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THE GREEN REVOLUTION:

GENERATIONS OF PROBLEMS

by

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The Green Revolution: Generations of Problems*

by

Walter P. Falcon**

The recent flood of literature on the green revolution has a certain similarity to the theologians' writings on God: both are concerned with existence, consequences and salvation, and both are equally contradictory in their conclusions! I am realistic, therefore, about what one additional paper can add to the green revolution controversy and have chosen to concentrate on two limited objectives: (a) a brief survey of the usage and the impact of the new high-yielding seed varieties, and (b) a more lengthy discussion of the longer-run consequences of rapid technological transfer to the less developed countries. I have deliberately avoided a quantitative projection of future production and prices, and have attempted to focus instead on general problems and mechanisms.[1/]

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* I am especially indebted to my colleague, Carl Gotsch, for helpful suggestions. Many of the ideas presented here are the product of our collaborative work on Pakistan, although he bears no responsibility for this version of them. I have also benefited from the comments of Hollis Chenery, Ralph Cummings, Jr., Morton Grossman, O. Donald Hoerr, Bruce Johnston, Charles Mann, Edward Mason, Gustav Papanek, Robert Repetto, Vernon Ruttan, Lyle Schertz, and Raymond Vernon. Portions of this research were supported by funds provided the Harvard Center for International Affairs by the Agency for International Development under contract CSD-1543.

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1/ Readers interested in commodity projections are referred to Barker [4], Efferson [10], F.A.O. [11], [12], Gotsch and Falcon [17], and West [45], [46].

Since the food-population-employment-growth problems with which I am concerned are most severe in Asia, since that is where the new varieties appear to have had most impact, and since that is where my personal experience has been, this essay has a strong Asian focus. It draws heavily on the Pakistan experience and continues, albeit more pessimistically, in much the same vein as recent writings by Barker [3], Cummings [6], Hardin [20], Johnston [24], and Wharton [47].

The First Generation: Great Production Successes, But Important Limitations

A quantitative history of the new varieties has been given by Brown [5], Dalrymple [42], Schertz [36], and Willett [41], as well as by the Agency for International Development in their extensive Spring Review of New Cereal Varieties.[2] Since this whole story, including the pioneering work of the Ford and Rockefeller Foundations, is now rather widely known, several general comments about it will suffice.

The picture that emerges for wheat and rice in Asia is fairly clear. Starting from a position of only a few thousand acres in 1965/66, there has been a spectacular growth in the use of the new seeds, particularly in the case of wheat. By 1968/69, it is estimated that over 30 million acres were planted to the improved varieties. (See Tables 1 and 2.) These high-response varieties and the concomitant rapid growth in

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2/ More than twenty papers were prepared for this review. A very cogent summary of them is given by Rice [35].

Table 1. Use of New Varieties, South and Southeast Asia

Rice

Country	Total Rice Area 1968/69	Area of New Varieties 1966/67	Area of New Varieties 1968/69
	(Thousand Acres)	(Thousand Acres)	(Thousand Acres)
Burma	12,297	#	470
Ceylon	1,637	-	17
India	91,344	2,142	6,500
Indonesia	20,950	-	416
Laos	1,550	#	4
Malaysia (West)	1,182	104	225
Nepal	-	-	105
Pakistan (East)	21,212	#	300
Pakistan (West)	3,743	10	761
Philippines	7,904	204	2,592
Vietnam (South)	5,528	-	109
TOTAL	167,347	2,460	11,499

Wheat

	Total Wheat Area 1968/69	Area of New Varieties 1966/67	Area of New Varieties 1968/69
Afghanistan	5,500	4	300
India	39,432	1,278	10,000
Iran	4,925	-	25
Lebanon	151	-	1
Nepal	371	16	133
Pakistan	14,977	250	6,020
Turkey	20,015	1	1,780
TOTAL	85,371	1,549	18,259

Less than 1,000 acres.
Source: Barker [3] and Dalrymple [42].

Table 2. Fertilizer Consumption in Asia, 1965/66 and 1968/69

(Thousand metric tons of N, P_2O_5 and K_2O)

Country	1965/66	1968/69
Afghanistan	-	14.0
Burma	6.1	65.0
Ceylon	77.8	111.4
China (Taiwan)	230.2	272.7
India	764.7	1,682.0
Indonesia	94.5	212.2
Iran	41.0	83.9
Japan	1,928.0	2,300.0
Korea (South)	376.4	478.5
Laos	0.1	3.0
Lebanon	14.7	24.2
Malaysia (West)	60.0	79.0
Nepal	1.0	3.0
Pakistan	148.9	391.8
Philippines	138.0	148.5
Singapore	6.5	105.0
Thailand	33.0	35.0
Turkey	149.1	380.0
Vietnam (South)	92.9	115.0
Total	4,162.9	6,504.2

Sources: 1965/66: FAO [13], February 1968; 1968/69: FAO [13], February 1970.

fertilizer use have produced yields per acre about double those possible with most of the older, local strains.

In more aggregative terms, wheat production in Asia during 1969 exceeded the 1960-64 average by 30 percent, while rice in 1969 exceeded the 1963-67 average by 18 percent.[3/] Although the weather factor in these calculations may be substantial, there can be no doubt that great strides have been made in increasing foodgrain production. One need only to have walked through fields devoted to the new varieties to realize that parts of Asia will never be the same again as a result of this technological improvement.

On the other hand, the extraordinary growth of production in certain areas such as the Pakistan and Indian Punjab has, in my opinion, caused a loss of perspective on the total Asian picture. In aggregative terms, only about 9 percent of the rice land in 1968/69 was in improved varieties and for wheat about 23 percent. Given the areas that have had rapid increases to date, there are important reasons to believe that continued rapid rates of adoption on additional areas are unlikely.

Throughout Asia one of the most severe constraints is adequate and controllable water supplies. In the case of wheat, for example, it is the higher-rainfall coastal area of Turkey and not the great Anatolian plain where the new varieties have flourished. In India and Pakistan

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3/ See Rice Situation [43] and World Agricultural Production and Trade [44]. This calculation excludes Mainland China, North Korea and North Viet Nam. Little is known about the use of new varieties in these three countries, but several newspaper stories (e.g., The New York Times, October 25, 1969), indicate that new seeds were a partial explanation of the improved food situation of 1969.

the same point holds for wheat and obtains a fortiori in the case of rice. Although some of the largest rice yields produced anywhere in the world have come from the province of Sind in southern West Pakistan, this type of irrigated region is relatively limited in South Asia. Indeed, in most of the eastern half of India, in East Pakistan and other Asian countries, it has been very difficult to adapt varieties capable of high yields under uncontrolled monsoon conditions. While there has been limited success in such regions as Bengal and Java, again it has been largely in the winter months under irrigated conditions. District-by-district analyses for Pakistan and India show clearly the very high correlation between the growth in crop production and controlled water supplies. Moreover, fertilizer use is highly correlated with both the previous variables. For example, in India, approximately 80 percent of the total fertilizer consumed in 1968 was concentrated in 25 percent of the districts, with most of the latter being those with irrigation systems.[4/] In short, the new varieties require controlled irrigation; without that control, fertilizer provides only a low return; and without new seeds and fertilizer, the possibilities for rapid increase in crop output have distinct limitations.[5/]

A second important constraint on adoption of the new technology in Asia has been the inadequacy of pesticide programs in most countries.

