. It was calculated from a time series regression using prices of paddy rice rather than the retail prices (to which consumers would supposedly respond). This would not do violence to the estimate of the price elasticity of demand if the relation between the farm and retail price had been constant; but as we discuss later (see Chapter 8), this has not been the case.

*See Appendix Table 14.

3. Their result comes from a restricted demand equation (where a value for the income elasticity was imposed), whose R^2 value is inexplicably larger than that for their unrestricted model (p. 16).

4. Appendix Table 14 shows the values of the price elasticity of demand for rice for 36 different countries and regions; in all, 53 different estimates. While it is recognized that these estimates come from widely varying social and economic circumstances, it is interesting to note that the maximum value is -0.65, while the simple average (excluding Gutiérrez and Hertford) is -0.309.

We started by accepting Pinstrup-Andersen's value for Cali of -0.354 as a proxy for the Colombian urban sector. We calculated a value for the rural sector of -0.575, by inflating the urban value using the proportions for the Venezuelan results (the only other Latin American country reporting rural and urban values). Then by weighting with the population proportions, we obtained:

$$\eta = 0.45\ (-0.575)\ +0.55\ (-0.345) \qquad (5.29)$$

$$\eta\ \ -0.449$$

Given this approximate method of deriving η, we felt that a sensitivity analysis would be warranted. We therefore examined values of –0.300 and –0.754. The first is generally the lower bound of the lower income countries in Appendix Table 14; the latter value reported by Cruz de Schlesinger and Ruiz (1967) is taken as the upper bound of the feasible range.

5.4.3 Price elasticities of supply (ϵ_I, ϵ_{II} and ϵ)

As indicated in the model,we require estimates of the elasticities of supply of irrigated (I), upland (U) and total rice output. The only known estimate* is a value of 0.235 for total output, presented by Gutiérrez and Hertford (1974). It is derived from a supply equation incorporating an expected price, the price of sesame (a competitor in production, in the irrigated sector) and the area sown; 96 percent of the variation in Colombian output between 1950 and 1969 was explained. We start our analysis by accepting this value, as the short-run supply elasticity of total rice output. It is in keeping with the values from other country studies shown in Appendix Table 14. However, we must now derive separate estimates of the elasticities for the irrigated and upland sectors.

From the identity

$$Q_T = Q_I + Q_U$$

where Q is output and the subscripts T, I and U refer to total, irrigated and upland, respectively, then it can be simply shown that

*The supply function presented by Cruz de Schlesinger and Ruiz (1967) contains only a trend variable.

$$\epsilon = \alpha\ \epsilon_I + (1-\alpha)\,\epsilon_U \qquad (.5.30)$$

so that if we can find either ϵ_U or ϵ_I, given the other and ϵ, togther with α (the proportion of output from the irrigated sector), we can solve for the remaining unknown elasticity.

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

$$Q_{U,t} = -1.47 + \underset{(10.5)}{0.99A_{U,t}} + \underset{(0.1),}{0.01PR_{(t-1)}} + \underset{(3.1)}{0.6PC_{(t-1),\,(t-3)}}$$

$$-\underset{(-0.3)}{0.04PY_{(t-1)}} + \underset{(0.1)}{0.02PS_{(t-1)}} - \underset{(-1.7)}{0.35PM_{(t-1)}} \qquad (5.31)$$

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

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 preceding 3 years

$PY_{(t-1)}$ = 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" distribution, and all variables are expressed in logarithmic form.

The level of variance of output explained is high, due in large part to inclusion of area sown.However, this and the lagged price of cattle are the only two significant variables. The lagged price of cattle carries a positive sign. Much of the upland rice comes from the North Coast and Piedmont areas of the Llanos. In these areas cattle competes with upland rice for land.However, higher cattle prices stimulate the demand for greater areas of pasture; and as rice is frequently used as a transition crop in the clearing of land and establishment of pasture,then the positive relationship between cattle prices and upland rice otuput is as expected. The cassava and maize coefficients have the expected negative signs, but the price of sesame has a positive, but nonsignificant coefficient.*

The estimated price elasticity of supply of upland rice (ϵ_U) is 0.01, but the coefficient is not significantly different from zero. While we have preferred a more intuitive approach (described below) to estimating (ϵ_U) and (ϵ_I), these results do suggest that the elasticity of upland rice supply is probably low and almost certainly lower than the elasticity of supply of irrigated output.

As the proportion (α) of output coming from the irrigated sector changed from 50 to 90 percent over the period 1964-1974, three subperiods were selected and the average value of α taken for each subperiod (Table 32). We now argue that

$$\epsilon_I > \epsilon > \epsilon_U$$

and from equation (5.30), we can derive the two boundary values of ϵ_I corresponding to $\epsilon_U = 0$ and $\epsilon_U = \epsilon_I$, in each of the three subperiods. The midpoint of the possible range of values for ϵ_I was arbitrarily chosen and the corresponding values of ϵ_U calculated. The results are shown in Table 33 for the preferred estimate of $\epsilon = 0.235$, and in Table 34 for a value of $\epsilon = 1.500$. Appendix Table 15 presents the six sets of elasticity values which are used in the sensitivity analysis.

Table 32. **Proportion of rice production from the irrigated sector: Colombia (1964-1974); three subperiods.**

Subperiod	Av proportion of total output from the irrigated sector* (α)
1964-1967	0.58
1968-1971	0.73
1972-1974	0.87

* From Table 11

*Gutiérrez and Hertford (1974) found a similar result in their equation for total rice supply.

Table 33. **Values of supply elasticities for three subperiods: $\epsilon = 0.235$.**

Subperiod	α	Value of ϵ_I when $\epsilon_U = 0$	$\epsilon_U = \epsilon_I$	Midpoint ϵ_I	Implied value* of ϵ_U
1964-1967	0.58	0.405	0.235	0.320	0.118
1968-1971	0.73	0.73	0.322	0.279	0.116
1972-1974	0.87	0.87	0.270	0.235	0.115

* From equation (5.30)

Table 34. **Values of supply elasticities for three subperiods:$\epsilon = 1.500$.**

Subperiod	α	Value of when $\epsilon_U = \epsilon 0$	$\epsilon_U = \epsilon_I$	Midpoint ϵ_I	Implied value* of ϵ_U
1964-1967	0.58	2.586	1.500	2.043	0.750
1968-1971	0.73	2.055	1.500	1.778	0.748
1972-1974	0.87	1.724	1.500	1.612	0.750

* From equation (5.30)

6. GROSS BENEFITS, COSTS AND NET BENEFITS OF HYV's IN COLOMBIA

6.1 Gross benefits

The model presented in equations (5.10) to (5.15) was estimated; and using this set of equations for each year from 1964 to 1974, the gross benefits to consumers and producers (upland and irrigated) were calculated using (5.3), (5.8) and (5.9), respectively. The data used for the quantities of rice are from Table 11, and for deflated farm prices (expressed in 1964 pesos) from Table 14. The total gross benefits are given by the sum of consumer and producer (upland and irrigated) benefits.

The results are shown in Table 35 for the preferred elasticity estimates ($\eta = -0.449$ and $\epsilon = 0.235$). Results for the other five combinations of elasticities are shown in Appendix Table 16.

In Table 36, we compare our "most likely" estimates (for $\eta = -0.449$ and $\epsilon = 0.235$) with the "intermediate" estimates given by Ardila (1973, p. 132). Both sets are expressed in \$(Col.)m. 1964. Despite a number of differences in the assumptions underlying the two studies, the total gross benefits are remarkably similar. However, the distribution between consumers and producers is markedly different in the two studies due to different values of the elasticity of demand. Ardila used a value of −1.372 (from Gutiérrez and Hertford, 1974), while the "preferred" value in this study is −0.449. The consequence of this difference is that Ardila attributes 80 percent of the total gross benefits to producers and 20 percent to consumers, while in the present study "benefits" to producers are always negative, implying foregone incomes (Table 35). Consumer benefits are positive because in the absence of HYV's, the volume of rice reaching the domestic market would have been much lower, and hence the internal price (P_3 in Figure 6) would have been very much higher. However, precisely for the same reason, producers as a whole have foregone returns to fixed factors (land and entrepreneurial skills). With the rapid expansion in output engendered by the HYV's, prices received by producers were much lower than they would have been in the absence of HYV's. Both upland and irrigated producers have foregone income as a result of the introduction of HYV's. This result

Table 35. **Gross benefits* to consumers and producers of new rice varieties in Colombia (η = -0.449 and ϵ = 0.235).**

Year	Consumer gains	Foregone income to producers			Total gross benefits
		Upland	Irrigated	Total	
	($m)				
1964	3.0	– 1.1	– 0.9	– 2.0	1.0
1965	19.4	– 8.0	– 4.4	– 12.4	7.0
1966	0.0	0.0	0.0	0.0	0.0
1967	63.0	– 27.1	– 14.6	– 41.7	21.3
1968	823.6	– 304.1	– 207.9	– 512.0	311.6
1969	495.0	– 177.2	– 140.5	– 317.7	177.3
1970	806.3	– 256.7	– 246.2	– 502.9	303.4
1971	1,228.0	– 302.2	– 453.2	– 755.4	472.6
1972	2,341.8	– 550.8	– 855.2	– 1,406.0	938.8
1973	3,826.1	– 850.6	– 1,377.6	– 2,228.2	1,597.8
1974	9,340.0	– 1,917.4	– 3,536.0	– 5,353.4	3,986.6

* Expressed in 1964 pesos

should in no way be construed as meaning that rice producers "lost money" due to the introduction of HYV's. Obviously, if the production of HYV's had not been "profitable," their expansion to almost 100 percent of the irrigated area would not have occurred. As noted in Section 4.5, real production cost per ton fell due to introduction of HYV's. All we can legitimately conclude is that in the absence of HYV's, the price of rice in Colombia would have presumably been very much higher;

Table 36. **Comparison of preferred estimates of total gross benefits* with those presented by Ardila (1973).**

Year	Present study	Ardila (1973) intermediate level
	($m)	
1964	1.0	30.0
1965	7.0	15.4
1966	0.0	1.1
1967	21.3	18.8
1968	311.6	213.9
1969	177.3	212.8
1970	403.5	290.3
1971	472.6	454.7
Total	1,294.3	1,237.0

* Expressed in 1964 pesos

in that case the net incomes of producers would have been higher by the amount shown in Table 35. In spite of the foregone income to producres, the gross benefits to Colombia as a whole (producers plus consumers) have been positive and substantial.

6.2 Estimates of the quantity and gross value of additional rice due to HYV's

The model presented graphically in Figure 6 can be simplified by considering only the total supply curves (S'TR and STR) and assuming equilibrium prices prevailed in each year.

Figure 8 shows this simplified form where P_1 and Q_1, and P_0 and Q_0 refer to prices and quantities, with and without the new varieties, respectively. The quantity Q_2 corresponds to OE in Figure 6 and is the quantity produced without HYV's, assuming actual prices. What is of interest is the quantity Q_0 which can be estimated by

$$Q_0 = Q_1 - (Q_1 - Q_2) \cdot [1 - (\epsilon/\eta)]^{-1} \quad (6.1)$$

Using our preferred elasticity estimates of 0.235 and −0.449 for ϵ and η, respectively, the quantity Q_0 is shown in Table 37; $Q_1 - Q_0$ is then the additional production due to HYV's. It was valued at the export prices received by Latin American exporters and over the period 1964-1974, and totalled $(US)350m (in 1974 dollars). Between 1967 and 1972 the estimated value of additional production was $(US)127 m, compared to an estimate of $(US)100m for the same period made by Jennings (1974, p. 1086).

6.3 Costs of rice research

In this section, the estimates of the costs of rice research in Colombia are explained and presented. There is a limitation to these estimates which must be emphasized at the outset. No attempt is made to include any costs incurred by the International Rice Research Institute (IRRI) in the development of IR-8 and IR-22, which occupied up to almost 60 percent of the area sown to HYV's in Colombia. Hence for these varieties we will overstate the net benefits, by allowing their contribution to production without discounting their full costs. However, if the measurement of net benefits is viewed from Colombia's standpoint, then it is valid to include only those costs incurred by Colombia in testing, multiplying and releasing the IRRI materials.

