TECHNOLOGY, PRICES AND INCOMES

IN

WEST PAKISTAN AGRICULTURE

SOME OBSERVATIONS ON THE GREEN REVOLUTION

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January 1972

TECHNOLOGY, PRICES AND INCOMES IN WEST PAKISTAN AGRICULTURE: SOME OBSERVATIONS ON THE GREEN REVOLUTION*

I. Introduction

An astute definition of "progress" is that it is a process in which one set of problems is exchanged for another. Though the observation may be a bit shopworn, it appears to be the most apt description of the profound economic, social, and political changes that are currently taking place in a number of the less developed countries of the world: the so-called "green revolution."[1] The story of these radical increases in agricultural output has been widely told: how research work on cereals, initially under the Rockefeller Foundation auspices in Mexico and subsequently under a joint Ford-Rockefeller venture in the Philippines, produced new genetic materials capable of utilizing much higher fertilizer dosages; how these varieties were spread, again largely through the work of private foundations but complemented by U.S. technical assistance, to a large number of countries throughout the world; and how the "miracle seeds," coupled in many areas with water development, have resulted in an entirely different attitude toward the potential contribution of the agircultural sector in a number of less developed countries.[2] Although the first wave of enthusiasm (at least regarding the extent to which this program provides an anseer to the problem of feeding or employing the world's poor) is now beginning to wear off, there seems to be little doubt that these efforts constitute some of the most far-reaching technical assistance programs ever undertaken.[3/]

But the problems associated with the radical changes in the underlying production structure have not been long in showing themselves. Wharton, for example, writes:

> "It will be no easy task to achieve the potential increased production offered by the new technology, particularly when it involves millions upon millions of diverse farms and farmers scattered over the countryside. If the increased production is in fact obtained, this will automatically produce a whole new set of second-generation problems which must be faced if development is to be sustained and accelerated. Therefore, two considerations need to be borne in mind. First, there is reason to believe that the further spread of new varieties will not be as fast as early successes might suggest. Second, new problems arising out of the spread of the new technology, whatever its speed, need to be foreseen and acted upon now. The probable developments in each case have the greatest significance for economic growth and for

the conduct of international relations."[4/]

The following study seeks to provide more quantitative evidence on certain of the latter issues--particularly those dealing with the relationship between prices, technical change and selected dimensions of the income distribution question. The vehicle for the investigation is a case study of a district in the Pakistan Punjab, an area that, in addition to having a rather large body of base data for agriculture, has experienced a green revolution of unparalleled swiftness.

II. Technology, Prices and the Optimal Allocation of Resources on a Representative Farm

The micro analysis of various types of representative farms has been carried out within a linear programming framework. The basic model has been presented elsewhere and has been supplemented for this paper with several crop activities (wheat, rice and maize) whose input-output coefficients are assumed to reflect the new high yielding cereal varieties.[5/] Data for the advanced technologies were drawn largely from the agronomic research carried out by the Department of Agriculture of the Government of West Pakistan. At some points, these results were modified by discussions with agricultural experts assigned to the technical assistance programs of the Ford Foundation and the U.S. Agency for International Development.[6/]

There are no general census materials that provide a basis for ascertaining the impact of the new technology on the relative incomes of various social classes in the rural areas of West Pakistan. Consequently, the best that can be done is to build up quantitative estimates of its likely effects by first examining its effects on individual farms and then applying the results to a distribution of land by farm size. Section II takes up the first question in the context of a set of farm management models that seek to determine what happens to the optimal allocation of resources when the input-output coefficients in agriculture have changed significantly from their traditional values. These results are then applied to a farm size distribution taken from Sahiwal District, the area in which the data for the model were collected. A brief epilogue deals with the likely political fallout of the calculated changes in the structure of incomes.