4/ See Grossman [19], Chapter 4.

5/ For a further discussion of environmental factors in Asia see Hseih and Ruttan [21]. The same generalizations probably also hold for much of Latin America and Africa. Although there has been inadequate testing of the new varieties in these regions, experiments in the Pampas, for example, show the adverse yield effects of relatively low and uncertain rainfall on the new varieties.

Many of the older, local varieties had been selected and retained precisely for their ability to withstand pests and diseases. Although Barker /2/ indicates that improving the pest- and disease-resistance of new strains is more easily accomplished than developing varieties tolerant of varying moisture stress, the pesticide problem is enormous nonetheless. Any solution to it must deal realistically with organizational issues and with the important externalities that are involved. For with postage-stamp sized holdings, it does one farmer little good to spray if his neighbors do not. There are also the further problems of getting the right spray, the right equipment, and the right information to farmers at the right time. A fast-reacting pesticide system has not been easy in most of Asia, and, in my opinion, the deficiencies in pest and disease control will continue to be the second most important limitation on the technology/supply side.6/

The foregoing comments, and the other extensive literature now available on individual countries seem, therefore, to be suggestive of several conclusions. First, the adoption of new technology in the second, third, and n^{th} blocks of 30 million acres for wheat and rice are likely to be much slower in coming. These blocks must include smaller farmers, about which more will be said later, and must reach into areas where water supplies are uncertain. Although it is possible that the plant breeders and geneticists can develop new strains that will overcome many of the remaining pesticide and water problems -- their performance until

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6/ One hopeful sign in the pesticide area is the recent development of granular compounds which can be applied by broadcast methods. This technology is much more neutral to scale and avoids many of the equipment and timing problems.

now has certainly been impressive -- there has been only moderate success to date along these lines. A corollary to this point is that, in the future, the almost "cost-free" nature of the new seed technology[7] will change appreciably. The planning, constructing and running of irrigation systems is a time consuming and expensive business. Instead of having only to convince farmers to use more fertilizers, large public and private investments -- often on the order of $50 or more per acre -- will be needed. These in turn will require increased public revenues through taxation and/or aid. Whether large investments of this type can be justified on economic grounds is another matter; the answer will require a complete reassessment of costs and benefits of agricultural growth within an economy-wide framework.

Second, given the regional constraints on new varieties for wheat and rice in Asia, and given the continuing need for broad-based and rapid agricultural growth as a part of the overall development process, there is an urgent need for increased national and international varietal research on additional commodities. In addition to wheat and rice, some encouraging work on corn and sorghum is under way; however, work on oilseeds, pulses and fibers, as well as on livestock[8], has hardly

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7/ I do not mean by this statement to indicate that the purchase of the joint input, fertilizer, was costless. However, the shift in production function was very large, and even when the additional costs of all joint inputs were deducted, profits per acre increased enormously.

8/ Brown [5], Hardin [20], and others have advocated diversification into livestock as one palliative to the income problems of less developed countries. For Asia, I am skeptical about the practicality of such a suggestion. Religious and cultural factors preclude beef and/or swine in many regions, and the disease problems of poultry are especially difficult for small farmers. Perhaps even more discouraging are three other factors, (a) the length of time required to implement an improved livestock system, (b) the average income levels that prevail in the area, and (c) the relative price of livestock to grains. In West Pakistan, the farm support price of wheat is about $2.65/60 lb. bushel (at the official exchange rate), whereas the retail price of beef tenderloin (clearly not prime!) is about $.50 per pound.

begun.[9/] Vested interests in the developed countries, especially in the case of cotton, are a part of the explanation, but surely not all of it. While genetic research in Taiwan, the Philippines and India has become impressive, most other Asian countries have lagged -- even in adaptive research on wheat and rice. To call for more research has been the ubiquitous recommendation for years; in this case, however, it really is important.

Third, and related closely to the previous points, it is clear that economists and others must stop thinking strictly in aggregative terms about national and international commodity problems, and must give increased attention to regional questions within countries. India, Pakistan, and Indonesia are all classic cases of countries where regional commodity problems and policies are rapidly becoming of dominant importance. To anticipate comments in the next sections, it is necessary only to contemplate pricing and adjustment problems for wheat and rice, the major wage goods, when yields per acre in one-third of a country have doubled, but have held constant elsewhere within the same nation.

9/ My colleague, Morton Grossman, argues that with only two or three commodities and a few regions so far involved, the whole process ought to be called the Green Evolution. In India, for example, wheat acreage since 1964/65 has increased 20 percent, and production by 50 percent; but wheat is only 22 percent of total foodgrain production and is even less of total agricultural output. Total foodgrain production since 1964/65 has increased by only 2.5 percent annually. In 1968/69, non-foodgrain production, one-third of total agricultural production, was 9 percent less than in 1964/65. It is in this total growth sense, therefore, that evolution is the more appropriate term.

The Second Generation: Problems of Marketing, Markets, and Resource Allocation

In the regions of Asia where the production revolution has occurred, the impact on marketed surplus has been nothing short of phenomenal. Even with a moderately high on-farm demand from increased output, marketings have risen much more than proportionately to production. While the response of public and private sectors in a few regions has been quite good, the pace of change, the preoccupation with production, and the ability of policy makers to handle only a few issues simultaneously have meant that few policy actions were taken before crises erupted. Transportation bottlenecks have often been a problem, as an example from West Pakistan will illustrate. In Sind (the lower half of the hour-glass-shaped Indus Basin) rail marketings of rice in 1969 completely swamped the system. Large uncovered piles of rice accumulated at railheads, and prices to farmers fell substantially.[10/] Millers were working equipment at capacity and were running into severe inventory and working capital

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10/ Efferson /9/, p. 18, reports as follows:

> "Every mill visited in the Southern rice area had large supplies of paddy on hand. In most cases, all available paddy go-downs were filled and hundreds of tons of paddy were stored in the open, in piles on the drying floors, and without protection. These same mills had their milled-rice storage facilities filled to capacity. When asked why they were not moving the rice, they suggested that the situation at the railroad loading points be checked. At the stations it was found that all sheltered storage was filled and the yards were piled high with sacked milled rice, much of it without cover of any type. This rice was still owned by the millers. At the Larkhana Station, for instance, sufficient milled and sacked rice ready for shipment to Karachi was available to fill 100 wagons, and more than one-half of this 2,000 tons was in the open, available for attacks by birds, rodents, and possibly thieves, and subject to major damage and deterioration by the first rain. This same situation was reported to exist at many other shipping points in the region."

constraints. (As usual, they were blamed for the decline in price.) It nearly required a French-style, pitchfork rebellion to obtain more rail cars, to change government policy to permit trucks to deliver rice to the port, etc.[11/] In the meantime, however, farmers were "hurt," at least relative to what would have been the case with a better transport system and a faster-moving government policy machinery.