The total costs are based on expenditures by three entities:

1. The National Rice Program of ICA

2. The contribution of the growers through FEDEARROZ under Ley 101 of 1963, which created the **Cuota de Fomento Arrocera**. This law authorizes the collection of $0.01/kg from growers. All rice buyers are responsible for deducting it

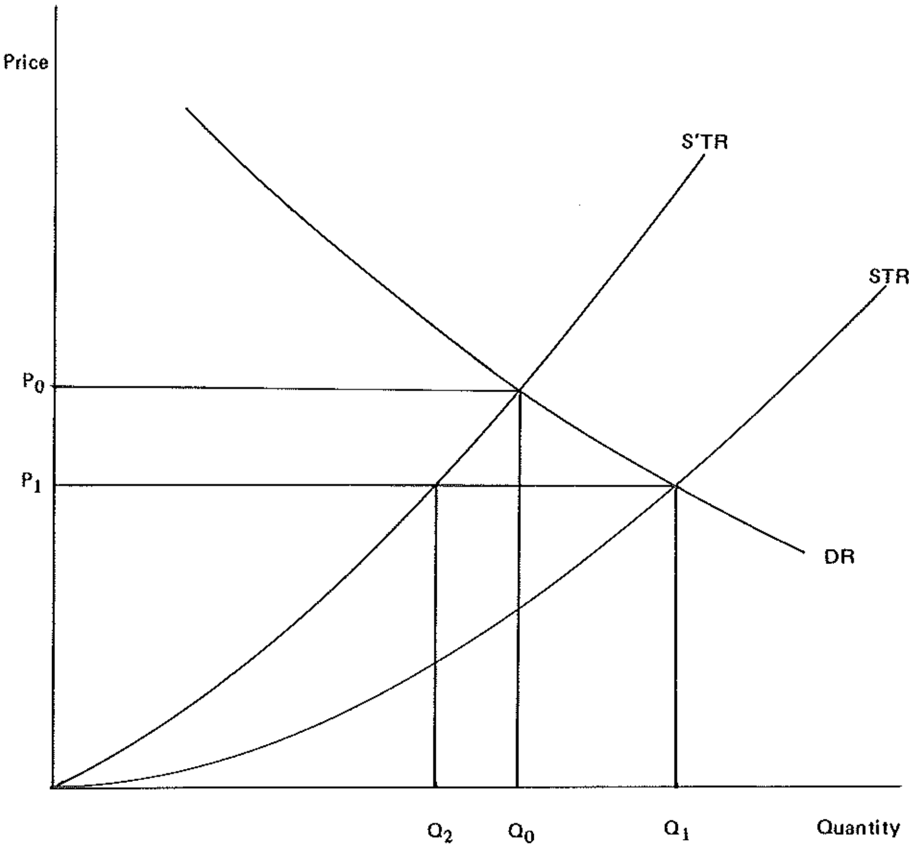

Figure 8. Simplified model showing impact of HYV's on equilibrium prices and quantities of rice.

from growers' receipts. The law authorizes FEDEARROZ to administer this fund, and it is used for support of research, regional testing, publishing technical bulletins, presenting training courses to field agronomists, and financing the Technical Division of FEDEARROZ.

3. International Cooperation.*

The data for these three categories, respectively, were obtained as follows:

*In including the costs of International Cooperation, we apparently contradict the previous argument that "only those costs incurred by Colombia" should be included. The assumption is, however, that had those externally provided funds not gone to rice research that would have been available to Colombia for investment in other areas with a similar payoff; i.e., they did have an opportunity cost for Colombia.

Table 37. **Estimates of the quantity and gross value of additional rice production in Colombia due to HYV's 1964-1974.**

Year	Actual prod.[1]	Estimated prod. without HYV's at actual prices[2]	Estimated prod. without HYV's at equilibrium[3]	Additional prod.[4]	Price received by Latin American exporters	Value of additional prod.
	(m.t.)				$(US)/m.t.	$(US)m.
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 the series to $(Col.) 1964, instead of his $(Col.) 1958; for 1971-1974, unpublished data supplied directly by ICA*

2. Based on a constant collection rate of 45 percent (FEDEARROZ, 1975), for the period 1963-1974

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

The costs for each of the three categories are shown by years in Table 38. It is interesting to note that the producer contributions (through FEDEARROZ) began at a time when new varieties were being released by ICA but before the significant production increases came from the new varieties.

Table 38. **Costs* of rice research program in Colombia 1957-1974.**

Year	Source			Total
	ICA	FEDEARROZ	International cooperation	
	($m)			
1957	0.03	0.00	0.00	0.03
1958	0.11	0.00	0.27	0.38
1959	0.20	0.00	0.26	0.46
1960	0.31	0.00	0.25	0.56
1961	0.69	0.00	0.15	0.84
1962	0.62	0.00	0.06	0.68
1963	0.28	2.91	0.06	3.25
1964	0.61	2.70	0.06	3.37
1965	0.79	2.83	0.06	3.68
1966	0.82	2.45	0.06	3.33
1967	1.33	2.21	0.06	3.60
1968	1.49	2.44	0.06	3.99
1969	2.67	2.02	1.25	5.94
1970	2.78	2.05	2.58	7.41
1971	1.69	2.20	4.68	8.57
1972	1.58	2.23	3.90	7.71
1973	1.38	2.06	2.67	6.11
1974	1.31	2.19	2.41	5.91

* Expressed in 1964 pesos

*Personal communication, División de Presupuesto y Finanzas, Sección Ejecución y Análisis Presupuestal, December 18, 1975.

Table 39. **Investment* in rice research per ton of irrigated paddy rice production in Colombia (1957-1974).**

Year	Excluding international cooperation	Total
	($/m.t.)	
1957	0.14	0.14
1958	0.47	1.64
1959	0.83	1.90
1960	1.18	2.13
1961	2.52	3.08
1962	1.75	1.93
1963	9.28	9.45
1964	8.60	8.76
1965	9.14	9.29
1966	9.58	9.76
1967	9.30	9.45
1968	7.34	7.45
1969	9.89	12.53
1970	8.72	13.37
1971	5.32	11.73
1972	4.32	8.73
1973	3.37	5.98
1974	2.46	4.16

* Expressed in 1964 pesos

To obtain a more meaningful view of the trends in investment in rice research, Table 39 was constructed, showing the amount invested per ton of irrigated paddy production. The results clearly demonstrate the intensified program built up with Colombian resources during the 1960's. Recently, there has been a decline in the volume of real resources devoted to rice research per unit of rice output. The data for total investment in research per ton of irrigated paddy production show a marked rise in the late 1960's during the intensive period of development of Colombian varieties. It is notable that the total investment per unit output has fallen over the last four years, as the irrigated area sown to new varieties reached saturation. Were it not for the problem of decaying resistance to rice blast disease, then one might expect this to remain stable or ever decline further in the future.

6.4 Net benefits and rates of return

Table 40 presents the flows of net benefits from 1957 to 1974, under each of the six elasticity estimates examined. Net benefits were calculated by subtracting the cost (Table 38) from each of the corresponding flows of gross benefits (Table 35 and Appendix Table 15). The 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
1971	8.57	638.73	486.33	464.03	311.73	359.73	207.43
1972	7.71	1,564.39	1,333.89	931.09	700.49	622.19	391.69
1973	6.11	2,953.19	2,703.79	1,591.69	1,342.29	997.59	748.09
1974	5.91	9,051.69	8,626.79	3,980.69	3,555.79	2,173.59	1,748.69
Internal rate of return (%)		101	96	94	87	89	79
Benefit/cost ratio		148	133	77	63	51	35

1 Expressed in 1964 pesos
2 From Table 38
3 η = Price elasticity of demand for rice
4 ϵ = Price elasticity of supply for rice

included the costs of the national rice program of ICA since its inception in 1957. This was done as the investments in research and training during those early years undoubtedly contributed to the development and spread of subsequently released varieties.

Since 1968 the net benefits have grown substantially, reaching almost $4,000m in 1974 for the preferred set of elasticities. The analysis of the sensitivity of the results to different elasticity estimates shows that the value used for the price elasticity of supply of rice is not very crucial. The two widely disparate values tested (0.235, the preferred value, and 1.5) only made a difference of 10 percent in net benefits in 1974 when the preferred demand elasticity (−0.449) was used. The results are more sensitive to changes in the demand elasticity. Higher values reduce the net benefits accrued to consumers. An infinitely elastic demand would result in no benefits to Colombian consumers; such is the case for a crop that is totally exported.

Two measures of the efficiency of the investment in rice research are also shown in Table 40. The Internal Rate of Return is that rate which reduces the present value of the flow of net benefits to zero.* It is a measure of the profitability of the investment of public and private funds in rice reserach. "An internal rate of return of 20 percent, for example, means that, on average, each dollar invested returns 20 cents per year from the time it is invested until the cut off date" (Peterson, 1967, p. 664).

For the preferred elasticities, the Internal Rate of Return was 94 percent. Given that one estimate (Harberger, 1972, p. 155) that the social opportunity cost of public funds in Colombia is between 10 and 11 percent, there is little doubt that the program represented a highly efficient use of funds.

Table 40 also shows the benefit/cost ratio** as an alternative measure of the pro-

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*The mathematical definition of the Internal Rate of Return is that rate p which makes

$$\sum_{i=1}^{n} (\text{Net Benefits})_i \, (1 + \rho)^{-i} = 0$$

It is recognized that when more than one sign change occurs in the net benefit stream (as in the case of Table 40), there is a problem of multiple solutions to this equation (Hirshleifer 1970, p. 77). In fact, the net benefit streams of Table 40 theoretically have two Internal Rates of Return which satisfy the above equation. However, in this case the perturbation below zero in 1966 is so slight that eliminating it (by reversing the signs for 1965 and 1966) makes no detectable difference in the Internal Rates of Return shown in Table 40.

The analysis was conducted for the 30-year period 1957-1986. The level of net benefits for 1974 was assumed to continue throughout the period 1975-1986. This simply implies that were the 1974 level of expenditures to be continued until 1986, they would continue to generate the level of gross benefits observed in 1974. In fact, because the above equation involves discounting all the values back to 1957 and the rates of return are all high, the results are very insensitive to the assumptions made concerning future costs and benefits.

**Calculated as the ratio of the present value of Gross Benefits to the present value of Research Costs, using a discount factor of 10 percent (Harberger, 1972, p. 155).

fitability of the program. Its value of 77 reinforces the conclusions with regard to the social efficiency of this program. Finally, whichever measure of profitability is used and whichever combination of elasticities chosen, the social profitability of the program, in terms of efficient use of scarce resources, has apparently been extremely high.*

*These high returns are not uncommon in agricultural research. Ayer and Schuh (1972, p. 581) report an internal rate of return of 89 percent for cotton in São Paulo, Brazil; Akino and Hayami (1975, p. 8) report values up to 75 percent for rice in Japan; Peterson (1967, p. 669) reports 20 to 30 percent for poultry in the U.S.A.; Barletta (1974) reports 75 percent for wheat in Mexico; Griliches (1958) reports 35 percent for corn in the U.S.A.; Ardila (1973) reports 58 to 82 percent for rice in Colombia up until 1971; and Montes (1973) reports 76 to 96 percent for soybeans in Colombia.

7. DISTRIBUTION OF NET BENEFITS

7.1 Introduction

In this chapter, we address the question of the distribution of the net benefits; i.e.,the equity question. Simply stated, we are asking which groups in society benefited the most from the technological change in the Colombian rice industry. In answering this question, considerable limitations in the available data were encountered, requiring several important assumptions; these should be borne in mind in reviewing the results. Partly for this reason, the procedures are explained in some detail. In addition, it is believed that this is the first study to address the distribution of net benefits on a national basis, certainly with respect to income levels.

7.2 Distribution of benefits and costs by sectors

The first set of results is presented in Table 41, which gives a summary of the gross benefits, costs of the research program and the net benefits for various groups of society. The figures for gross benefits are based on the benefits shown in Table 35 for the preferred set of elasticity estimates. The values in Table 41 are the sum of the benefits for the period 1964-1974, expressed in $(Col.) m. 1970, compounding forward the years 1964-1969 and discounting back the years 1971-1974, both using Harberger's estimate of 10 percent for the real rate of return on capital in Colombia (1972, p. 155).

In a similar manner the costs of the research from the three sources (ICA, FEDEARROZ and International Cooperation) from Table 38 were summed and are shown in Table 41. The costs of the ICA program were assumed to come from general tax revenue and divided between consumers and producers on the basis of urban and rural proportions of total tax revenues in 1970 (Jallade, 1974, Tables 3.4 and 3.6, pp. 26-27). The producer contribution was further broken down between upland and irrigated producers on the basis of the production coming from each sector in 1970. The contributions from FEDEARROZ were distributed between the upland and irrigated sectors, assuming a 45 percent collection rate of one centavo per kg from all producers, except 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	–

* All data expressed in $m. 1970

ducers with less than 10 ha. Expressed in 1970 pesos, $(Col.) 81.6 m. were devoted to rice research between 1957 and 1974. The contributions were made in the following proportions:

	%
Consumers:	27
Producers:	50
Irrigated:	39
Upland:	11
International:	23
Total:	100

In view of the fact that producers' incomes would have been higher in the absence of the rapid technological change, it is pertinent to inquire why 50 percent of the research costs were borne by producers themselves. Were they simply contributing to their own economic demise? And if so, does this not imply irrational behavior on their part? The answer lies, in part at least, with the discussion of the "agricultural treadmill" hypothesis in Section 4.5. Colombian rice production is dominated by large, progressive irrigated producers (see Section 4.10), who founded and continue to support FEDEARROZ. Amongst these producers are undoubtedly a high porportion of "early adopters" who gain, at least temporarily, from the rapid adoption of new agricultural technology. The extensive network of technical advisors that is maintained by FEDEARROZ is an important source of information to members, not only regarding new varieties but also with respect to a wide range of cultural practices. By supporting FEDEARROZ, these growers have rapid access to the latest technical information regarding rice production, and the continually evolving and dynamic nature of rice technology means that they can repeatedly be amongst the early adopters of any cost-reducing technologies. Hence given that there are continual gains to be made from the rapid adoption of both varieties and, equally importantly, optimal cultural practices, financial support of FEDEARROZ is not an irrational decision for a rice producer. The rapid postwar growth of private, grower-financed Farm Management Clubs in the U.K., Australia and New Zealand, is a parallel phenomenon.

Consumer contributions (through tax-financed support of public research) are consistent with an industrially dominated body politik, which captures the benefits of a cheap food policy through lower wages in the manufacturing sector (as discussed below in Section 7.4).

7.3 Distribution of benefits and costs by income level

To evaluate the distributional impacts of the technological change, the gross benefits, the costs of the research program and the consequent net benefits were distributed across income groups for consumers, and upland and irrigated producers. In each case the annual average impact (benefits and costs) for 1970 was estimated. The total in each case was the sum of the gross benefits or costs expressed in 1970 pesos and divided by the appropriate number of years.

Gross benefits to consumers were assumed to be directly proportional to the quantity of rice consumed. The research costs (paid through taxes) borne by consumers were distributed on the basis of the proportion of total tax receipts from each income strata in the urban sector. The results, showing the net benefit to consumers by income level, are shown in Table 42.