Table 1 presents a number of solutions to the "basic" model. The assumptions are that this 12.5 acre farm represents a typical small holding in the Central Punjab, that it is owned and operated by a cultivator and his family, that the source of power is a single pair of bullocks and that the

Table 1. Optimal Cropping Patterns in the Mixed Farming Area of the Central Punjab (12.5-Acre Farm)

I.D.	Crops Acres	Traditional Technology (1) Without Tubewell	(2) With Tubewell	Advanced Wheat Technology (3) Without Tubewell	(4) With Tubewell	Advanced Rice Technology (5) Without Tubewell	(6) With Tubewell	Advanced Wheat and Rice Technology (7) Without Tubewell	(8) With Tubewell	Advanced Wheat, Rice, Maize Tech. (9) Without Tubewell	(10) With Tubewell
NET REVENUE (rupees)		2337	3180	2552	3577	2415	3231	2652	3678	2963	4320
CRC	Coarse Rice	.28		1.08		.87	1.70	1.16	3.45		
SFR	Summer Fodder (required)	.67	.67	.60	.67	.64	.67	.60	.67	.60	.67
SFO	Summer Fodder (optional)	.67	.67	.60	.67	.64	.67	.60	.67	.60	.67
CTD	Cotton	2.42	6.86	2.45	2.25	1.52	5.97	2.22			
KVG	Summer Vegetables	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
WHF	Wheat	4.74	1.69	5.57	6.26	5.87	1.69	5.51	7.00	5.12	6.75
GRM	Gram									1.62	1.80
OIL	Oilseeds	2.89		1.97		2.06		1.88		.23	
BER	Winter Fodder (required)	.80	.89	.80	.89	.80	.89	.80	.89	.80	.89
BEO	Winter Fodder (optional)		.89		.85		.85		.65		.89
MAZ	Maize									2.75	4.45
SUG	Sugarcane	.60	1.00		1.00	.80	1.00	.14	1.00	1.00	1.00
RVG	Winter Vegetables		.20		.20		.20		.20		.20
FRT	Fruit		.30		.30		.30		.30		.30
TOTAL CROPPED ACREAGE		13.77	14.57	13.16	14.49	14.10	15.34	13.15	16.23	13.82	19.02
CROPPING INTENSITY		110	117	105	116	113	123	105	130	110	152

* Cropping intensity is defined as cropped acreage/cultivated acreage. Complete double cropping would produce a cropping intensity of 200 percent. Sugarcane and fruit are counted twice.

** The following maximum constraints are operative in the model: optional summer fodder-200 maunds; optional winter fodder-400 maunds; sugarcane-1 acre; summer vegetables-.10 acres; winter vegetables-.20 acres; fruit-.30 acres. See Appendix A for a justification of these constraints.