Similar stories on milling, grading, storage and transport can be told for other countries as well. The problem of limited, old-style mills, unable to handle increased supplies and to produce "export-quality" rice, is well documented in reports and government documents that I have seen for at least five Asian countries. These physical problems of marketing have been exacerbated by social factors in several countries of Southeast Asia, where specific ethnic or racial groups have traditionally controlled most of the commerce. Regardless of the efficiency of the marketing system, rural problems have tended to be blamed on these groups. Justly or unjustly, middle-men are an important factor in social and political unrest in these countries. This unrest, in turn, has posed the problem of either taking over milling in the public sector, or of developing a set of incentives and guidelines for the private trade that will protect the public interest as seen by the policy makers. Efficiency

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11/ The problem on trucks was indicative of the marketing problems that can arise under these rapidly changing conditions. Rail cars were historically graded and sealed at the point of origin. Trucks could not be sealed, and no grading system existed at the point of destination. Until the latter could be remedied, the use of trucks was banned. In addition, there was fear of increased smuggling if trucks were permitted to move the rice.

and ideology are often in conflict on this point, and the net result in many regions has been that the developments in marketing skills have lagged.

There have also been varietal/quality questions that have posed difficulties both domestically and internationally. The early IRRI rice varieties had tendencies to sun-check and to show "white belly." The baking quality of the Mexican varieties of wheat was also deemed less good (or at least different) by many Asian consumers. As a result, the new varieties sold at substantial price discounts in the market (often 20 percent). Although the new varieties were generally still much more profitable for farmers to produce, problems of consumer acceptance caused considerable anxiety among farmers, consumers, and policy makers.12/ However important these difficulties may have been in the short run, they are clearly transitional in nature. New varieties are already being developed and introduced which will overcome many of the most severe quality problems.

In addition to the readily identifiable milling, transport, and grading questions, there are also formidable second-generation problems concerned with pricing and markets. There are economic and political dimensions to these questions, and both aspects must be incorporated into meaningful answers.

A number of the food-deficit countries have historically had a

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12/ The historical record shows that when the present local varieties were introduced many years ago, they too were criticized on quality grounds. Hence, the acceptance point should probably not cause undue concern.

structure of relative prices that bore little relationship to world prices. Although in allocative efficiency terms, such a structure has always had drawbacks, the problem takes on even more serious proportions when countries and regions close their food import gap and become potential exporters. Adjusting domestic support prices, which at the official exchange rate are often double or more the world price, is no easier politically in these countries than in the United States.

Some indication of variations in price supports among countries can be obtained from the calculations of Schertz /36/. The range in the case of paddy is very large -- $36/ton in Burma, $93 in the Philippines, and $123/ton in Ecuador. In the case of wheat, the price of one ton also varies greatly -- $64 in Mexico, $87 in Turkey, and $101 in India. Clearly a part of this range is due to the overvalued exchange that characterizes many of the developing countries. On the other hand, absolute and relative prices among crops within countries often bear no relationship to international norms, and adjustments are essential if farmers are to be given the correct price signals, and if the social benefits of agricultural production are to be kept at the forefront of the development strategy.

The foregoing point can be seen clearly with another illustration from West Pakistan. With the new wheat-fertilizer technology, and a government-guaranteed price almost double the world market price at the official exchange rate, wheat was extremely profitable. The wheat supply curve shifted outward to the right very rapidly,[13/] and in 1968 the

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13/ Empirical estimates of these supply curves under varying technologies are given in Gotsch and Falcon /15/, Chapter 4, and in Annex A of this paper.

government tied up more than $100 million in supporting the price of wheat. These funds precluded other development expenditures that were more "productive," in part because of inflexibility of monetary and fiscal policy. Moreover, the great profitability of wheat with guaranteed prices and new technology began to cut into the acreage of cotton, the major export commodity. Given wheat's relative and absolute price, the fact that it was the major wage good, and that even at reduced prices it was an enormously profitable commodity to grow, the sensible[14/] conclusion was to lower its price. This would have assisted urban workers (whose riots, by the way, were a major factor in the change in government and the reimposition of martial law later in 1969), and would have moved the country towards a wheat price more in line with international comparative advantage. This was not done, however, for a variety of legitimate and illegitimate reasons. The argument was always put in terms of reduced production, although income transfer was the real issue. The harmful regional income effects on rainfed areas unable to use the new technology were also quite legitimately cited as reasons for not lowering the support price. Moreover, a number of observers claimed that reduced prices would be a "disincentive" and "would kill the revolution." In the end, agricultural interests prevailed and the high price was retained.[15/] The fundamental point -- that incentive is a composite of yield and price (i.e.,

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14/ Sensibility, like beauty, is of course in the eyes of the beholder!

15/ It was lowered by about 12 percent for a brief time and then reinstated.

profitability) and not just price -- was overlooked, as were the broader needs of the economy. That somehow agriculture might or should share the results of the cost-reducing effects of the new technology had been disregarded.

In addition to internal pricing difficulties, an even larger problem looms ahead on the international side. For those regions "lucky" enough to emerge as surplus areas, the problems of breaking into international grain markets have rarely appeared so difficult. The International Wheat Agreement appears to be seriously undermined, and there has been a considerable softening in rice prices, particularly in the lower-quality grades.[16/]

Several elements of the international dimension deserve mention. What happens to "world prices" for wheat and rice is obviously dependent on what happens to the green revolution in the developing countries as well as to the agricultural policies of the developed nations. As indicated previously, there are reasons to believe that portions of Indonesia, India, and East Pakistan are likely to be net importers for some time. On the other hand, the quantity traded internationally is so small relative to production -- less than four percent in the case of rice -- that increases in production in key countries such as India are likely to have important international price repercussions. Perhaps even more important than what happens in the developing countries is what happens to agricultural policy in the advanced countries. Unable to adapt to rapid

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16/ See Barker /4/.

technological advances and structural change themselves, these countries have instituted support systems that use commodity exports to solve sectoral income distribution problems.[17] The P.L. 480 program of the United States, in spite of its considerable merit at times, certainly comes under this heading. The E.E.C. is "developing" similar arrangements, creating such anomalies as France supplying Indonesia with rice at concessional terms. Japan, with support costs triple the world market price for several million tons of rice, is in the process of supplying Korea with 300,000 tons of rice, payable in 30 years with only 1½ percent interest rates and a 10-year grace period.[18] In short, less developed countries breaking into export markets will be faced with three kinds of problems: (a) a tenacity among developed countries in fighting for shares of the commercial market, and a willingness to cut prices to retain them, (b) an increasing amount of foodgrains being supplied by developed countries at concessional terms to countries that might "normally" be the trading partners of developing countries,[19] and (c) an inability, or at least difficulty, of the less developed world to compete in "buyers'" markets in terms of specific grades, quality, deliverability, etc. The foregoing does not mean that the developing countries cannot sell in international markets. What it does mean, however, is that planners in these countries must be hard-headed about the quantities, and especially the prices at

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17/ See Gotsch [14].