The distribution of gross benefits to producers (in this case, foregone income) for each size group was calculated by assuming the foregone income was proportional to total production in each group. The results together with the average annual "losses" per farm are shown in Table 43. The costs of rice research borne by producers, by size group, are shown in Table 44. The ICA costs were distributed on the basis of the proportion of production from each size group, assuming the tax contributions were proportional to output. The distribution of the FEDEARROZ costs has already been discussed. Table 44 also shows the annual average costs per farm. Combining the results for gross benefits per farm (Table 43) with research costs per farm (Table 44) gives the distribution of net benefits by size group (Table 45).

One further step is required in order to estimate the distribution of these net "benefits" in relation to producer income. Ideally, income distributions are required for upland and irrigated rice producers by size of farm. As no such data are known to exist, resort was made to a distribution of rural income by farm size for 1960 (Berry, 1974, p. 610). The income data were inflated to 1970 values using the Price Index shown in Table 14. We have no basis for knowing whether rice producers would have higher or lower incomes than the rural average for each farm size group. However, our principal interest is in the relative distribution of benefits by income level, rather than in the absolute income levels. Table 46 shows the annual average "net producer benefits" (negative) as a percentage of the average income level corresponding to each size group.

The consumer net benefits shown in Table 42 (last column) were converted to a per household basis, by dividing the number of households in each income group (Jallande, 1974, p. 22). Both rural and urban households were included, as the rural sector is also a rice consumer.* The average annual net benefits per household (first column, Table 47) were then expressed as a percentage of 1970 household income for each income group (second column, Table 47).

The net benefits to consumers were positive for all levels of income. The absolute annual average net benefits tend to decline at higher income levels, after reaching a peak in the second-to-lowest income group. As a percentage of household income, the net benefits accrued most significantly to the lowest income groups, indicating that the technological change in rice favored the lowest income households both absolutely and relatively. The relative distribution of consumer benefits by income level is shown in Figure 9. In Figure 10, the cumulative distribution of net benefits

*This assumes that the rice consumption patterns in the rural areas correspond to the urban data shown in Table 42.

One study of rural food consumption reports that in a nonrice-growing rural area, 10 percent of calories and proteins in the average family diet came from rice (Swanberg and Shipley, 1975). These data are only slightly below the urban figures reported in Section 4.1. Other rice producing areas and traditional consuming areas such as the Atlantic Coast could be expected to have higher levels of rice consumption.

Table 42. Distribution of gross benefits, researchcostsand net benefits to consumers by level of income (1970).

Level of Income*	°/o of total rice consumed**	°/o of total taxes paid***	Gross benefits	Research costs	Net benefits
($)	(°/o)	(°/o)	($m)	($)	($m)
0 – 1,000	0.3	–	4.1	–	4.1
1,001 – 2,000	1.0	0.02	13.6	245	13.6
2,001 – 3,000	2.5	0.03	34.0	368	34.0
3,001 – 4,000	3.8	0.04	51.6	491	51.6
4,001 – 6,000	10.5	0.10	142.6	1,227	142.6
6,001 – 8,000	13.4	0.65	182.0	7,980	182.1
8,001 – 10,000	10.4	0.48	141.2	5,893	141.3
10,001 – 12,000	8.3	0.35	112.7	4,297	112.7
12,001 – 14,000	6.5	1.42	88.3	17,434	88.3
14,001 – 16,000	6.7	1.35	91.0	16,574	91.1
16,001 – 18,000	4.0	0.78	54.3	9.576	54.3
18,001 – 20,000	3.6	2.07	48.9	25,414	48.9
20,001 – 24,000	6.1	3.27	82.8	40,148	82.8
24,001 – 28,000	5.0	5.28	67.9	64,826	67.9
28,001 – 32,000	2.2	2.86	29.9	35.114	29.9
32,001 – 36,000	3.4	3.20	46.2	39,288	46.2
36,001 – 40,000	1.9	2.02	25.8	24,801	25.8
40,001 – 48,000	3.3	3.34	44.8	41,007	44.8
48,001 – 58,000	2.2	8.33	29.9	102,273	29.9
58,001 – 68,000	0.9	4.50	12.2	55,249	12.2
68,001 – 80,000	1.3	4.36	17.7	53,531	17.7
80,001 – +	2.7	55.55	36.6	682,031	35.6
Totals	100.0	100.00	1,358.1	1.227,777	1,356.9

* Less than 0.01°/o
** From unpublished DANE data relating to Encuesta de Hogares (householdsurvey)
*** Estimated from Jallende (1974)

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
40 – 50	– 154.0	– 8,475	– 101.4	– 12,786
50 – 100	– 542.3	– 10,392	– 390.1	– 17,216
100 – 200	– 477.9	– 17,483	– 994.9	– 35,331
200 – 500	– 451.7	– 20,169	– 1,065.6	– 90,961
500 – 1,000	– 248.3	– 59,401	– 757.7	– 196,245
1,000 – 2,500	– 142.2	– 98,681	– 790.6	– 260,409
2,500 – +	– 119.8	– 162,550	– 813.5	– 535,902
Totals	– 3,542.1	– 8,901	– 5,292.9	– 37,595

Table 44. Distribution of annual average research costs borne by producers by farm size: total and per farm (1970).

Farm size (ha)	Average annual research costs ($)			Average annual total costs per farm ($)		
	Upland	Irrigated	Total	Upland	Irrigated	Total
0 – 1	202	527	729	*	3	a
1 – 2	607	2,633	3,240	*	5	1
2 – 3	809	2,107	2,916	1	5	1
3 – 4	758	2,282	3,040	1	9	1
4 – 5	758	4,213	4,971	1	14	3
5 – 10	2,356	14,220	16,546	1	16	3
10 – 20	44,641	36,516	81,157	10	27	14
20 – 30	38,877	30,371	69,248	15	33	20
30 – 40	30,940	32,829	63,769	16	40	23
40 – 50	27,806	33,707	61,513	17	47	26
50 – 100	97,926	129,384	227,310	21	63	33
100 – 200	86,298	330,045	416.343	35	129	83
200 – 500	81,546	353,393	434,939	40	332	140
500 – 1,000	44,843	251,396	296,239	118	716	405
1,000 – 2,500	25,632	262,280	287,912	196	950	707
2,500 – +	21,587	269,653	291,240	322	1,954	1,421
Totals	505,556	1,756,556	2,261,112	14	137	46

* Less than $0.50 per farm

Table 45. Distribution of annual average net benefits per farm by farm size, by sector.

Farm size (ha)	Upland	Irrigated	Total
	($)	($)	($)
0 – 1	–876	–845	–610
1 – 2	–1,943	–1,411	–1,337
2 – 3	–3,222	–1,347	–2,055
3 – 4	–4,653	–2,479	–3,037
4 – 5	–5,519	–3,924	–3,824
5 – 10	–6,137	–4,423	–4,274
10 – 20	–7,513	–7,390	–5,923
20 – 30	–7,744	–9,065	–6,639
30 – 40	–8,139	–11,092	–7,823
40 – 50	–8,492	–12,833	–8,673
50 – 100	–10,413	–17,279	–11,205
100 – 200	–17,518	–35,460	–27,781
200 – 500	–20,209	–91,293	–47,251
500 – 1,000	–59,519	–196,961	–136,557
1,000 – 2,500	–98,887	–261,359	–238,701
2,500 – +	–162,872	–637,856	–479,913
Totals	–8,915	–37,732	–16,051

with respect to the cumulative percentage of households is compared with Colombian income distribution. In this type of graphical analysis (a Lorenz curve), curves falling, above or below the 45° line show an unequal distribution of income; the greater the distance from the line of perfect equality, the greater the inequality in the distribution. The graph can be interpreted as follows: 25 percent of households (an arbitrary point marked on the graph) received 4 percent of the income in Colombia but captured 28 percent of the net benefits due to new rice varieties. Another reading (not marked) is that 50 percent of the households received 14 percent of the income but captured 64 percent of the benefits.

Turning to producers, the group most severely affected was the small (i.e., low-income) upland producers. For these producers, the annual average income foregone through lower rice prices (and no compensating technological change) represented a high proportion of their assumed 1970 income, to the extent that if their actual incomes had been below the rural sector average, this impact would have been even more pronounced. On the other hand, the foregone income to the irrigated producers varied more erratically depending on the size group, with the heaviest relative burdens

Table 46. Average annual net losses to producers as a percentage of 1970 income by sector.

Farm size (ha)	Av Income*		Av annual net losses as a o/o of 1970 income (o/o)		
			Upland	Irrigated	Total
0 – 1	1.	1,500**	58	56	41
1 – 2	2.	3,647	53	39	37
2 – 3	3.	5,330	60	25	39
3 – 4	4.	6,508	71	38	47
4 – 5	5.	7,406	75	53	52
5 – 10	6.	10,295	60	43	42
10 – 20	7.	15,652	48	47	38
20 – 30	8.	18,934	41	48	35
30 – 40	9.	23,394	35	47	33
40 – 50	10.	28,620	30	45	30
50 – 100	11.	35,904	29	48	31
100 – 200	12.	66,759	26	53	41
200 – 500	13.	115,398	18	79	41
500 – 1,000	14.	287,513	21	69	47
1,000 – 2,000	15.	532,389	19	49	45
2,000 – +	16.	1,480,199	11	36	32

* From Berry (1974, p.610), adjusted to 1970
** Assumed value

Table 47 . Annual average net benefits to consumers by income level.

Income group* ($)	Av annual net benefits ($)	Net benefits as $^o/o$ of income ($^o/o$)
1. 0 – 6,000	385	12.8
2. 6,001 – 12,000	642	7.1
3. 12,001 – 18,000	530	3.5
4. 18,001 – 24,000	333	1.6
5. 24,001 – 30,000	348	1.3
6. 30,001 – 36,000	353	1.2
7. 36,001 – 48,000	342	0.8
8. 48,001 – 60,000	200	0.4
9. 60,001 – 72,000	128	0.2
10. 72,001 – 84,000	232	0.3
11. 84,000 – +	135	0.1

* The distribution shown in Table 42 had to be reduced to that shown in this table, as the no. of households per income group was not available for the more detailed distribution.

falling on the 200-1,000 hectares group. However, the absolute impact may well be overstated if irrigated producers had incomes above the national average for rural income earners. Figure 11 shows the distributional impact on producers.

In conclusion, the positive benefits of the technological change all accrued to consumers, with the lowest income households receiving the largest gain, absolutely and relatively. The foregone income to producers appeared to fall most heavily on the small upland producers. Even if the average annual consumer benefits are included as benefits to upland producers, the small upland producer still appears as the most severely affected.

7.4 Foreign trade, technological change and income distribution

It has been demonstrated that the net benefits of the new rice varieties were captured by Colombian consumers, with a disparate share going to low-income consumers.

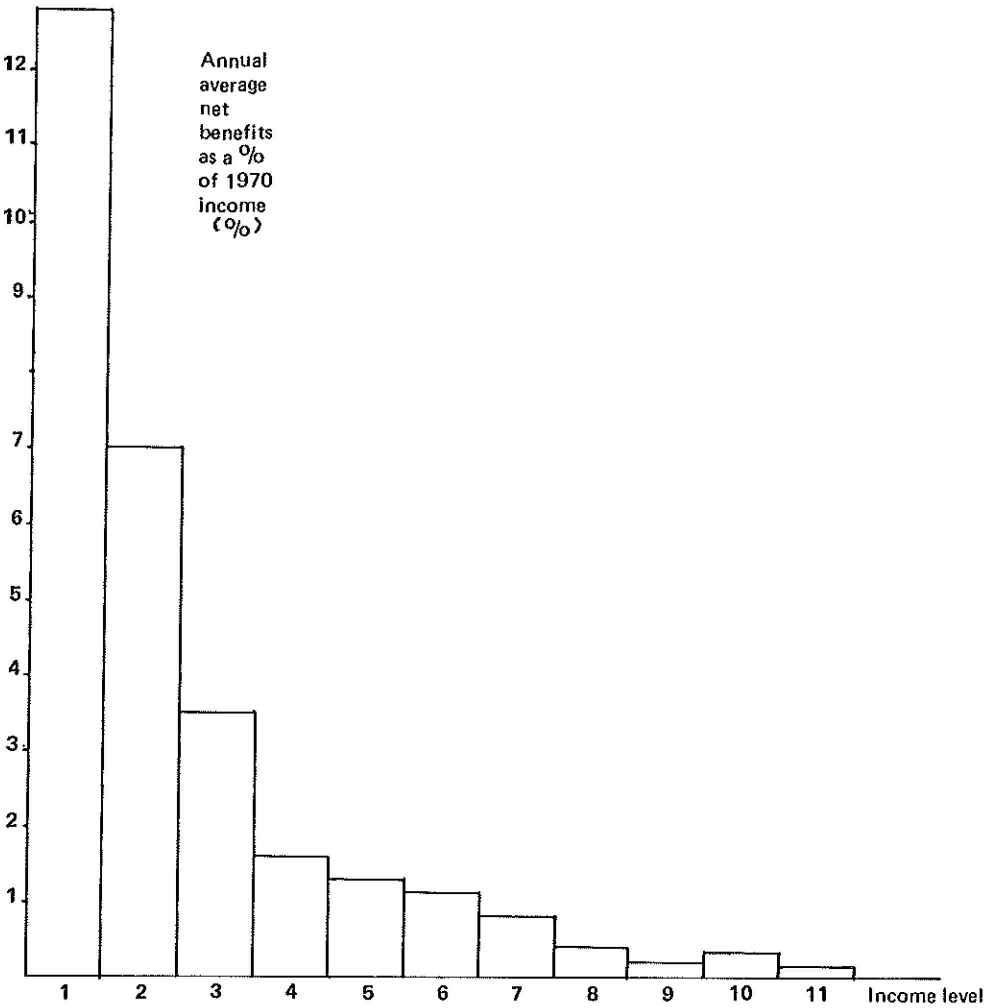

Figure 9. **Distribution of annual average net benefits to consumers by level of income.**