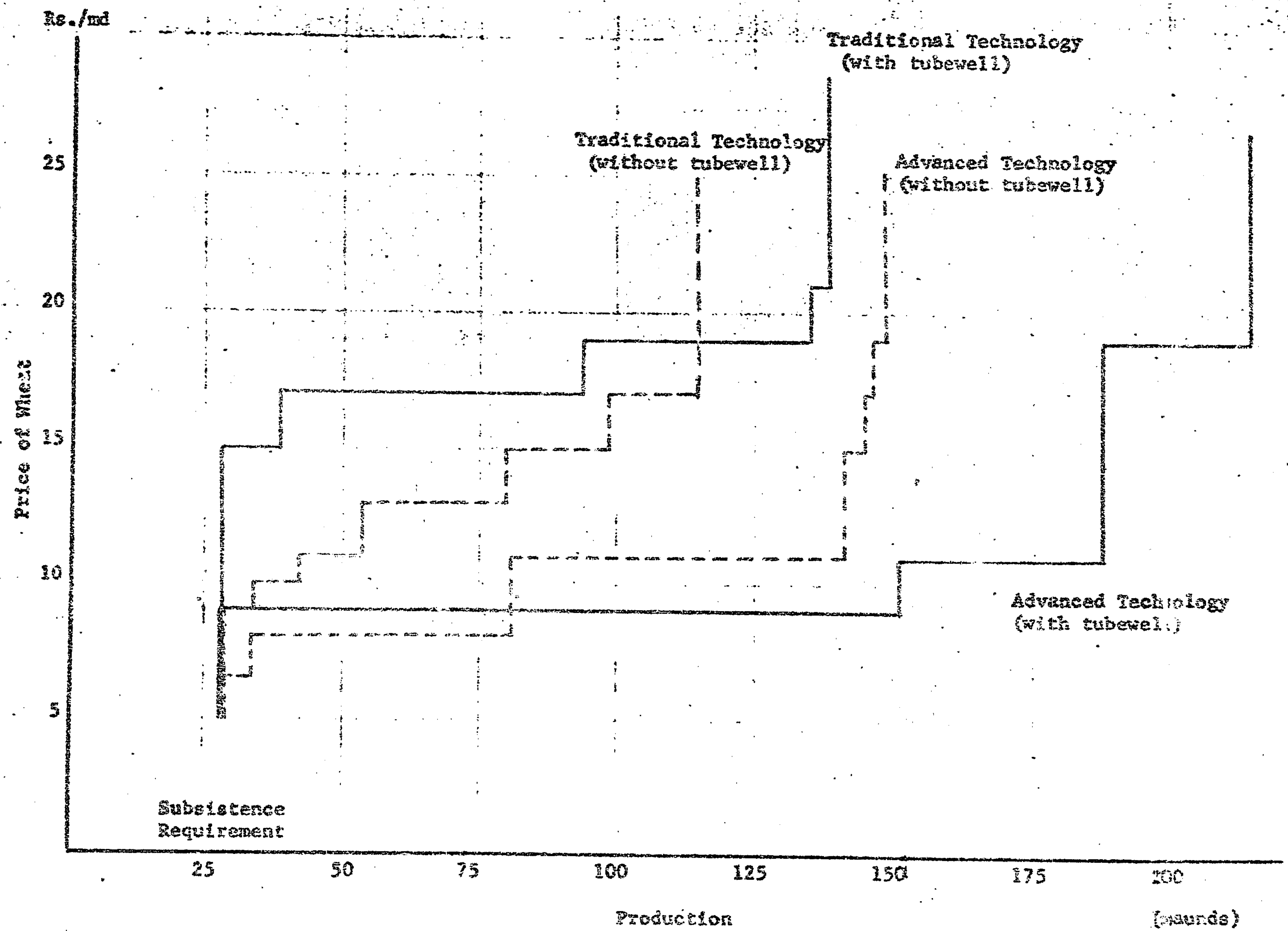
available surface water supply is proportional to the land owned under a typical irrigation distributary. In addition to these fixed assets, it is assumed there are two types of resource augmenting activities. The farmer may hire additional labor in peak seasons at the prevailing wage rate and he owns a 1/6 share in a tubewell which he uses to pump supplementary water.

Several interesting conclusions about the effect of the new technology emerge from these solutions. First, the increase in net revenue under "advanced" conditions is substantial.[7/] A comparison of columns 1 and 8 suggests that under the assumptions indicated above, profit maximizing farmers could improve their net revenues approximately 85 percent by introducing the new methods. Several factors are responsible: due to better irrigation facilities, there was a sizeable "acreage effect." On a farm assumed to contain 12.5 acrea available for cultivation, the cropped acreage increased from 13.8 acres to 17.7 acres, or about 35 percent. A second contribution results from the "yield effect" of the new varieties. Farm demonstration plots suggested that wheat yields could be expected to increase by 60 percent, rice by 100 percent, and maize by 90 percent; these estimates were incoeporated into the "advanced" activities of the model. Lastly, for most technologies, there were substantial "cropping pattern effects." This reallocation of land resources between crops was again due primarily to the flexibility of the supplementary water originating from the tubewell. (Note, for example, that with the exception of maize in Column 9, the "without tubewell" cropping patterns are quite similar.)

The interaction of these factors in the model is significant. If the two changes from traditional to advanced technology (tubewells and HYV) are taken independently, they yield an increase in net revenue of 35 and 25 percent respectively. The sum of their individual increases (60 percent), however, is well below the 85 percent increase produced when both are introduced simultaneously. This has nothing to do with the kind of physical complementarity of which agronomists speak, but results rather from the opportunity to increase the acreage under the profitable HYV when a flexible supply of supplemental irrigation water is available.