18/ See McKnight [27], p. 9.

19/ What may "save" third countries in this competition is an inability of the U.S. and other government to move quickly in response to food aid requests.

which wheat and rice can be exported, and the concomitant internal price adjustment (or export subsidy) that will be required at these levels.[20/] [21/]

The foregoing marketing and demand problems, any one of which could be the subject of a major paper, suggest several conclusions. First, the production gains in certain regions have shown how rapidly second-generation marketing problems can arise. Hopefully in the future, policy makers will heed earlier the warnings given by marketing specialists, and will react before crisis situations develop. Unless these milling and transport problems are solved, farm prices will decline steeply, and the quality problems of exporting will be all the more difficult. What is particularly needed in several Asian countries is a marketing strategy which resolves the basic public/private/foreign investment questions on marketing facilities. Also needed is an explicit recognition of the interaction of price support policies and techniques on the behavior and efficiency of marketing firms.

Second, planners must pay increasing attention to the adjustment and pricing problems attendant on the new varieties. The narrow focus on foodgrains and relative neglect of other crops must be re-evaluated in a multi-crop setting. In particular, the cropping patterns of many of the

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20/ When, for example, Assistant Secretary Palmby /33/ warns U.S. wheat growers at their convention that they should be thinking about feed-grain prices for wheat, the price situation can, I believe, be regarded as serious!

21/ In another paper /17/, Carl Gotsch and I were chastised for being too bearish about the international rice market. But by way of illustration, Indonesia in late 1969 was able to purchase substantial quantities of rice in Burma at about $80/ton. Although this rice was fairly low in quality, it does suggest that this figure, rather than the $200 quoted in mid-1969 for 5-7 percent broken, Thai rice ought to be one that planners should keep in mind.

irrigated areas of Asia which can best use the new varieties are quite sensitive to profitability changes.[22] What constitutes an appropriate incentive price for foodgrains in these areas with the new varieties has changed substantially; unfortunately the rhetoric which characterized the later 1950's and early 1960's, regarding the need for ever higher agricultural prices, has not changed. Vested interests in agriculture are already a fact of life in these countries, and economists concerned with agriculture must keep in mind the overall needs of development, not just the needs of the agricultural sector. Since most agricultural goods are tradable, what is especially needed in the less developed countries is an assessment of the domestic costs of earning or saving foreign exchange from producing various agricultural and non-agricultural commodities.[23] The real tragedy would be for these countries to retain outmoded pricing policies which lead to great inefficiencies in resource use, stock accumulations, and/or highly subsidized agricultural exports -- exports which were uneconomically grown in real terms in the first place. Unfortunately, experience in dealing with such problems in developed countries does not inspire confidence, nor do recent policies in a number of Asian countries.

Third, the advanced countries must consider more seriously the

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22/ See Gotsch and Falcon [16], and Annex A.

23/ See Hufbauer [22], Lawrence [25], and Stern, Falcon and Gotsch [38]. In West Pakistan, prices (f.o.b. Karachi) for wheat, rice, cotton, and maize are respectively 170 percent, 160 percent, 100 percent, and 235 percent of world market prices at official exchange rates of Rs. 4.75 per dollar. By contrast, the rupees required to earn or save a dollar of foreign exchange are respectively Rs. 5.25, Rs. 3.34, Rs. 3.84 and Rs. 3.34 for these same crops.

distorting effects of their dumping programs. The talk of a world market price for wheat or for rice is largely a fiction, and concessional pricing arrangements will be a sharp deterrent to the generation of third-country foodgrain exports.

Fourth, since there is little reason to have confidence in the developed countries' ability to deal with their sectoral income distribution problems without resort to concessional efforts, the developing countries should look increasingly to domestic markets for absorbing additional supplies. On this point, there is some room for optimism. What has been seriously underestimated, I believe, is the investment and employment uses to which wheat and rice, the wage goods, can be put. The basic elements in this argument can be stated as follows:[24] With significant increases in production, foodgrain prices in a closed economy would fall. However, given the fact that much of the increase came from cost-free technological change, prices could fall somewhat and still provide strong incentives to farmers. In addition, with adequate stocks of grain, the government can have a much more expansionary fiscal and monetary policy. (Indeed, in India, Pakistan, and Indonesia, the lack of adequate food supplies has been a major constraint on the size of the development budget.)[25] The more expansionary monetary and fiscal policy -- particularly if it is directed toward labor-intensive public projects -- can shift the

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24/ See Lewis, Falcon and Gotsch [36], and Mellor [28], [29] for a fuller exposition of these ideas.

25/ That this is a reasonable reaction can be illustrated by the Indonesian economy. In 1966, that economy underwent an inflation of more than 600 percent, in large part because of rice shortages. Fortunately, rice and other policies have changed since that time.

demand curve for grains, helping to counteract some of the decline in prices.[26/] Given the fact that the price of the wage good is a major development constraint in much of Asia, especially as seen by Finance Ministers, the increases in production from the green revolution can thus continue after initial import substitution has been exhausted. These increases can be converted into investable resources through fiscal and monetary expansion, and the country (perhaps even the agricultural sector if the investments are rural) would be much better off.[27/] This should be a basic element of strategy for countries moving into foodgrain surpluses. Moreover, it seems especially important for countries who find themselves with seriously distorted internal prices. This approach should provide time both to solve the institutional problems of entering international trade and to make transitional changes in relative and absolute price levels without having to rely on stock accumulation or "excessive" subsidies on agriculture.[28/] Such a strategy also has much in common with a sensible P.L. 480 policy which can effect shifts in the demand curve through investment policies, thereby helping to counteract much of the decline in prices that would have resulted from increased supplies.

26/ Among low income workers in South Asia, for example, about two-thirds of the budget goes for food, and within the food category about half is for foodgrains.

27/ The most famous of the attempts at a Rural Works Program is discussed by Thomas [39].

28/ Whether a subsidy is excessive in social terms can be seen through a series of calculations which determine the domestic cost of earning or saving foreign exchange for given commodities. The above comment should, therefore, not be construed as being against export subsidies as a matter of principle.

The Third Generation: Social Forces and Uncertain Consequences

The first generation production problems and the second generation marketing and demand difficulties created by the green revolution are a formidable list. Nevertheless, they are largely short-run issues on which economists have worked for years. By contrast, the third generation problems, having to do with equity, welfare, employment and social institutions generally, are questions that have received inadequate attention even in the developed countries. Part of the problem arises, as Dorner /8/ has forcefully argued, because the United States' rural institutions were almost all in place when the agricultural economics profession originated at about the turn of the century. In short, the profession has had very little experience in dealing with what may be the overriding problems facing Asia today.