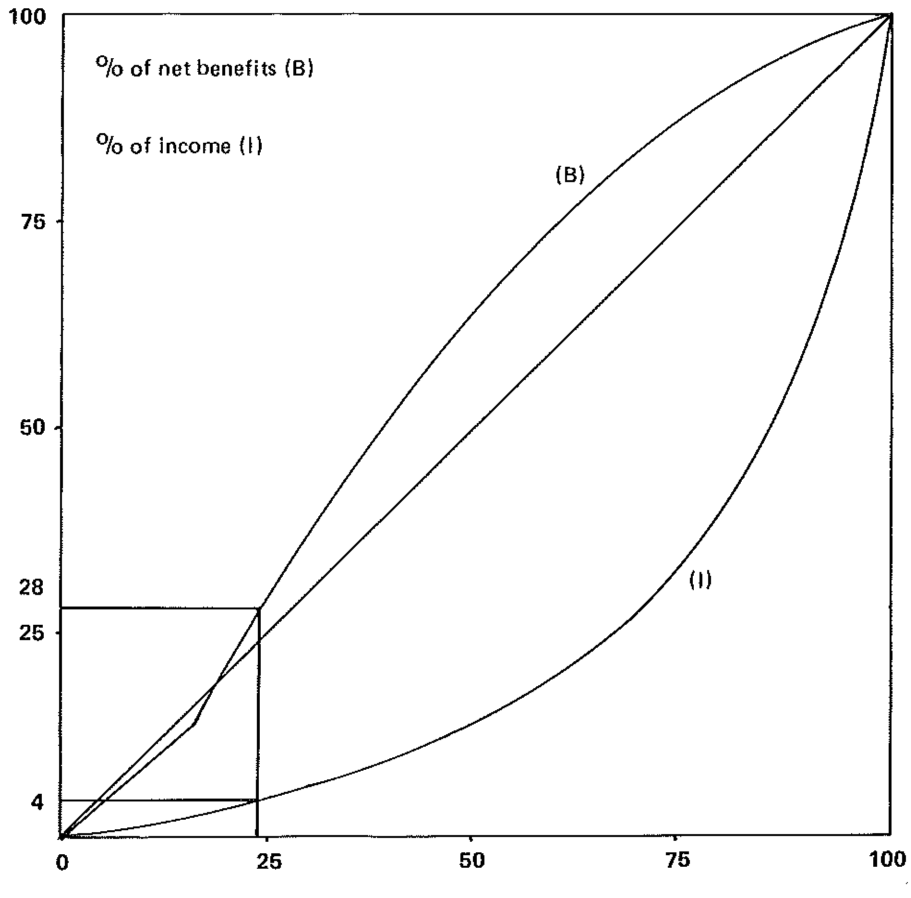

Figure 10. **Distribution of income and net consumer benefits from HYV's in Colombia.**

The net income of rice producers would have been higher* in the absence of the HYV's. It is of interest to inquire why this pattrrn of distribution resulted; was it the result of a deliberate policy to use agricultural research as a vehicle for changing the income distribution in favor of low-income consumers, or was it a result of a particular set of economic policies in operation at that time, not necessarily or directly connected to rice production and consumption? The following discussion is presented in the hope of shedding some light on these questions; the answers would appear to be of importance to those concerned with the planning and funding of both national

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

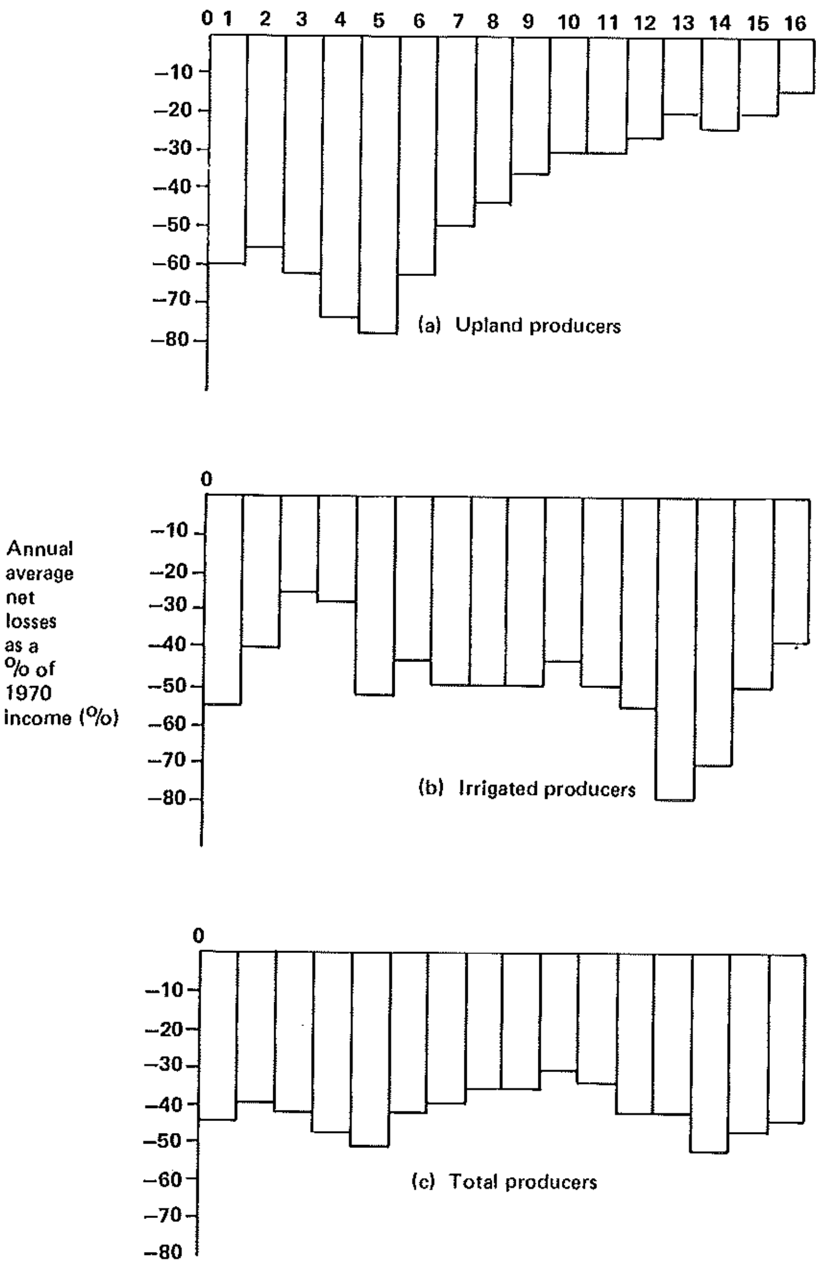

Figure 11. Distribution of annual average net losses to producers by level of income.

and international agricultural research programs, whenever equity criteria are used for establishing research priorities.[1] .

The basic premise adopted here is that the distributional outcome of the new rice technology in Colombia was principally a result of the set economic policies adopted at the national level, not directly related to the rice sector. Specifically, it is argued that Colombia's industrial protection policy, through the use of tariffs against imported manufactured goods, has a three-pronged bias against the agricultural sector, including, of course, the rice-production sector. In the first place, the prices of manufactured inputs used by agriculture are raised. Secondly, returns to investment in manufacturing are augmented by the tariff barriers, encouraging more domestic resources to flow into the industrial sector. Their availability to agriculture is thereby reduced, or alternatively, their prices are inflated, making the generally unprotected agricultural sector less competitive. Finally, and most importantly, in the present context, the price of foreign exchange could be maintained artificially low,[2] implying that agricultural exports are less attractive. This bias against the agricultural sector has been widely noted. Little et al. (1970, pp. 177-178) note that "protection of manufacturing produces a bias against agriculture, in that it reduces resources available for agricultural investment, as well as reducing the incentive to produce and sell, especially as far as exports are concerned. . .. Our view is that the bias has been excessive; that in several of the countries[3] the effect on agricultural production has been damaging, and that agricultural exports earned less than they should have done in most countries."

It is believed that the Colombian case conforms to this general situation. Certainly, virtually no rice was exported[4] during the period of rapid expansion of output (1968-1974) which accompanied the introduction of HYV's. It is hypothesized that this lack of exports was due to the relatively unattractive exchange rates offered to potential rice exporters, as a result of the industrial protection policy. It should also be noted that for an eight-month period ending May 1974, there was a Government ban on rice exports; this could be interpreted as a deliberate consumer-oriented policy.[5]

The set of general economic policies (including tariff protection and the related price of foreign exchange), together with the particular sector or commodity policies

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[1] Ardila and Valderrama (1975) report that the equitable distribution of income is a criterion employed within ICA for selecting projects. Lopes Neto (1975) reports a similar criterion is included "in the definition of priorities and resource allocation for research" (p. 40).

[2] For a model relating the level of industrial protection to the price of foreign exchange, see Scobie and Johnson (1974).

[3] Their study includes three Latin American countries: Brazil, Argentina and Mexico.

[4] Some of the production in 1974 was carried over as stocks into 1975 when Colombia did recommence exporting rice.

[5] At the same time it should be noted that prior to 1974 Colombia maintained a tariff of 45-55 percent against imported rice for consumption, indicative of the vacillation between a consumer-orientated and a producer-orientated rice policy that has typified Government intervention (Leurquin, 1967).

that prevail at any point of time, are a product of continually evolving economic and political forces. These forces are often opposed, reflecting the interests of different groups. Producer organizations are typically concerned with presenting cases for remunerative farm prices and promoting exports. On the other hand, manufacturing groups press for tariff protection and overvalued exchange rates, which have the additional side effect of fostering cheap domestic food supplies (especially in the presence of rapid technological change in agriculture), hence lowering the price of wage goods and indirectly subsidizing the price of labor to the manufacturing sector. As Barroclough (1970, p. 914) notes, rapid urbanization (together with growth in the industrial, banking and financial sectors) has increased the political weight of manufacturing relative to agricultural interests. So that while FEDEARROZ has vigorously represented the interests of rice growers since its inception (Leurquin, 1967, pp. 241-244) and frequently won concessions favoring rice producers, its influence tends to be overridden by national economic strategies promoted by an increasingly powerful entrepreneurial class whose political power base lies less and less with agricultural interests (Dix, 1967). The net result of these forces has been that the benefits of the new rice varieties were captured by consumers, as a result of the cheap food policies which are consistent with, and complementary to, protection of the industrial sector.

As a result of the unfavorable price of foreign exchange, the expanded production was sold almost exclusively on the domestic market. As Harberger (1970, pp. 1007-1008) notes, "the basic principle here, of course, is that each new restriction on imports lowers the equilibrium exchange rate relative to the internal price level, thus reducing the market incentives facing the export trade." With a moderately inelastic domestic demand curve, internal prices fell, resulting in the capture of the net benefits by rice consumers.

In an effort to demonstrate the comparative advantage that Colombia would have had as a rice exporter under a more favorable exchange rate policy, Table 48 was constructed. The shadow price of foreign exchange which reflects the real value of foreign exchange earnings to Colombia has been somewhat arbitrarily taken as 50 percent above the nominal exchange rates prevailing between 1968 and 1974. This value is a subjective estimate based on very sketchy information. Dudley and Sandilands (1975, p. 333) use a value of 40 percent for the period 1963 to 1971*; they refer to a study by Musalem for the period 1950-1970, which proposed shadow rates of 100 percent higher than the nominal buying rate for dollars. The average tariff protection in Colombia in February 1975 was 31 percent (Departamento de Planeación Nacional, 1975, p. 35) but is generally believed to have been substantially reduced since 1970.

The important conclusion of Table 48 is that at a more attractive exchange rate, Colombia would have been able to compete favorably in external markets with other

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* Their estimate is based on a similar value of the level of effective protection given to manufacturing; however, there is no reason to assume that effective protection rate measures directly the overvaluation.See Harberger (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
1972	3,298	34.32	96	164	+ 41	3
1973	4,470	37.34	120	212	+ 43	20
1974	6,121	43.04	145	333	+ 57	1

1 Based on price paid to farmers, plus milling and transport to port
2 Actual rate inflated by 50 % to reflect overvaluation
3 Weighted av export prices received by 6 consistent exporters from Latin America (Nicaragua, Guyana, Surinam, Argentina, Brazil and Uruguay)
4 (4 — 3) /(4) 100

Latin American exporters. However, starting in 1975, the domestic price of rice has fallen to a level which makes exporting attractive, and it is probable that Colombia will now become a consistent rice exporter. This will mean that future benefits of new rice technology will be captured by producers and foreign consumers, rather than by Colombian consumers as has been the case.

8. AN ANALYSIS OF THE MARKETING MARGINS FOR RICE IN COLOMBIA*

8.1 Implications of marketing margins

The role and efficiency of the marketing sector is a question that is continually raised in the context of developing economies. Frequently, the "intermediaries" are denounced either as speculators or performing no real economic function.** Government agricultural marketing policies are then aimed at eliminating the middleman, supposedly avoiding speculation and lowering the price of food to consumers. The following analysis is aimed at examining changes in the rice marketing margins in Colombia and asking to what extent such changes could have been expected as a result of normal competitive economic forces, rather than reflecting an imperfectly competitive structure in the marketing sector, which might call for government intervention.