The effect of variations in output prices on net revenue under different technological assumptions is also of interest. For example, Figure 1 shows that the introduction of tubewells tends not only to shift the predicted supply curve of wheat but to increase its elasticity as well. This

Figure 1. Normative Supplies for Wheat in the West Pakistan Punjab



is particularly evident in comparing the <u>with</u> and <u>without</u> tubewell case under traditional technology. The use of supplementary water decreased the comparative advantage of wheat with respect to cotton (the two compete for land during the overlap of the summer and winter seasons), and shifted the wheat supply curve to the left. At the same time, the possibility of altering the seasonal distribution pattern of water has made for greater sensitivity to the wheat-cotton price ratio. The result is that the two normative curves shown for traditional wheat varieties cross. The same mechanism produces the crossing of the curves depicting the impact of additional water supplies with high-yielding varieties. Its effect is less visible, however, because the profitability of the new varieties insures that a major part of the winter acreage in irrigated areas will be planted to wheat <u>regardless</u> of the availability of supplementary water.

<u>Regional Differences</u>: From the foregoing description of the impact of high yielding varieties (HYV) and tubewells on agriculture in the Central Punjab, it is obvious that a number of changes in the cropping pattern can be anticipated as new agricultural technology becomes available. Not all areas in West Pakistan have this versatility, however, and a rather different picture of the effect of the "green revo-

lution" emerges from an examination of technological change in the Provinces of Sind and the Northwest Frontier.

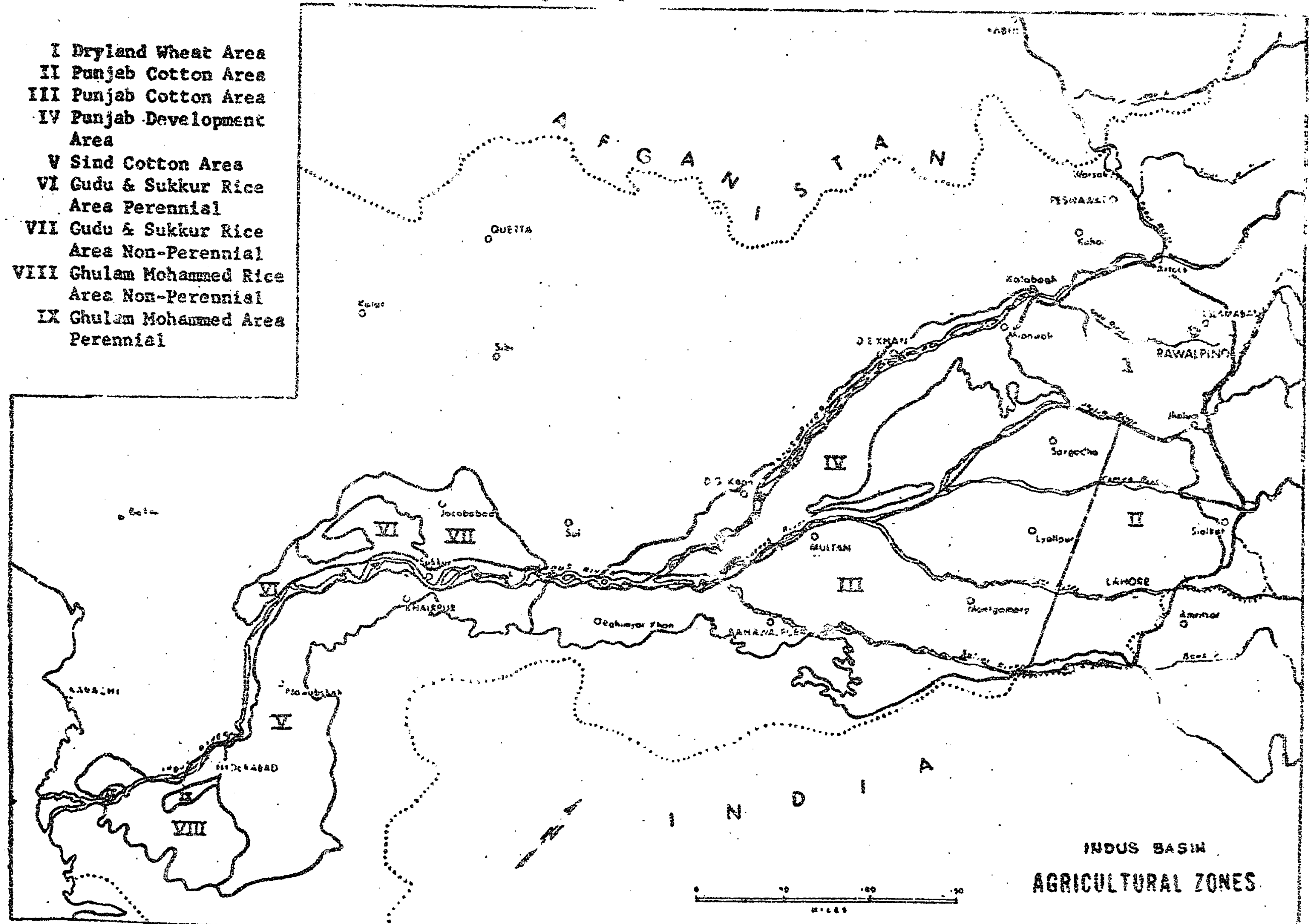
As Figure 2 indicates, the Sind (Areas V, VI, VII, VIII, and IX) is comprised of a number of different canal systems. Those designated as "non-perennial" supply water only during the summer months when the rivers run full from the monsoons and snow melts in the North. Most of these areas, except for land that is near the river and the larger canals, are underlain with saline groundwater. This combination of (1) surface water concentrated in the "khafif" (spring planted) season, and (2) an inability to store water underground, severely limits the cropping options that farmers have.