These third-generation factors arise from four principal sources: (a) population growth rates in excess of 2.5 percent annually in areas already extraordinarily densely populated, (b) very low average income levels, coupled simultaneously with great regional and personal disparities in income, wealth and political power, (c) limited opportunities for non-farm employment even if the manufacturing and service sectors grow very rapidly, and (d) the possibility for technological leap-frogging with agricultural inputs and techniques which are often of a labor-displacing nature. The resulting dilemma can be baldly stated: The Asian countries need agricultural growth if ever they are to break the chains of poverty; but they need equity as well, for obvious humanitarian reasons, and also if they are not to find themselves in a continuous cycle of violence and

repression. The challenge of these forces is far greater in magnitude than the problems ever faced by the U.S. and most other currently developed nations. Moreover, the latter are not in much of a position to help. Although they are perhaps capable of exporting the growth technology, they have few institutional forms to export that can come to grips with the income distribution and employment questions that now plague Asia.

India, Pakistan, and Indonesia, three enormously large and regionally heterogeneous countries, present stark examples of the problems outlined above.[29/] Even with the rapid growth of the industry and service sectors, it is clear, as Johnston [23] has shown, that non-farm jobs cannot hope to keep pace with the population explosion.[30/] Increasing agricultural un- or underemployment and/or larger unemployment in cities seem inevitable. The specific question at issue in this paper, however, is the effect of the green revolution on the structural process. The answer is far from clear cut, and will be dependent in part on the subsequent policies that are followed.

With respect to short run, direct employment effects of the green revolution, the inconclusive evidence that exists has recently been summarized by Shaw [37]. The data indicate that in some areas the shortened growing season may permit multiple croppings and add to labor "requirements." Increased yields per acre may also require more labor. On the other hand,

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29/ In Bengal, for example, population density in "rural" areas already exceeds 1,300 per square mile and could rise to 2,500 within twenty years. Each five year plan India adds more people to her population than twice the total population of Ghana. See Revelle and Thomas [34].

30/ To keep this point in perspective, in Pakistan the livestock sub-sector of agriculture currently contributes more to GNP than combined large- and small-scale industry.

if wheat, for example, becomes sufficiently profitable to displace a more labor-intensive crop such as cotton, total man days of labor may be reduced. In short, the employment effects of the new varieties must be analyzed in very specific regional contexts; however, in the aggregate the new varieties appear to be employment-creating in character.[31/]

Perhaps even more important than the direct effects, and often neglected in discussions on employment, are the side effects of increased food supplies/lower food prices on public and private savings and investment generally. As noted earlier, the food-price constraint is an important one and has a pervasiveness that extends far beyond the agricultural sector. Here too the green revolution helps, provided that its potential for increasing savings is realized and is transferred into real investment.

Far more disturbing, however, are two other features of the green revolution on employment, welfare and stability. Both of these derive basically from the unequal regional growth that seems to be a concomitant of the new technology. The process is as follows: The regions with irrigation, such as the Punjab, have the ability to respond rapidly to the new technology. A combination of the resulting production, plus an agricultural price policy which reflects concerns for non-growing districts as well as vested agricultural interests, will mean that incomes in the irrigated regions grow at phenomenal rates. That is all to the good; the difficulty is that welfare, between regions as among people, is more a relative concept than an absolute idea. It is not, for example, that

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31/ A precise statement of the aggregate employment effects would require demand schedules, supply schedules and factor-substitution schedules for agriculture, plus all the inter-industry effects.

West Pakistan is absolutely well off by any international standard. But it is the income (and imperialistic attitude) there relative to that in East Pakistan that threatens to tear the country apart. Although general tax and subsidy systems, as well as other measures of government policy, could rectify this inequity, it is necessary to look only at the developed countries to know the impracticality of such a suggestion. In this inter-regional sense, therefore, the green revolution is hardly a stabilizing influence.

Within a given region, the mechanism producing greater income inequality is much the same, and the form is even more virulent. Although in theory the new seeds and fertilizer are neutral to scale, in practice they are not.[32/] Under rationed conditions, and unfortunately these often prevail for inputs in Asia, it is the larger farmers who obtain the fertilizer and receive the irrigation water. Moreover, with the prices and technology now prevailing, agricultural incomes of large farmers have risen dramatically. This too is not "bad," but the side effects may be. Land prices are rising rapidly, as farmers seek to expand size and find new outlets for their increased incomes. Even more important is the drive that these windfall gains are providing for certain types of mechanization. Although this is a broad question, deserving also of a separate study, several points deserve mention. First, there are powerful forces that are pressing for mechanization of all kinds. Large

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32/ Strictly speaking, the seed-fertilizer technology is neutral, but the factor and product markets in which the technology is used often have large imperfections. In the case of irrigation wells, however, there are definite economies of scale.

farmers, foreign and domestic industrialists, politicians and even aid agencies[33/] have vested interests in promoting various implements, including tractors. Some forms of mechanization may be labor-displacing, others not.[34/] However, large farms in wheat areas are an example of where tractors and combines will be introduced, barring strong government action to the contrary. The net result will be to make tenants into laborers, and to increase the number of people displaced from agriculture. Just as in the inter-regional illustration, the intra-regional effects of the green revolution are likely to increase the inequality of incomes within agriculture. There will indeed be agricultural growth in these areas; but probably increasing tension among classes as well.[35/] Perhaps the growth in service and supply industries in small towns can absorb this additional displacement.[36/] But the adjustment problems with which the U.S. had trouble in coping under much more favorable demographic circumstances and over a century, must be dealt with in Pakistan in 20 years. This labor displacement process was not "easy" in the U.S.; in

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33/ The I.B.R.D., for example, is currently proposing a $25 million loan to finance tractors in India, and has several other similar loans pending. In Pakistan, an I.B.R.D. mechanization loan also provided for the special importation of tractors at the official exchange rate and, in addition, provided special credit arrangements.

34/ The agricultural evidence by Shaw /37/ indicates how necessary it is to talk about specific regions, commodities and implements before concluding anything about labor displacement.

35/ See Munthe-Kaas /31/. Although the rural poor may not "lead" the class or regional fights, they are likely to be involved -- even used -- in the process by disaffected leaders on either the right or the left.

36/ Grossman /19/, Chapter 2, indicates that it was the rural cities of around 100,000 in India where population and jobs grew the fastest in the 1960's.

Asia the situation is distressing even to contemplate. It is not an accident that the journals and newspapers are now frequently carrying such essays as "Green and Red Revolutions" [30].