In Chapter 7, the distribution of benefits to producers and consumers was analyzed. However, there is an additonal link in the production chain which we have not addressed to this point. The production and distribution of milled rice involves transport, storage, insurance, milling, packaging, wholesaling and retailing. We will refer to the totality of these operations as belonging to the marketing sector. This sector can be regarded as simply another production stage in producing the final product, milled rice, in the hands of the eventual consumer. As such, we could construct a model to analyze the producer returns at different levels of the production-marketing sequence.*** Because of insufficient data on the prices and quantities at each stage and over time, we will restrict the following analysis to an examination of the farm-to-retail marketing margin. We are concerned with how this has changed

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*The authors are indebted to Bruce L. Gardner of the President's Council of Economic Advisors, Washington, D.C., for his guidance and insights in the preparation of this chapter.

**Indicative of the "anti-intermediary" sentiment is the fact that wholesalers and assemblers of rice cannot use warehouse receipts as collateral for bank loans (Riley et al., p. 217).

***As suggested by Carlson (1969, p. 161) and attempted by Chew (1971).

over time, especially since the introduction of the new varieties. Specifically, we are concerned whether any of the benefits of the new farm technology have been captured by the marketing sector, rather than being passed on to the final consumers of rice.

8.2 Observed margins

The nominal and real prices (expressed in 1964 pesos) for rice at three levels of the marketing chain were shown in Table 14. A summary (Table 49) shows that in real terms the farm-to-retail price spread has been constant for twenty-five years, despite some rise and subsequent fall in the absolute price levels at all points in the chain.

There are at least three reasons why one might have expected the real costs of the marketing sector to fall:

1. A greater proportion of the total rice crop is now produced nearer the main consumption center of Bogotá, presumably lowering the total transport costs (see Section 4.4).
2. Improved roads may have reduced the per unit costs of transport.
3. Any technological changes in the milling process may have lowered unit costs (e.g., the change from sun drying to machine drying with a consequent reduction in broken grains (Leurquin, 1967, p. 259).

However, with a large increase in the proportion of the total crop coming from IR-8, which has inferior milling quality due to breakages in the grain (Table 10), the costs of producing first grade rice may have been expected to rise. But if on balance the marketing margins of rice were expected to fall, then their apparent failure to do so might suggest some imperfections in the marketing sector.

8.3 An investment cycle in rice milling

While on average the farm-to-retail marketing margin remained constant, it did increase notably over the period of the introduction of new varieties and the associated expansion of production. This rise is especially marked when the margin is expressed as a percentage of the farm price (Table 50), increasing from a record low of 115 percent in 1968 to a record high in 1973 of 218 percent.

The last two columns of Table 50 show the annual changes in the farm-to-retail margin and a three-year moving average of these changes. The moving average was constructed to smooth out the annual changes, in an attempt to reveal any underlying trends. These data are presented in Figure 12, where a striking cyclical pattern is evident.

An investment cycle in the milling sector is proposed as a possible explanation of this cyclical behavior in margins. 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	3,096	3,559	1,590	463	2,053	2.36
1972-74	1,007	2,542	2,972	1,535	430	1,965	2.95

* Expressed in 1964 pesos

city is fully utilized, which results in margins being driven up as production increases over time. Rising margins lead to incentives to invest in expanded milling, storage and packaging facilities, which then, because of some overcapacity, results in a lowering of the margins.* Under this hypothesis, the rising trend in the farm-to-retail margin observed since 1967 is nothing more than a cyclical upswing in the margins, which has been repeatedly observed over a 22-year period.

Unfortunately, only sporadic data on installed capacity in the milling sector are available to provide a test of this investment cycle hypothesis. However, the observations that do exist are consistent with the explanation proposed for the cyclical pattern of Figure 11.

In 1961, installed milling capacity was reported to be double the production of paddy rice, and strong competition existed among millers to obtain paddy rice (Cruz de Schlesinger and Ruiz, 1967, p. 34). Data for the years 1964 and 1967 indicate that installed capacity did rise between those two years, as the cyclical model would have predicted (Leurquin, 1967, p. 257 and FEDEARROZ, unpublished data). Riley et al. (1970, p. 210) note that in 1968 the state of Valle had 15 rice mills which were operated at 38 percent of capacity, although this is partly a localized phenomenon reflecting declining rice production in the region.

The cyclical investment behavior proposed to explain the pattern of changes in the rice marketing margin depends in part on the argument that the milling sector repeatedly overinvests in installed capacity, approximately every 5 to 6 years. One possible explanation for this overinvestment would be if the investment had to be made in large discrete lumps. This is rejected, however, as rice milling is not subject to such large economies of scale; in 1964 there were 340 rice mills in the country (Leurquin, 1967, p.257) and 353 in 1967 (FEDEARROZ, unpublished data). Repeated overinvestment implies that there is no learning process on the part of the milling sector; and in addition, their ability to predict the demand for their services is poor. This is somewhat surprising in view of the fact that the larger millers themselves are frequently growers and also obtain paddy rice by contracts with independent farmers. These phenomena should result in a more predictable throughput of paddy rice. However, whatever the explanation of the cycle, it does strongly suggest that the introduction of the new varieties was not necessarily accompanied by an increasingly cartel-type marketing structure, capturing abnormal profits.

8.4 An analysis of the predicted change in the farm-to-retail marketing margin

In this section we examine the question: by how much could the farm-to-retail margin have been expected to change due to the introduction of the HYV's and the concomitant rise in output of paddy rice?

Gardner (1975) has presented an analytical framework which allows this question

* Leurquin (1967 n. 23, p. 255) cites evidence of similar price competition among Louisiana millers, and Slater et al. (1969 p. 9-48) note the existence of excess rice milling capacity in the San Francisco River region of N'E. Brazil.

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
1964	1,581	117	552	19	2,133	158	352	36
1965	1,787	112	471	14	2,258	142	125	93
1966	1,552	103	509	17	2,061	137	–197	–97
1967	1,432	101	409	15	1,841	130	–220	–197
1968	1,328	91	337	12	1,665	115	–176	–134
1969	1,198	98	462	19	1,660	136	–5	–78
1970	1,424	127	182	7	1.606	143	–54	9
1971	1,265	121	426	18	1,691	162	85	–20
1972	1,196	134	404	19	1,600	179	–91	176
1973	1,777	182	358	13	2,135	218	535	156
1974	1,632	142	528	19	2,160	188	25	–

* The absolute differences are based on the real price data in Table 14.
** The relative differences are the absolute differences expressed as a % of the lower value in each case.

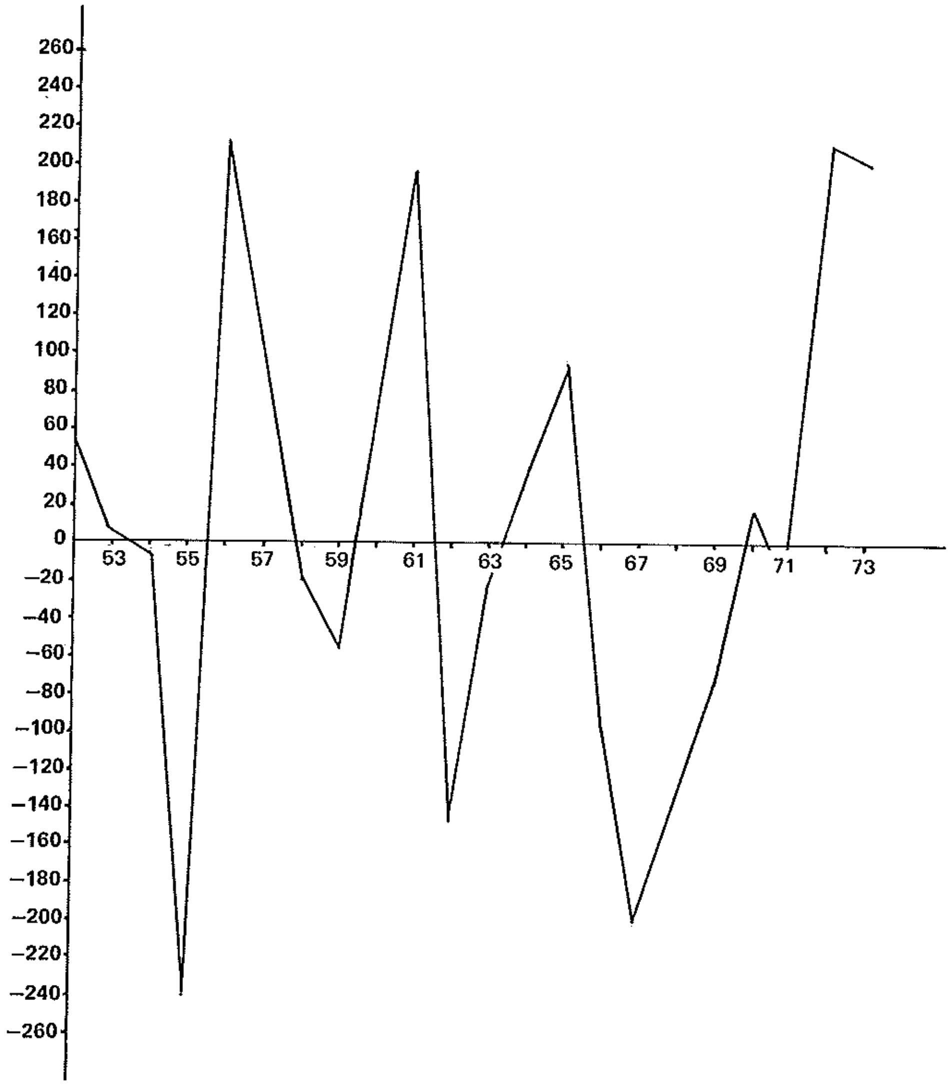

Figure 12. Three-year moving average of the annual changes in the farm-to-retail marketing margin: Colombia (1952-1973).

to be addressed. When there is a technical improvement which shifts the crop supply function, both the farm price and the retail price can be expected to fall (as shown in Table 49). But for the marketing sector to produce, transport, store and distribute more polished rice will require more of the other inputs used by this sector (labor, milling machinery, storage and transport services, packaging materiales, etc.). The increased demand for these inputs will raise their prices so long as their elasticities of supply are not infinite. This will raise the cost of nonfarm inputs to the marketing sector relative to the price of paddy rice, hence increasing the ratio of the retail to the farm price (as shown in the last column of Table 49).

Let the marketing sector's production function be:

$$MR = f(PR, O) \tag{8.1}$$

i.e., the sector produces (and distributes) milled rice (MR), using as its inputs, paddy rice purchased from growers (PR) and other marketing services (O).

The demand by final consumers of milled rice is dependent on the retail price P_r and other factors (population, income, etc.), N, which shift the demand curve.

$$MR = D(P_r, N) \tag{8.2}$$

To these equations are added the supply and demand equations for each of the inputs PR and O. The milling sector is assumed to demand profit-maximizing quantities of PR and O, so that in both cases the value marginal product of the input will be equated to its price:

$$P_0 = P_r\, f_0 \tag{8.3}$$

$$P_f = P_r \cdot f_{MR} \tag{8.4}$$

where the physical marginal products are represented by f_O and f_{MR}[the first partial derivatives of (8.1) with respect to 0 and MR, respectively]. The supply functions of paddy rice and other inputs to the milling industry are given by:

$$P_f = F(PR, W) \tag{8.5}$$

$$P_0 = G(P_0, T) \tag{8.6}$$

where W and T are shifters of the respective supply curves. In the present study, the relationship of interest is the elasticity (E_W) of the ratio (P_r/P_f) with respect to the supply curve shifter (W) of paddy rice; i.e.,

$$E_W = \frac{\%\Delta(P_r/P_f)}{\%\Delta W} \tag{8.7}$$

Based on the competitive model outlined above, Gardner (1975, p. 402) has derived the expression for this elasticity, which is given by:

$$E_W = \frac{\epsilon_W S_0 \epsilon_{MR} (\eta - \epsilon_0)}{-\eta (S_0 \epsilon_{PR} + S_{PR} \epsilon_0 + \sigma) + \epsilon_{PR} \epsilon_0 + \sigma (S_{PR} \epsilon_{PR} + S_0 \epsilon_0)} \quad (8.8)$$

where:

$\epsilon_{PR}, \epsilon_0$ = the elasticities of supply of the marketing inputs; viz., paddy rice (PR) and other (0)

η = elasticity of demand for milled rice

S_{PR}, S_0 = the value shares of paddy rice and other inputs; e.g., S_{PR} = (PR). P_f/ (MR) · P_r; and $S_0 = 1 - S_{PR}$

σ = the elasticity of substitution of paddy rice for other marketing inputs in the production of milled rice

ϵ_W = the elasticity of P_f with respect to W; this is set equal to 1 so that E_W measures the elasticity of (P_r/P_f) with respect to a change in W, sufficient to shift the supply of paddy rice by 1 percent.

However, direct application of (8.8) would be inappropriate as it was derived assuming no shift in the demand for milled rice. This assumption is patently violated in the case of the present analysis, extending over an eleven-year period. Ideally, one requires a new formulation of E_W, in which shifts in the demand for milled rice are allowed. However, a less sophisticated (and analytically simpler) approach is adopted here. Increases in the demand for milled rice can be expected to reduce the marketing margin,* while increases in the supply of paddy rice would tend to widen the margin.

The elasticity of the marketing margin with respect to a shift in the demand curve is given (Gardner, 1975 p. 401) by:

$$E_N = \frac{\eta_N S_0 (\epsilon_{PR} - \epsilon_0)}{D} \quad (8.9)$$

where η_N is the elasticity of demand for milled rice with respect to N, and D is the denominator of equation (8.9).