Indeed, until additional fall ("rabi") water becomes available from Tarbela Dam, the traditional rice-fallow-rice or rice-dubari-rice rotation is virtually the only alternative. (The residual rice moisture which is currently used to grow a crop of vetch or chickpeas in the rabi season is insufficient for a crop of Mexipak wheat.)

Even in the perennial canal areas, there is unlikely to be much change in land allocation as a result of the seed-fertilizer revolution. Yields on the existing wheat and rice areas have been increased significantly. But as long

Figure 2. Major Crop Zones in West Pakistan

I Dryland Wheat Area
II Punjab Cotton Area
III Punjab Cotton Area
IV Punjab Development Area
V Sind Cotton Area
VI Gudu & Sukkur Rice Area Perennial
VII Gudu & Sukkur Rice Area Non-Perennial
VIII Ghulam Mohammed Rice Area Non-Perennial
IX Ghulam Mohammed Area Perennial



February 1967

IBRD 1954

Adapted from: Study of the Water and Power Resources of West Pakistan: Comprehensive Report, Indus Basin as the areas are constrained in their cropping intensities by the availability of water, the land trade-offs that figure so prominently in altering the supply curves for crops grown with tubewells (Figure 1) will not be operative.

The predicament of the dryland areas of the Northwest Frontier Province (Area I) is similar to that of the rice tracts of the Sind. Rainfall is virtually the sole determinant of the cropping pattern and the advent of the new varieties of wheat is unlikely to produce any significant alterations in land use patterns. Fortunately, several recent studies suggest that in a sizeable portion of the area, earlier pessimism can be somewhat modified regarding the ability of HYV to react to rainfed conditions.[8/] But the general conclusion that the supply curve of wheat in the rainfed area is likely to be highly inelastic remains valid.[9/]

III. Technology, Prices and the Distribution of Incomes

The previous section dealt with the impact of new technology and variable prices on the resource allocation decisions of a representative farm. In the following paragraphs, these results are extended to produce several alternative estimates of the effect on the distribution of incomes among the small farmer class. Each of the alternatives corresponds to an assumption about the prices and availability of seed, fertilizer and water to various holding sizes.

Estimates of the relationship between farm size and incomes were obtained from the programming model by parametrically varying the land surface water and tubewell capacity constraints. For example, while family labor and bullock power remained fixed, the size of the "basic" farm (12.5 acres) was varied downward to 5 acres and upward to 25 acres. The net revenues obtained were then reduced by such fixed items as the depreciation of equipment and buildings and the various taxes and cesses that are normally paid by the cultivators (see Table B-1). The resulting incomes by farm size can be read from the solid lines in Figure 3.

As expected, where the HYV technology is available to all, small farmers benefit relatively more than do their larger neighbors. For example, on the 5-acre farm, income increases from Rs 350 to Rs 1250 or approximately 250 percent; on the 25-acre farm, the increase is from Rs 3750 to Rs 5875 or 57 percent.