Several recommendations and reconsiderations are suggested in the light of these third-generation questions. First, as long as the new varieties remain limited to a few regions and as long as farm incomes are primarily dependent on acreage rather than people, it is naive to believe that the new technology for agriculture is likely to be a stabilizing influence. Growth generally is de-stabilizing, and this form of unequal agricultural development is particularly so. Even if the first borrowings of technology are neutral to scale (which in practice they are probably not) then subsequent borrowings are likely to be labor-displacing unless strong policy measures are introduced. The magnitude of this phenomenon will vary by commodity and region, but the direction seems fairly clear. Second, some way must be found to close the gap between social and private benefits on certain forms of agricultural technology. It is not sufficient to appeal to the "Japanese method" of cultivation, to urge labor-intensive techniques for agriculture and industry, or to proclaim the virtues of small-scale industry. Such pronouncements must be transformed into instruments of direction and control: high taxes on tractors; a possible lowering of wheat and rice prices as a stimulant to the rest of the economy; much higher interest rates on capital and higher <u>defacto</u> rates for foreign exchange; progressive land taxes and perhaps even ceilings on farm size so as to make uneconomical, from a private point of view, certain forms of technology. And in any Asian country, no one should discount the size

and power of the forces that are likely to be against most of these policies.

Third, neither growth nor equity problems in Asia can be solved by the green revolution or even by the agricultural sector alone. The employment problem, in particular, is total-economy in character, whose solution requires increased savings, more foreign exchange, higher investment rates, altered factor and product pricing structures -- in short, economic development. While agricultural policies should not aggravate the situation, meaningful answers to these issues must look to other sectors as well.

Fourth, given the tearing effect that unequal regional growth has on the national fabric, there is need to stress again the importance of developing new technology for the monsoon/dryland areas.

Finally, while there is need to keep social and private benefits from diverging among the large farms, the opposite side of the coin is to assist small farmers. From Table 3, it is clear that huge numbers are involved, under any reasonable definition of smallness. Given the resources available, and the political interests that are involved, a broad-based welfare system does not seem to be the answer. Nor do special loan or credit arrangements to small farmers which are used for unproductive investments. There is reason to be even more skeptical, as has been amply demonstrated in the United States, about price support or input subsidies as an instrument. It is the large farmer who has the marketed surplus and who uses most of the inputs. (Nearly one-third of the farmers in Indonesia, Pakistan, and India, for example, are net purchasers of grains.)

Table 3. Distribution of Farm Size in Indonesia, Pakistan and India

Area (acres)	Indonesia[b] (1963)		East Pakistan[c] (1960)		West Pakistan[c] (1960)		India[a] (1961)	
	No.Farms (000)	Percent	No.Farms (000)	Percent	No.Farms (000)	Percent	No.Farms (000)	Percent
Under 1	5,423	44.7	1,492	24	742	15		
1 to under 2½	3,218	26.5	1,677	27	856	18		39.1
2½ to under 5	2,173	17.9	1,615	26	806	16		22.6
5 to under 7½	653	5.4	698	12	581	12		12.8
7½ to under 12½	399	3.3	442	7	759	16		14.9[g]
12½ to under 25	413	2.3[d]	188	3	729	15		6.1[h]
25 to under 50			26[e]	*	286	6		4.5[e]
50 to under 150					88	2		
150 and above					14	*		

* Percentage less than 0.5.

a/ Gene Wunderlich [48]. Percentage distribution only is available, based on sample surveys.

b/ Asian Development Bank, Asian Agricultural Survey [1].

c/ 1960 Pakistan Census of Agriculture [18].

d/ Amount is for over 12½ acres.

e/ Amount is for over 25 acres.

f/ Amount is for all holdings below 2½ acres.

g/ Amount is for 7½ to under 15 acres.

h/ Amount is for 15 to under 25 acres.

It is spurious to argue for higher farm prices or increased subsidies to "help the small farmer," for it would be hard to design a more inefficient system for reaching them. (Some rough calculations for India and Pakistan indicate that of $10 transferred via a price support system, only about $1 goes to "small" farmers.) The small-farmer argument, which is always displayed by the representatives of larger farmers whenever pricing is an issue, should be viewed very skeptically.

Except for the obvious and important point of assuming a ready supply of inputs such as fertilizer, the literature of agricultural development has little to offer in the way of positive suggestions for dealing with the agricultural production alternatives for millions of small Asian farmers. Providing credit in kind (as under the BIMAS program in parts of Indonesia) has worked in some circumstances, as have a few cooperative arrangements. The program at Comilla in East Pakistan, for example, has shown the merit of cooperative credit, marketing and pump facilities at the village level. On the other hand, most of the cooperatives of South and Southeast Asia have been run as heavy-handed government agencies with little local support except among the rural elite who have benefitted from them. Similarly, loan programs especially designed for small farmers have generally had little success because of prohibitively high transaction costs for issuing and monitoring small loans. Perhaps most promising as an aid to the smaller operator is the provision of adequate supplies of irrigation water. The employment effects from this type of infrastructure are substantial, and reliable water supplies may provide the flexibility for diversifying and intensifying output. On the whole, however, the outlook is far from bright for the smaller farmer.

Given all these problems, it is not clear what will happen, or even what ought to happen. However, an extraordinary recent article by Dandekar [7, pp. 54-55] offers two possibilities that should induce much serious thought about institutions and agricultural organization in Asia:

> "The problem is how to hold and reverse this process [of growing income inequality.] Communism presents in my opinion a logically well-conceived solution and a well-tried strategy. Briefly, it consists of three stages. The first stage is expropriation. Its purpose is to abolish the feudal institution of tenancy and to destroy politically, the landlord class. The second stage is re-distribution of the expropriated land in equal holdings. Its purpose is to win allegiance, support and participation of the agrarian masses and also to demonstrate the absurdity, under conditions of overpopulation, of distributing land in equal holdings on the principle of land for everyone. The third stage is consolidation or collectivization of the land so distributed into sizable areas under cooperatives or communes. It is in this final form that the reorganized agrarian structure is able to meet the challenge of the situation. I have no doubt that the communist strategy can break through the vicious circle of poverty and rescue an overpopulated agricultural country out of the conditions of overpopulation." . . . . [On the other hand,]
>
> "If, in a situation of overpopulation, capitalist agriculture is to be promoted and encouraged, there is not land enough, at the same time, to give a small plot of land to members of the landless. In fact, their numbers may grow . . . . The fundamental issue of equality cannot be resolved by such means. But people are willing to be patient if a more elementary issue is attended to, namely the right to a living through gainful employment. . . . the capitalist sector in agriculture, as in industry, must be taxed sufficiently to enable all the residual landless labour to be gainfully employed on works which will create capital in agriculture and infrastructure from which ultimately the capitalist sector will profit."

Myrdal [32], for one, does not believe that the second alternative is feasible on political grounds. If it is not, then the first solution with all its attendant production and other difficulties, ought not to come as a surprise to Asian governments or their advisors.

Concluding Comments

The foregoing assessment of the Green Revolution is hardly one of wild enthusiasm. The purpose has not been to argue that it should not have happened or to deny its great production successes in certain regions. Rather, the intent has been to indicate how limited a solution the revolution is, given the broader development problems of South and Southeast Asia.