The analysis is based on the change between 1965-1967 and 1972-1974. The vertical shift in the supply curve was calculated by evaluating the 1972-1974 total supply curve** at the average production for 1965-1967 (see Figure 13). The percentage change in W was then calculated as [100(66–1506)]/1506 = -95.6 percent.

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*This result depends on the assumption that the elasticity of supply of paddy rice is less than the elasticity of supply of other inputs to the marketing sector (Gardner, 1975, p. 406).

**This is found by taking the average of equation (5.13) evaluated for each year from 1972 to 1974.

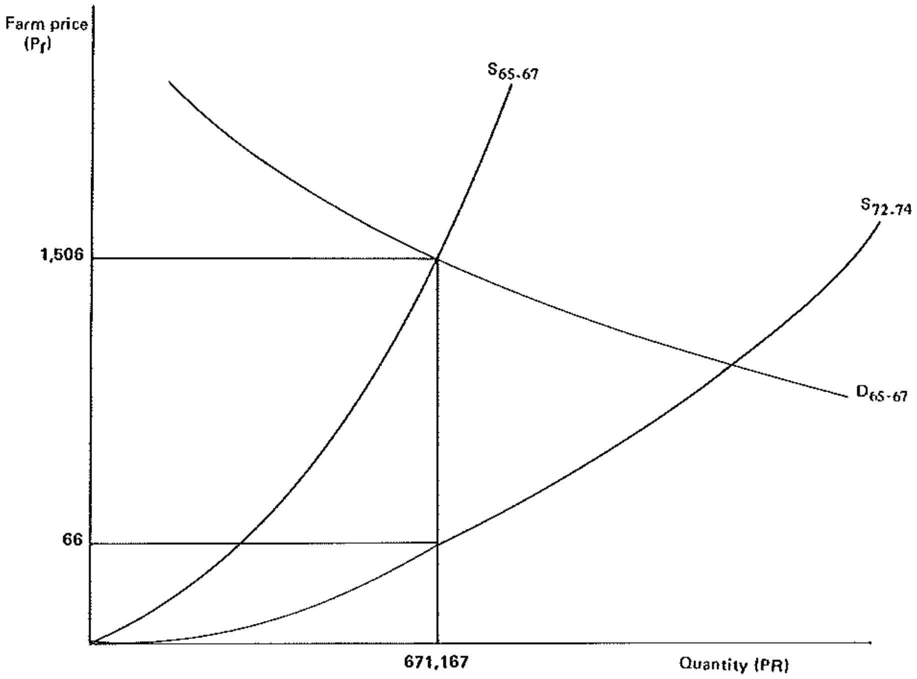

Figure 13. Vertical shift in the supply curve of paddy rice.

To estimate the horizontal shift in the demand curve, the 1965-1967 demand curve was evaluated at the average retail price in 1972-1974 (see Figure 14) and the resulting percentage change in N evaluated as [100(1,263,023-709,256)]/709,256 = 78 percent.

The following values of the parameters were used to estimate E_W and E_N:

$$\eta = -0.449$$

$$\eta_N, \epsilon_W = 1$$

$$\epsilon_{PR} = 0.235$$

$$\epsilon_0 = 0.4$$

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

$$S_{PR} = \frac{P_f}{P_r} \cdot \frac{PR}{MR} \tag{8.10}$$

The assumed milling ratio gives:

1 ton (PR) = 0.65 tons (MR)

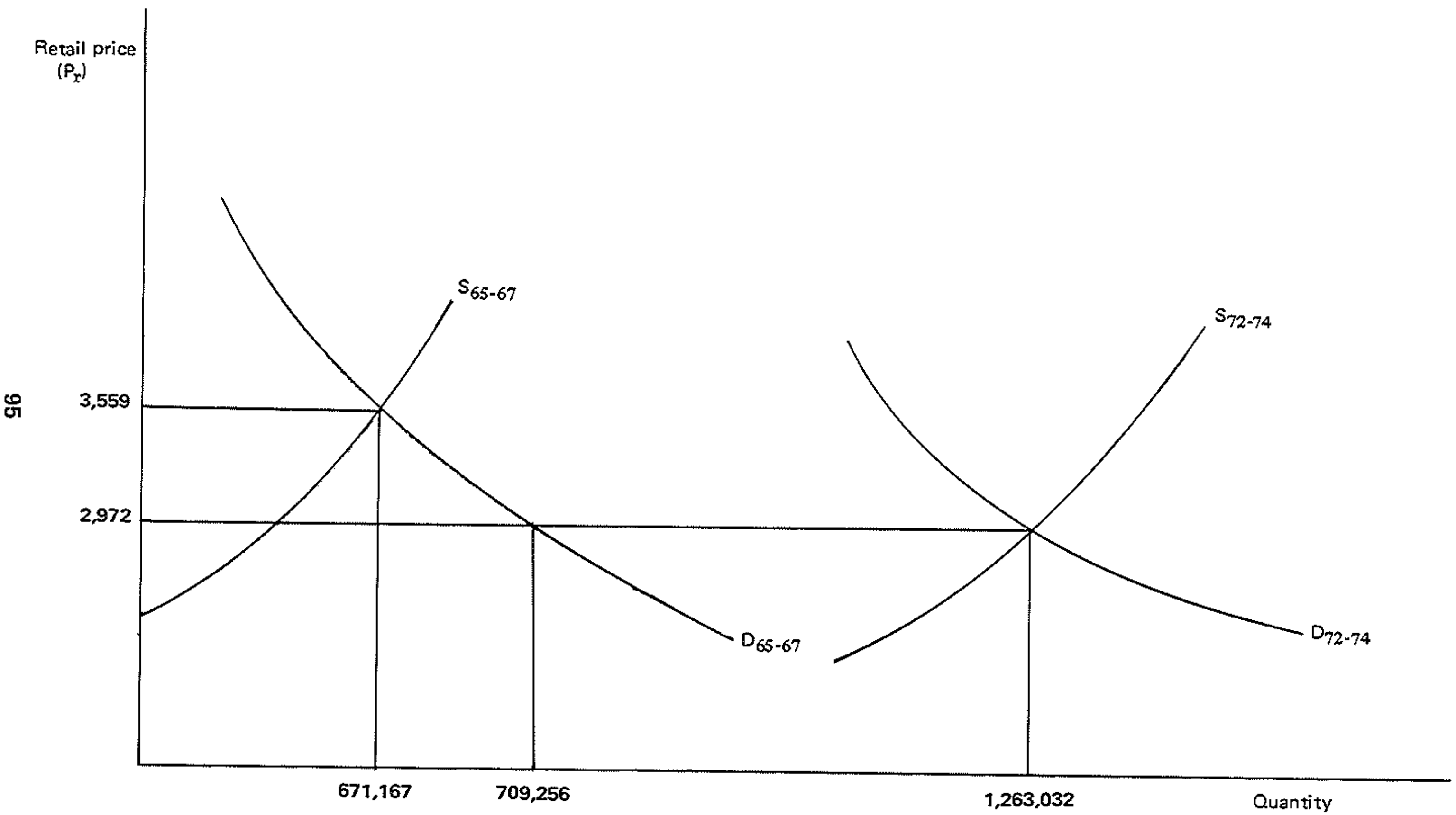

Figure 14. **Horizontal shift in the demand curve for rice.**

or $$\frac{PR}{MR} = 0.65 \qquad (8.11)$$

The average ratio of (P_f/P_r) for the two periods was used, giving a value of 0.38; this results in a value for S_{PR} of 0.24 from (8.10).

It is likely that the substitution possibilities between paddy rice and other inputs in the production of milled rice are limited, implying a low value of σ. Gardner (1975, p. 406) suggests a method whereby an approximation to σ can be obtained.

$$\sigma \simeq \frac{\%\Delta S_{PR}}{\%\Delta (P_r/P_f)} + 1 \qquad (8.12)$$

Using equations (8.10) and (8.11) and superscripts 0 and 1 for the periods 1965-1967 and 1972-1974, respectively,

$$\sigma \simeq \frac{[0.65\,(P_f/P_r)^1 - 0.65\,(P_f/P_r)^0]/0.65\,(P_f/P_r)^0}{[(P_r/P_f)^1 - (P_r/P_f)^0]/(P_r/P_f)^0} = 0.2 \qquad (8.13)$$

This estimate of σ agrees with the intuitive reasoning that the elasticity of substitution would be low. Using these values, E_W and E_N were calculated as -0.4 and -0.33, respectively.

$$\%\Delta (P_r/P_f)\,|_{dN=0} = E_W\,(\%\Delta W) = (-0.4)\,(96.6) = 38\% \qquad (8.14)$$

and

$$\%\Delta (P_r/P_f)\,|_{dW=0} = E_N\,(\%\Delta N) = (-0.33)\,(78) = -26\% \qquad (8.15)$$

giving a total "net" effect of (38-26) or 12 percent; i.e., if the rice marketing sector had behaved in accord with the competitive pricing model implicit in these derivations and had been fully adjusted to the change in the output due to HYV's, we would have expected a 12 percent increase in the marketing margin. In fact, the margin rose from 2.36 to 2.95 (see Table 40), or by 25 percent. However, it is suggested in conclusion that this result, rather than necessarily indicating an imperfectly competitive marketing sector, merely reflects the dynamic adjustment process outlined above. The normal cyclical pattern of rises and falls in the marketing margin were occurring. The marketing margin widened somewhat due to noncyclical competitive forces following the rapid increase in paddy rice production, the "remainder" of the observed rise being due to the cyclical investment pattern.

8.5 Formation of rice prices

In an attempt to partially explain the formation of the ratail price grade rice in Bogotá, a model presented by Timmer (1974) was tested. Basically, this model is built on the following identity:

$$P_r = (\alpha)(1/c)P_f + A \quad (8.16)$$

where

P_r, P_f = retail and farm prices of rice, respectively

α = reflects proportional marketing charges, if $\alpha = 1$, then there are no proportional charges

A = absolute marketing charges

c = milling ratio.

By adding a random error term to equation (8.16), the model can be fitted using simple linear regression. If A is significantly greater than zero, then there is evidence of absolute marketing charges; i.e., the costs of marketing are independent of the per unit value of rice. If the reciprocal of α/c is much less than an expected milling ratio of say 0.65, there would be evidence of proportional charges; i.e., costs varying with the per unit value of rice.

The following equation was estimated:

$$P_r = \underset{(3.7)}{1{,}394} + \underset{(4.9)}{1.45}P_f \quad (8.17)$$

$R^2 = 0.51$; D-W = 1.6; n = 25.

where the t- values are given in parentheses. The estimate of A is significantly greater than zero, and the reciprocal of the farm price coefficient is 0.69, close to an expected value of 0.65 in the absence of proportional charges. Hence we conclude that the marketing charges are absolute rather than proportional, confirmed by the constant absolute margin shown in Table 49. An additional run of equation (8.17) gave a nonsignificant coefficient for a variable, reflecting the proportion of the crop coming from HYV's. This added further support to the hypothesis that there were no abnormal rises in the marketing margin associated with the introduction of HYV's. In conclusion, we find no evidence to support the rather widely held contention that an imperfectly competitive milling-marketing sector exercised its market power to capture abnormal profits following the introduction of new rice varieties.

CHAPTER 9

SUMMARY

The principal highlights of this report are:

1. Since 1950 rice production in Latin America has grown at an annual average rate of 3.6 percent, compared with 2.8 percent for world output.

2. Latin America produced 3.6 percent of world output in 1974; Brazil and Colombia are the major producers, representing 56 percent and 13 percent, respectively, of Latin American production in 1974.

3. Until the mid-sixties, yields were constant, but rising yields accounted for 75 percent of the increase in production between 1965 and 1974.

4. Only the Caribbean is a net importing region with Cuban imports accounting for half the region's total.

5. In 1970 over 75 percent of Latin American exports were sold outside the region. Future expansion in exports will likely depend on markets in Europe and Africa.

6. In 1974 at least 800,000 hectares (or 12 percent) of the rice area was sown to dwarf varieties.

7. In 1974 Latin American output was 14.5 percent higher than it would have been in the absence of HYV's; excluding Brazil, this figure is 40.3 percent. In 1972-1973 Asian production was estimated to be 4.9 percent higher due to the presence of HYV's.

8. In Colombia the introduction of new varieties commenced in 1964 as a result of an expanded program of rice research in ICA and with the subsequent collaboration of CIAT.

9. Adoption of HYV's has been rapid and widespread; they now occupy virtually all the irrigated sector.

10. National average yields have risen from 1.8tons/ha in 1965 to 4.4tons/ha in 1975.

11. A strong national rice growers federation (FEDEARROZ) has undoubtedly contributed to the rapid rise in output.

12. New varieties developed for irrigated culture gave a comparative advantage to the irrigated sector, displacing upland production. In 1966 upland production was 50 percent of Colombian output; in 1975 it was 9 percent.

13. Rice prices fell (in real terms) as a result of the expanded output. In the period 1965-1969, the average farm price was $1,437 per ton. In 1970-1974 it was $1,037 per ton, a fall of 28 percent. The costs of production per ton fell by 30 percent over the same period.

14. Rice became cheaper relative to other major foodstuffs; in 1965 1 kg of beans purchased 1.82 kg of rice; by 1974, it purchased 3.47 kg of rice.

15. Colombian rice production is concentrated in large irrigated holdings. In 1970 it is estimated that almost 70 percent of the national output came from irrigated farms of over 50 ha.

16. Rice is the major item in the Colombian diet; in 1972 it was the most important source of calories (13.6 percent) and the second most important source of proteins (12.7 percent).

17. The development and release of HYV's was a highly efficient use of public and private funds; the research program was estimated to have generated an internal rate of return of 94 percent.

18. The gross value of additional rice production between 1964 and 1974 was estimated at $(US) 350 m.

19. Rice prices were much lower than they would have been in the absence of HYV's; hence Colombian consumers were the beneficiaries of the research program. Both absolutely and relatively, the greatest net benefits went to the lowest income consumers. Fifty percent of Colombian households received 14 percent of the income, but captured 62 percent of the net benefits from the introduction of HYV's.

20. Producers of rice would have received higher prices and had higher incomes in the absence of the new varieties. Small upland producers were the most severely affected, but numerically they are a minor group (about 6,000 in 1970).

21. No evidence was found that the marketing sector captured abnormal profits from the introduction of HYV's.

22. The net benefits were highly skewed toward the low-income consumer, as almost all the additional output was sold on the domestic market.

23. Protection given to the manufacturing sector has allowed Colombia to maintain an overvalued exchange rate which has discouraged potential rice exports.

24. The domestic price has now fallen to the point that exporting appears profitable.

25. If Colombia becomes a consistent rice exporter (as appears probable), future benefits from new rice technology will accrue to producers and foreign consumers rather than to Colombian consumers, as has been the case.

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APPENDIX TABLE 1. RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1950).

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)	('000 m.t.)		
MEXICO	106	187	1.7	28	0*	28
Cuba	69	104	1.5	0	293	—293
Other Caribbean	83	114	1.3	0	54	— 54
CARIBBEAN	152	218	1.4	0	347	—347
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	38	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
Brazil	1,873	2,931	1.5	165	0	165
Chile	25	80	3.2	2	0	2
Colombia	145	297	2.0	0	7	— 7
Ecuador	73	111	1.5	7	0	7
Fr. Guiana	0	0	0	0	1	— 1
Guyana	46	113	2.4	31	0	31
Paraguay	9	16	1.7	0	0	0
Peru	59	265	4.4	0	27	— 27
Surinam	19	58	3.0	4	0	4
Uruguay	13	47	3.6	11	0	11
Venezuela	33	40	1.2	0	25	— 25
SOUTH AMERICA	2,367	4,150	1.7	220	69	151
LATIN AMERICA	2,781	4,777	1.7	229	430	—201

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1952).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	84	151	1.7	2	0	2
Cuba	63	167	2.6	0	215	–215
Other Caribbean	92	129	1.4	0	56	– 56
CARIBBEAN	155	296	1.9	0	271	–271
Belize	1	1	1.0	0	1	– 1
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
Bolivia	17	28	1.6	0	9	– 9
Brazil	2,425	3,367	1.3	3	0	3
Chile	29	87	3.0	4	6	– 2
Colombia	153	272	1.7	19	0	19
Ecuador	101	182	1.8	33	0	33
Fr. Guiana	0	0	0		1	– 1
Guyana	53	135	2.5	40	0	40
Paraguay	9	20	2.2	0	0	0
Peru	69	259	3.7	14	0	14
Surinam	20	58	2.9	7	0	7
Uruguay	17	61	3.5	7	0	7
Venezuela	46	58	1.2	0	7	– 7
SOUTH AMERICA	3,012	4,739	1.5	141	23	118
LATIN AMERICA	3,470	5,465	1.5	162	345	–183

APPENDIX TABLE 1 (Cont.) RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA. (1954).

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	90	170	1.8	0	0	0
Cuba	93	245	2.6	0	197	–197
Other Caribbean	127	150	1.1	0	47	– 47
CARIBBEAN	220	345	1.7	0	244	–244
Belize	1	1	1.0	0	2	– 2
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
Bolivia	19	32	1.6	0	11	—11
Brazil	2,555	3,489	1.3	3	0	3
Chile	28	54	1.9	0	0	0
Colombia	188	320	1.7	0	2	— 2
Ecuador	59	126	2.1	21	0	21
Fr. Guiana	0	0	0	0	1	— 1
Guyana	58	130	2.2	54	0	54
Paraguay	9	19	2.1	0	–	0
Peru	67	243	3.6	0	19	—19
Surinam	22	65	2.9	12	0	12
Uruguay	19	64	3.3	8	0	8
Venezuela	55	60	1.1	0	1	— 1
SOUTH AMERICA	3,133	4,766	1.5	130	34	16
LATIN AMERICA	3,363	5,646	1.5	131	225	—94

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1956).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	115	235	2.0	1	0	1
Cuba	162	369	2.2	0	136	—136
Other Caribbean	129	158	1.2	0	61	—261
CARIBBEAN	291	527	1.8	0	197	—197
Belize	1	2	2.0	0	1	— 1
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
Bolivia	7	11	1.5	0	12	–12
Brazil	2,515	3,829	1.5	0	0	0
Chile	29	77	2.6	0	1	– 1
Colombia	190	350	1.8	0	10	–10
Ecuador	70	176	2.5	38	0	38
Fr. Guiana	0	0	0	0	1	– 1
Guyana	67	117	1.7	39	0	39
Paraguay	8	20	2.5	0	0	0
Peru	71	285	4.0	0	20	–20
Surinam	28	55	1.9	11	1	10
Uruguay	17	58	3.4	7	0	7
Venezuela	30	22	0.7	0	0	0
SOUTH AMERICA	3,092	5,217	1.6	119	45	74
LATIN AMERICA	3,636	6,007	1.6	128	328	–200

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1958).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)	('000 m.t.)		
MEXICO	121	252	2.0	7	1	– 6
Cuba	110	253	2.3	0	193	–193
Other Caribbean	131	179	1.3	0	83	– 83
CARIBBEAN	241	432	1.7	0	276	–276
Belize	1	2	2.0	0	1	– 1
Costa Rica	45	57	1.2	0	5	– 5
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
Bolivia	16	23	1.4	0	9	– 9
Brazil	2,966	4,795	1.6	10	0	9
Chile	40	110	2.7	0	9	– 9
Colombia	205	422	2.0	0	0	0
Ecuador	88	186	2.1	17	0	17
Fr. Guiana	0	0	0	0	1	– 1
Guyana	83	190	2.2	57	0	57
Paraguay	7	15	2.1	1	0	1
Peru	87	358	4.1	0	0	0
Surinam	29	79	2.8	18	0	8
Uruguay	14	53	3.7	1	0	1
Venezuela	28	39	1.3	0	27	– 27
SOUTH AMERICA	3,619	6,460	1.7	113	49	64
LATIN AMERICA	4,251	7,485	1.7	126	347	– 221

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1960).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	142	328	2.3	2	22	— 20
Cuba	160	323	2.0	0	160	—160
Other Caribbean	136	172	1.2	0	84	— 84
CARIBBEAN	138	495	1.6	0	244	—244
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
Chile	29	83	2.8	9	9	0
Colombia	237	473	1.9	0	39	–39
Ecuador	119	203	1.7	21	0	21
Fr. Guiana	0	0	0	0	1	– 1
Guyana	106	194	1.8	91	0	91
Paraguay	14	35	2.5	0	0	0
Peru	81	332	4.0	0	9	– 9
Surinam	25	72	2.8	19	0	19
Uruguay	16	59	3.6	20	0	20
Venezuela	58	81	1.3	0	12	–12
SOUTH AMERICA	3,942	7,287	1.8	321	74	247
LATIN AMERICA	4,571	8,254	1.8	335	351	– 16

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA. (1962).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	134	289	2.1	63	0	63
Cuba	164	230	1.4	0	160	—160
Other Caribbean	132	171	1.2	0	87	— 87
CARIBBEAN	296	401	1.3	0	247	—247
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
Brazil	3,722	5,580	1.4	0	0	0
Chile	33	86	2.6	0	12	–12
Colombia	254	550	2.1	3	0	3
Ecuador	110	211	1.9	34	0	34
Fr. Guiana	0	0	0	0	1	– 1
Guyana	82	161	1.9	73	0	73
Paraguay	15	28	1.8	0	0	0
Peru	73	270	3.6	0	43	–43
Surinam	28	75	2.6	22	0	22
Uruguay	21	77	3.6	14	0	14
Venezuela	74	131	1.7	0	3	– 3
SOUTH AMERICA	4,498	7,424	1.6	160	59	101
LATIN AMERICA	4,980	8,226	1.6	163	268	–105

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1964).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	133	274	2.0	0	3	— 3
Cuba	71	123	1.7	0	152	–152
Other Caribbean	78	142	1.8	0	113	–113
CARIBBEAN	149	265	1.7	0	265	–265
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
Brazil	4,005	7,580	1.8	236	–	236
Chile	31	71	2.2	0	12	– 12
Colombia	374	672	1.7	0	0	0
Ecuador	90	173	1.9	0	6	– 6
Fr. Guiana	0	0	0	0	1	– 1
Guyana	136	258	1.8	95	0	95
Paraguay	16	37	2.3	0	0	0
Perú	75	294	3.9	0	115	–115
Surinam	29	90	3.1	21	0	21
Uruguay	28	90	3.2	20	0	20
Venezuela	105	200	1.5	20	4	16
SOUTH AMERICA	4,963	9,672	1.9	427	138	289
LATIN AMERICA	5,471	10,513	1.9	439	525	– 86

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA. (1966).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	165	390	2.3	0	8	– 8
Cuba	32	68	2.1	0	140	–140
Other Caribbean	116	233	2.0	0	87	– 87
CARIBBEAN	148	301	2.0	0	227	–227
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
Chile	32	94	2.9	0	14	– 14
Colombia	290	661	2.2	0	0	0
Ecuador	105	182	1.7	0	0	0
Fr. Guiana	0	0	0	0	1	– 1
Guyana	103	198	1.9	102	0	102
Paraguay	17	39	2.2	0	0	0
Peru	107	461	4.3	0	72	–72
Surinam	34	120	3.5	18	4	14
Uruguay	34	116	3.4	37	0	37
Venezuela	114	223	1.9	63	0	63
SOUTH AMERICA	5,503	8,043	1.4	286	91	195
LATIN AMERICA	6,109	9,166	1.5	301	250	51

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1968).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	157	365	2.3	46	0	46
Cuba	88	100	1.1	0	145	−145
Other Caribbean	130	223	1.7	0	112	−112
CARIBBEAN	218	323	1;4	0	267	—267
Belize	2	2	1.0	0	2	— 2
Costa Rica	35	56	1.6	1	3	— 2
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	35	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
Bolivia	35	58	1.6	0	0	0
Brazil	4,595	5,595	1.2	70	0	70
Chile	25	76	3.0	0	67	– 67
Colombia	250	694	2.7	16	0	16
Ecuador	109	233	2.1	0	5	– 5
Fr. Guiana	0	0	0	0	1	– 1
Guyana	113	173	1.5	74	0	74
Paraguay	20	58	2.9	0	0	0
Peru	132	480	3.6	0	50	– 50
Surinam	36	120	3.3	15	0	15
Uruguay	28	134	4.7	68	0	68
Venezuela	125	244	1.9	9	5	4
SOUTH AMERICA	5,570	8,272	1.4	326	128	198
LATIN AMERICA	6,271	9,441	1.5	350	403	⊬ –53

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1970).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	200	330	1.6	0	16	– 16
Cuba	128	326	2.5	0	139	–139
Other Caribbean	151	267	1.7	0	107	–107
CARIBBEAN	279	593	2.1	0	246	–246
Belize	2	3	1.5	0	2	– 2
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
Brazil	4,400	5,130	1.1	149	2	147
Chile	31	70	2.2	0	50	– 50
Colombia	254	904	3.5	0	0	0
Ecuador	80	175	2.1	0	0	0
Fr. Guiana	0	0	0	37	7	30
Guyana	94	185	1.9	69	0	69
Paraguay	20	60	3.0	0	0	0
Peru	137	616	4.4	0	0	0
Surinam	36	120	3.3	35	0	35
Uruguay	28	106	3.7	74	0	74
Venezuela	110	206	1.8	0	4	– 4
SOUTH AMERICA	5,321	7,964	1.4	446	63	383
LATIN AMERICA	6,064	9,333	1.5	457	512	– 55

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1972).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	165	420	2.5	16	1	15
Cuba	140	350	2.5	0	256	–256
Other Caribbean	147	294	2.0	0	138	–138
CARIBBEAN	287	644	2.2	0	394	–394
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
Argentina	77	260	3.7	34	0	34
Bolivia	41	69	1.6	0	0	0
Brazil	4,900	7,500	1.5	33	6	27
Chile	19	55	2.8	0	53	– 53
Colombia	290	1,175	4.0	20	0	20
Ecuador	64	152	2.3	0	5	– 5
Fr. Guiana	0	0	0	30	1	29
Guyana	93	99	1.0	48	0	48
Paraguay	22	44	2.0	0	0	0
Peru	127	451	3.7	55	0	55
Surinam	41	138	3.3	36	0	36
Uruguay	35	137	3.9	65	0	65
Venezuela	136	272	2.0	7	0	7
SOUTH AMERICA	5,845	10,352	1.7	328	65	263
LATIN AMERICA	6,520	11,824	1.8	340	475	–135

APPENDIX TABLE 1 (Cont.) **RICE AREA, PRODUCTION, YIELD AND TRADE IN LATIN AMERICA (1974).**

Country	Area	Prod.	Yield	Exports	Imports	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
MEXICO	170	408	2.4	0	100	–100
Cuba	160	400	2.5	0	220	–220
Other Caribbean	122	214	1.7	0	160	–160
CARIBBEAN	282	614	2.1	0	380	–380
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 AND TRADE IN LATIN AMERICA (1975).**

Country	Area	Prod.	Yield	Exports*	Imports*	Net exports
	('000 ha)	('000 m.t.)	(tons/ha)		('000 m.t.)	
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	75	1.7			
Brazil	5,200	6,600	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 Dependencies Trinidad and Tobago
NOTE: Production is in '000 m.t. paddy; the trade data are in '000 m.t. milled.
Zero indicates no values recorded or less than 1,000 m.t.
Sources:
1. USDA: World agricultural situation, WAS. 7, ERS, June, 1975
2. USDA: The agricultural situation, WAS. 7, of the Western Hemisphere, ERS, 1964-1975.
3. USDA: Review of world rice markets and major suppliers, FAS M-246, August, 1972.
4. FAO: Production Yearbooks.
5. FAO: Trade Yearbooks.
6. FAO: World rice economy in figures: 1909-1963 Rome, 1965.
7. All data for 1975 from USDA, Rice Marketing News Vol. 57, no. 4, p. 4.