Four central themes stand out in the analysis. First, impressive as the gains to date have been, the term "revolution" can only be used correctly to describe about 10 to 15 percent of Asia. One of the greatest second-generation obstacles is that set of individuals who believe, explicitly or implicitly, that the first-generation solutions have been found. Many additional answers are needed, and any complacency on varietal research would be most unfortunate both in terms of growth and regional equity. Clearly also, a real revolution will require greatly expanded investments in irrigation and substantial improvements in systems for pest control.

Second, the sudden increases in agricultural output have already or will soon, necessitate basic pricing decisions on the parts of governments. It would be a great pity if the nations of Asia, in the face of remarkable productivity changes, maintained pricing structures which did not keep in mind the needs of the entire economy. As a result of the increased production from the green revolution, there is considerable potential for expanding the development effort with investment programs that are wage-good intensive. As regards exports, the developed countries

could play a major facilitating role; however, their probable increased use of dumping programs will provide the most formidable kinds of competition for those developing nations who generate export surpluses. Hence the internal market opportunities and the external market difficulties indicate the probable need for downward adjustments in relative grain prices in several Asian nations.

Third, the limited technological revolution in agriculture has permitted an easing of one critical development constraint. It has not, however, provided a panacea for solving the employment and equity problems, and indeed, has probably been de-stabilizing in the sense that it has widened income disparities within and between regions. Lest this view be regarded as too bleak, it should also be emphasized that without the green revolution, the development situation in these countries would now be even more dire.

Finally, although it is important to recognize and understand what has happened in the past, the great challenge of the future will be to forge institutions that can deal simultaneously with the demographic explosion, rapid economic growth and equality of income distribution. Certain obvious mistakes in policies can be avoided, such as the subsidization of tractors. However, there is little in the way of a broad, institutional blueprint in the history of the developed countries or in the general writings of agricultural economists that are now of much help on this issue. The Asian challenge of the 1970's will be to encourage growth elements in the economy -- such as the green revolution -- while at the same time fostering equity so as to prevent a decending spiral of violence and repression.

Annex A

New Varieties, Irrigation and Price Policy in West Pakistan

In /15/, Carl Gotsch and I present the results of farm management work done on representative farms from different regions of West Pakistan. Using linear programming techniques which (a) vary commodity prices in the objective function, (b) include the new seed-fertilizer technology in the form of additional activities, and (c) introduce increases in water supplies by varying the water resource constraints, the following sample graphs and tables were developed. We are fully aware of the problems involved in using programming techniques in this manner and in drawing conclusions from the results. On the other hand, the tables and charts presented here for central West Pakistan do supplement a number of the broader conclusions presented in the text of this paper. They are attached to provide some rough, albeit incomplete, quantitative insights on these issues.

* * * *

Conversion Units:

$1 equals Rs. 4.75

1 maund equals 82 2/7 pounds

Figure A-1 SUPPLY CURVES FOR RICE 12.5 acre Representative Farm
Central Punjab, West Pakistan

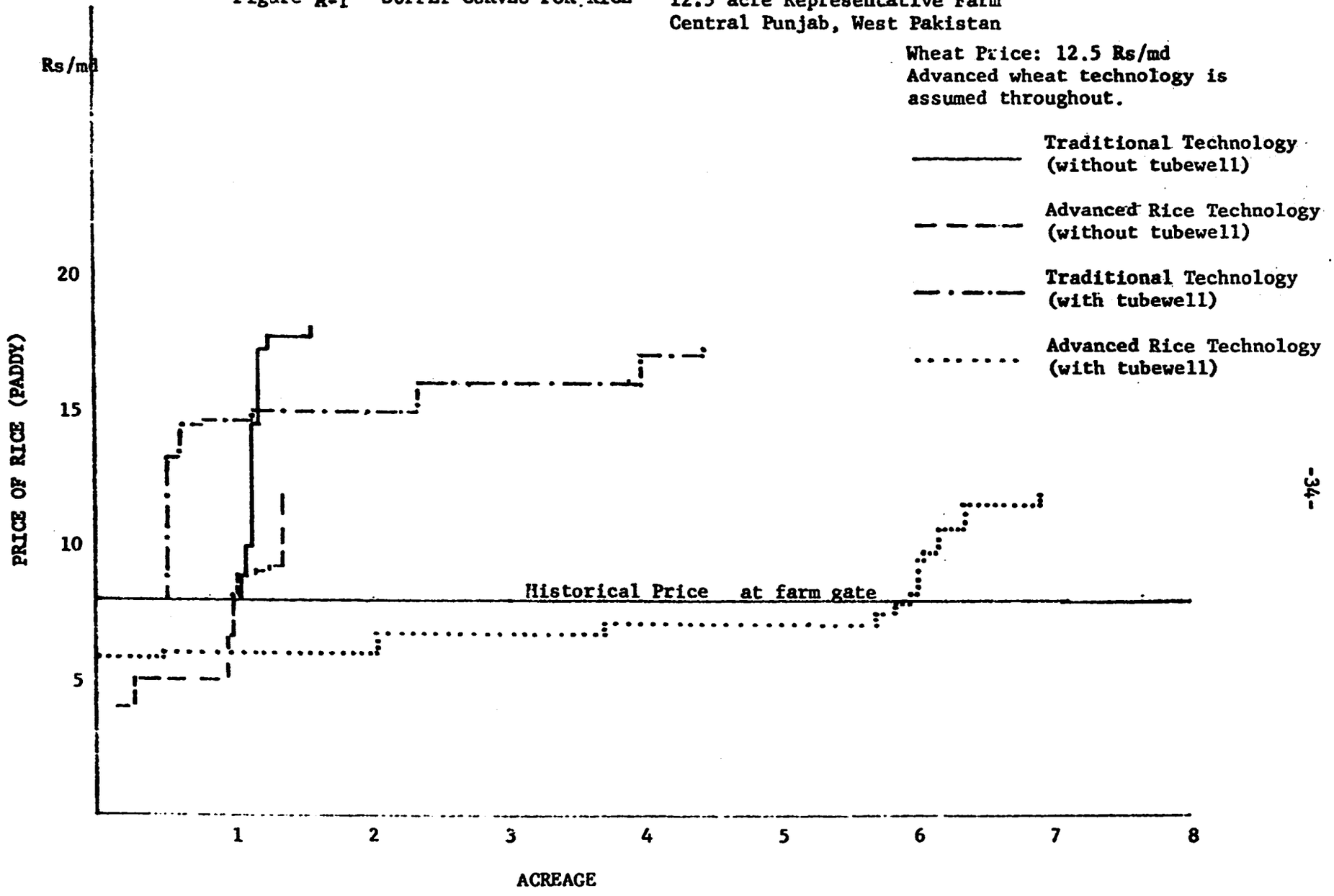

Figure A-2 SUPPLY CURVES FOR WHEAT
12.5 acre representative farm

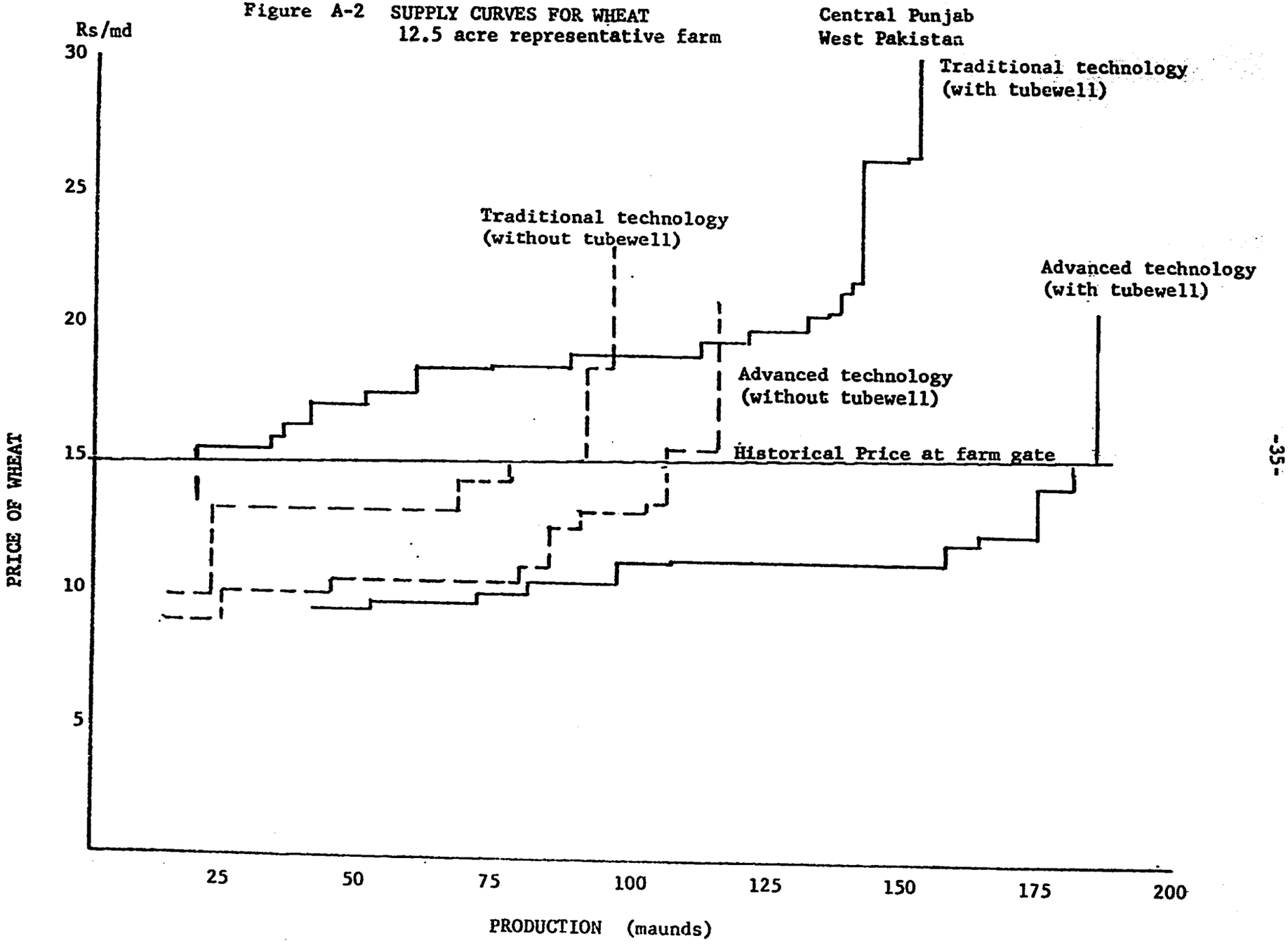

TABLE A.1 . OPTIMAL CROPPING PATTERNS 12.5 Acre Farm CENTRAL PUNJAB West Pakistan

I.D.	Crops (Acres)	Traditional Technology (1) Without Tubewell	Traditional Technology (2) With Tubewell	Advanced Wheat Technology (3) Without Tubewell	Advanced Wheat Technology (4) With Tubewell	Advanced Rice Technology (5) Without Tubewell	Advanced Rice Technology (6) With Tubewell	Advanced Wheat and Rice (7) Without Tubewell	Advanced Wheat and Rice (8) With Tubewell	Advanced Wheat, Rice, and Maize (9) Without Tubewell	Advanced Wheat, Rice, and Maize (10) With Tubewell
NET REVENUE (rupees)		2034	3192	2358	3649	2197	3382	2475	4131	2763	4387
CRC	Coarse Rice	.27		.61		1.04	3.93	.89	6.70		1.77
SFR	Summer Fodder (required)	.60	.67	.66	.67	.60	.67	.60	.67	.60	.60
SFO	Summer Fodder (optional)	.60	.67	.60	.67	.60	.67	.60	.67	.60	.67
CTD	Cotton	3.01	7.37	3.21	2.45	1.94	1.47	2.32		.58	
KVG	Summer Vegetables	.10	.10	.10	.10	.10	1.0	.10	.10	.10	.10
WHF	Wheat	5.13	1.13	5.33	6.15	5.22	5.07	5.10	6.50	5.57	5.70
GRM	Gram									2.19	1.76
OIL	Oilseeds	.31		.32							
BER	Berseem (required)	.80	.89	.80	.89	.80	.87	.80	.89	.80	.89
BEO	Berseem (optional	.85	.85		.85	.56	.85				.85
MAZ	Maize									2.78	3.54
SUG	Sugarcane		1.00		1.00	.59	1.00	.43	1.00	.29	1.00
RVG	Winter Vegetables	.13	.20	.20	.20	.20	.20	.20	.20	.01	.20
FRT	Fruit		.30		.30		.30				30

Table A-2. COMPARISON OF OPTIMAL CROPPING PATTERNS AT DOMESTIC AND WORLD MARKET PRICES (12.5 Acre Representative Farm with Tubewell) Central Punjab, West Pakistan

ID	Crops	Domestic Prices (acres)	World Prices (acres)
CRC	Coarse Rice (IRRI)		4.57
SFR	Summer Fodder (required)	.67	.67
SFO	Summer Fodder (optional)	.67	.67
CTD	Cotton		3.62
KVG	Summer Vegetables	.10	.10
WHF	Wheat (Mexi-Pak)	4.67	4.17
GRM	Gram		
OIL	Oilseeds		.67
BER	Berseem (required)	.89	.89
BEO	Berseem (optional)		
MAZ	Maize (J-1)	4.75	
SUG	Sugarcane	3.86	
RVG	Winter Vegetables	.20	.20
FRT	Fruit		

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