Appendix Table 2. **Classification of Colombian states by rice production system (1963 and 1970).**

1963				1970			
Upland		Irrigated		Upland		Irrigated	
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
100 – 200	3,235	18,982	5.87	13	8	7	6	72	46	94	79
200 – 500	1,915	17,943	9.37	13	8	4	4	85	54	98	83
500 – 1,000	528	9,865	18.68	7	4	1	1	92	58	99	84
1,000 – 2,500	251	5,648	22.50	5	2	1	**	97	60	100	85
2,500 +	168	4,758	28.32	3	2	**	**	100	62	100	85
Totals	45,399	140,714	3.10	100	62	100	85	–	–	–	–

* States of Antioquia, Bolívar, Boyacá, Córdoba, Meta, Nariño and Santander.
** Less than 0.5%

Appendix Table 4. Distribution of farms and rice area where rice is the principal crop: irrigated sector* of Colombia, by farm size (1959).

Farm size (ha)	No. of farms	Area of rice (ha)	Area/ farm (ha)	Percentage of				Cumulative percentages of			
				Irrigated area (%)	Total area (%)	Irrigated farms (%)	Total farms (%)	Irrigated area (%)	Total area (%)	Irrigated farms (%)	Total farms (%)
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: Total area (%)	Percentage of: Total no. of farms (%)	Cumulative percentage of: Total area (%)	Cumulative percentage of: Total no. of farms (%)	Percentage of farms with irrigation (%)
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
50 – 100	6,505	31,113	4.78	13	12	47	85	20
100 – 200	4,134	32,743	7.92	14	8	61	93	22
200 – 500	2,464	39,582	16.06	17	5	78	98	22
500 – 1,000	692	23,815	34.41	11	1	89	99	24
1,000 – 2,500	318	13,210	41.54	6	1	95	100	21
2,500 +	194	10,797	55.65	5	*	100	100	13
Totals	53,283	226,792	4.26	100	100	—	—	15

*Less than 0.5%

Appendix Table 6. **Distribution of rice farms, area, yields and production by farm size: Colombia (1966).**

Farm size (ha)	Farm producing rice (no.)	Total area harvested (ha)	Area/ farm (ha)	Yield (kg/ ha)	Production (m.t.)	Percentage of			Cumulative Percentages of	
						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			°/o of farms with irrigation (°/o)	°/o of total farms (°/o)	Cumulative °/o of total farms (°/o)
	Upland sector*	Irrigated sector**	Total no.			
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
200 – 500	1,120	586	1,706	34	6	99
500 – 1,000	209	193	402	48	1	100
1,000 – 2,500	72	152	224	68	***	100
2,500 +	37	76	113	67	***	100
Totals	19,900	7,041	26,941	26	100	

* States of Antioquia, Bolivar, Boyacá, Córdoba, Nariño Santander and Sucre.
** States of Atlántico, Caldas, Cauca, César, Cundinamarca, Huila, La Guajira, Magdalena, Meta, Norte de Santander, Tolima and Valle.
*** Less than 0.5°/o

Appendix Table 8. **Distribution of rice farms by farm size: Colombia; selected years.**

Farm size (ha)	No. of farms*			% of farms		
	1959	1966	1970	1959	1966	1970
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
200 – 500	3,819	3,101	41,455	38,013	6	6	17	16
500 – 2,500	1,926	1,138	48,239	46,148	3	2	20	20
2,500 +	–	205	–	21,326	–	*	–	9
Totals	64,935	48,973	243,286	233,213	100	100	100	100

* Less than 0.5%

Appendix Table 10. **Distribution of number of farms where rice is the principal crop by farm size, by sector.**

	Upland sector				Irrigated sector			
	No. of farms		% of farms		No. of farms		% of farms	
Farms size (ha)	1959	1970	1959	1970	1959	1970	1959	1970
0 – 1	1,661	1,199	4	6	172	89	2	1
1 – 2	3,887	1,872	9	9	490	274	6	4
2 – 3	3,553	1,489	8	7	428	235	5	3
3 – 4	2,792	1,004	6	5	256	146	3	2
4 – 5	2,211	802	5	4	168	161	2	2
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
Group av	6.2	6.1	5.8	—	—	5.9
IR-8	7.4	7.9	6.7	7.3	7.0	7.3
IR-22	—	7.1	6.3	6.1	5.7	6.3
CICA-4	—	7.2	6.1	6.4	6.1	6.5
Group av	7.4	7.4	6.4	6.6	6.3	6.9

* Calculated from unpublished data provided by the División de Administración de Distritos, Sub-gerencia de Ingeniería y Colonizaciones, INCORA.
** For first semester only

Appendix Table 12. **Estimates of the additional irrigated area sown due to the presence of HYV's: Colombia (1968-1974); assumption (A).**

	Upland sector				Irrigated sector				
							Area (ha)		
Year	Area* in absence of HYV's (A) (ha)	Yield** (kg/ha)	Prod. (m.t.)	National demand (m.t.)	Prod. needed (m.t.)	Yield** (kg/ha)	Required $(A_{N,t})$	Actual $(A_{I,t})$	Additional $(A_{A,t})$
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).**

	Upland sector				Irrigated sector				
							Area (ha)		
Year	Area in absence of HYV's (B) (ha)	Yield* (kg/ha)	Prod. (m.t.)	National demand (m.t.)	Prod. needed (m.t.)	Yield* (kg/ha)	Required ($A_{N,t}$)	Actual ($A_{I,t}$)	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	636,676	5,061	125,800	144,380	18,580
1972	130,925	1,555	203,588	900,911	697,323	5,174	134,774	170,620	35,846
1973	130,925	1,556	203,719	960,695	756,976	5,318	142,342	192,020	49,678
1974	130,925	1,570	205,552	1,024,447	818,895	5,200	157,480	272,950	115,470

* From Table 11

Appendix Table 14. **Some published estimates of price and income elasticities for rice.**

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Afghanistan			0.6	FAO (1971)
Albania			0.3	FAO (1971)
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		Income elasticity		Source
	Supply	Demand			
Bolivia			0.5		FAO (1971)
Brazil			0.2		FAO (1971)
Brazil			Rural	Urban	
Northeast			0.53	0.53	Getulio Vargas
East			0.30	0.19	Foundation (1968)
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)
	1.74 (LR)				
Brazil		–0.1805			Mandell (1971)
Brazil		–0.16			Mandell (1973)
Brazil (Goias)	0.30 (SR)				Villas (1972)
	0.34 (LR)				
Brazil (São Paulo)	0.61 (SR)				Pastore (1971b)
	1.96 (LR)				
Brazil (São Paulo)	0.42 (SR)				Toyama and Pescarin (1970)
	0.69 (LR)				

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Brazil (São Paulo)	0.62 (SR) 4.10 (LR)			Brandt et al. (1965)
Bulgaria			0.2	FAO (1971)
Burma			0.1	FAO (1971)
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]	Molta (1969)
			0.27 (M)[4]	
			0.04 (H)[5]	
Colombia (Cali)		–0.426 (VL)[6]	0.41 (VL)	P. Pinstrup-Andersen (Unpublished)
		–0.400 (L)	0.39 (L)	
		–0.397 (M)	0.39 (M)	
		–0.262 (H)	0.25 (H)	
		0 (VH)[7]	0.19 (VH)	
		–0.354 (AV)[8]	0.34 (AV)	
Communist Asia	0.2	–0.1		USDA (1971)
Congo (D.R.)			1.2	FAO (1971)
Congo (P.R)			1.0	FAO (1971)
Costa Rica			0.3	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Cuba			0.2	FAO (1971)
Cyprus			0.3	FAO (1971)
Czechoslovakia			0.1	FAO (1971)
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)
Guyana			0.2	FAO (1971)
Haiti			0.7	FAO (1971)
Hong Kong			0.2	FAO (1971)
Honduras			0.6	FAO (1971)
Hungary			0.2	FAO (1971)
Iceland			0.5	FAO (1971)
India			0.4	FAO (1971)
Indonesia			0.7	FAO (1971)

Appendix Table 14. (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Ireland			0.5	FAO (1971)
Iran			0.3	FAO (1971)
Iraq			0.7	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)
Maritius			0.4	FAO (1971)
Mauritania			1.0	FAO (1971)
Mexico			0.49 (R)[9] 0.18 (U)[10]	Secretaría de Agricultura (1966)
Mexico			0.3	FAO (1971)
Mexico		–0.3		Duloy and Norton (1973)
Mongolia			0.3	FAO (1971)
Morocco			0.4	FAO (1971)
Mozambique			0.8	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Near East			0.23	FAO (1971)
Nepal			0.3	FAO (1971)
Netherlands			0.2	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)
Poland			0.2	FAO (1971)
Portugal			0.1	FAO (1971)
Puerto Rico			0.4	FAO (1971)
Rhodesia			0.8	FAO (1971)
Romania			0.2	FAO (1971)
Rwanda			0.8	FAO (1971)
Sabah			0.1	FAO (1971)
Sarawak			0.1	FAO (1971)
Saudi Arabia			0.6	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
Senegal			0.4	FAO (1971)
Sierra Leone			0.3	FAO (1971)
Singapore			0.1	FAO (1971)
Somali			1.0	FAO (1971)
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) 0.31 (LR)			Behrman (1968)

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)
USA			0.2	FAO (1971)
USA		−0.27	0.68	Grant (1967)
USA		−0.15		Brandow (1961)
USA		−0.32	0.055	George and King (1971)
Uruguay			0.2	FAO (1971)
USSR	0.3	−0.3		USDA (1971)
USSR			0.3	FAO (1971)

Appendix Table 14 (cont.)

Country or region	Price elasticity		Income elasticity	Source
	Supply	Demand		
USSR and E. Europe			0.26	FAO (1971)
Venezuela		−0.53 (R-L)	0.50 (R)	Consejo de Bienestar (1965)
		−0.47 (R-H)	0.21 (R-H)	
		−0.38 (U-L)	0.26 (U-L)	
		−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
2 Long run
3 Low income
4 Medium income
5 High income
6 Very low income
7 Very high income
8 Average
9 Rural
10 Urban

Appendix Table 15. **Combinations of supply elasticities* used in the sensitivity analysis.**

Year	$\epsilon = 0.235$		$\epsilon = 1.5$	
	ϵ_U	ϵ_I	ϵ_U	ϵ_I
1964	0.118	0.32	0.750	0.043
1965	0.118	0.32	0.750	2.043
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 ($\eta = -0.300$ and $\epsilon = 0.235$).**

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
1970	1,488.9	-479.0	-621.9	-1,100.9	388.0
1971	2,419.9	-605.7	–1,166.9	-1,772.6	647.3
1972	5,617.8	-1,376.2	-2,669.5	-4,045.7	1,572.1
1973	10,257.5	-2,410.4	-4,887.8	-7,298.2	2,959.3
1974	30,886.3	-6,531.8	-15,296.9	-21,828.7	9,057.6

* Expressed in 1964 pesos

Appendix Table 16 (Cont.). **Gross benefits to consumers and producers of new rice varieties in Colombia ($\eta = -0.300$ and $\epsilon = 1.500$).**

Year	Consumer gains	Foregone income to producers: Upland	Irrigated	Total	Total gross benefits
		($m)			
1964	4.5	-1.6	-2.4	-4.0	0.5
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: Upland	Irrigated	Total	Total gross benefits
			($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	495.0	-177.2	-227.1	-404.3	90.7
1970	806.0	-256.7	-358.8	-615.5	190.5
1971	1,228.0	-302.2	-605.5	-907.7	320.3
1972	2,341.8	-550.8	-1,082.8	-1,633.6	708.2
1973	3,826.1	-850.6	-1,627.1	-2,477.7	1,348.4
1974	9,340.0	-1,817.4	-3,960.9	-5,778.3	3,561.7

Appendix Table 16 (Cont.). **Gross benefits to consumers and producers of new rice varieties in Colombia ($\eta = -0.754$ and $\epsilon_t = 0.235$).**

Year	Consumer gains	Foregone income to producers			Total gross benefits
		Upland	Irrigated	Total	
			($m)		
1964	1.8	-0.7	-0.1	-0.8	1.0
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 ($\eta = -0.754$ and $\epsilon_t = 1.500$).**

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
1970	408.3	-128.8	-142.7	-271.5	136.8
1971	593.0	-143.9	-233.1	-377.0	216.0
1972	984.6	-223.4	-361.8	-585.2	399.4
1973	1,491.2	-315.1	-421.9	-737.0	754.2
1974	3,164.0	-567.4	-842.8	-1,410.2	1,754.6

GLOSSARY

CIAT:	Centro Internacional de Agricultura Tropical
DANE:	Departamento Administrativo Nacional de Estadística
ECLA:	Economic Commission for Latin America
FEDEARROZ:	Federación Nacional de Arroceros
ICA:	Instituto Colombiano Agropecuario
IDEMA:	Instituto de Mercadeo Agropecuario
INCORA:	Instituto Colombiano de Reforma Agraria
IRRI:	Internacional Rice Research Institute
HYV's:	High-yielding varieties
ha:	hectares
m.t.:	metric tons
n.a:	not available