A more general impression of the effects of the technology can be gained by comparing the relative income distributions of the "traditional" and "advanced" solutions.

Figure 3 Income by Size of Farm

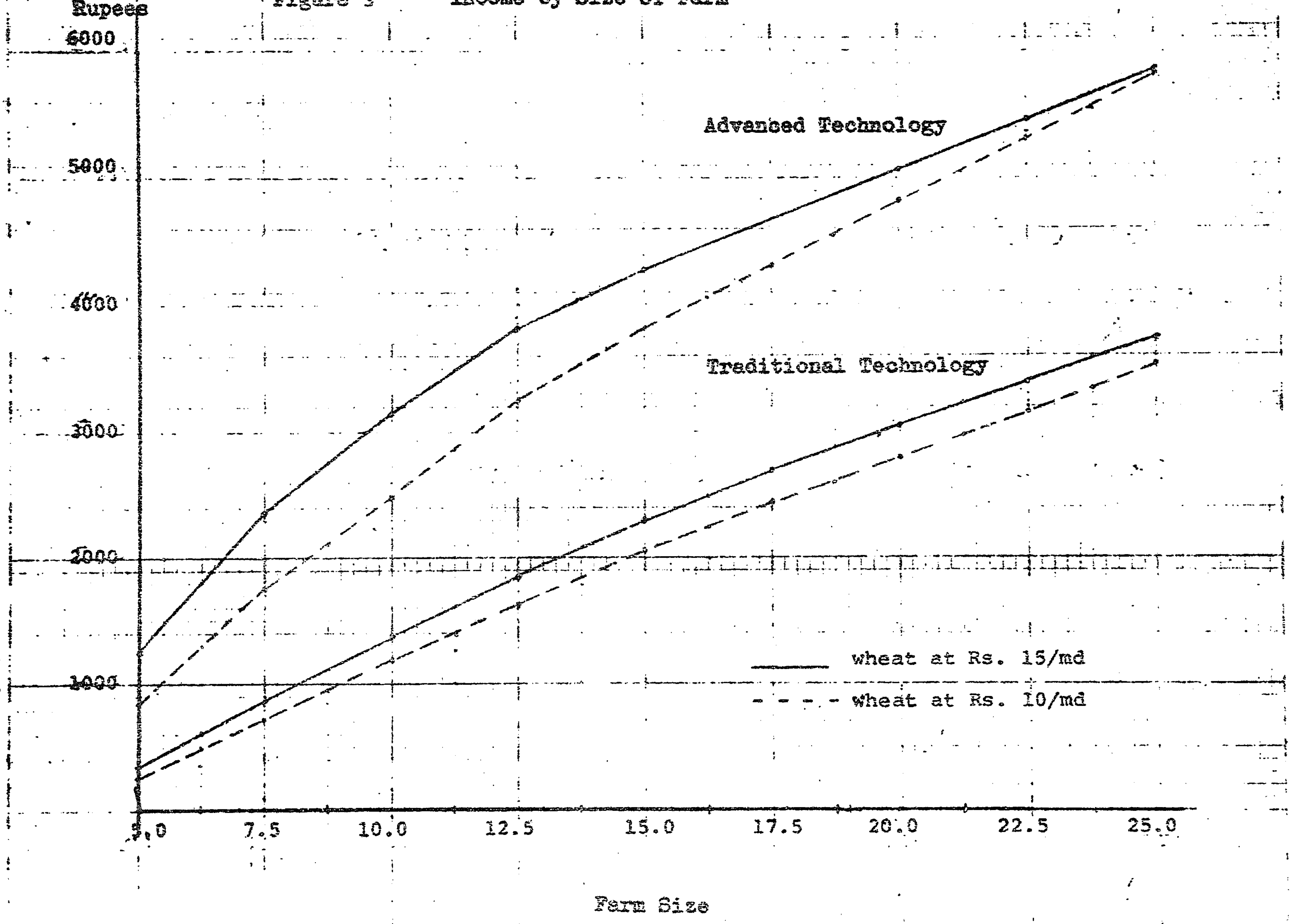


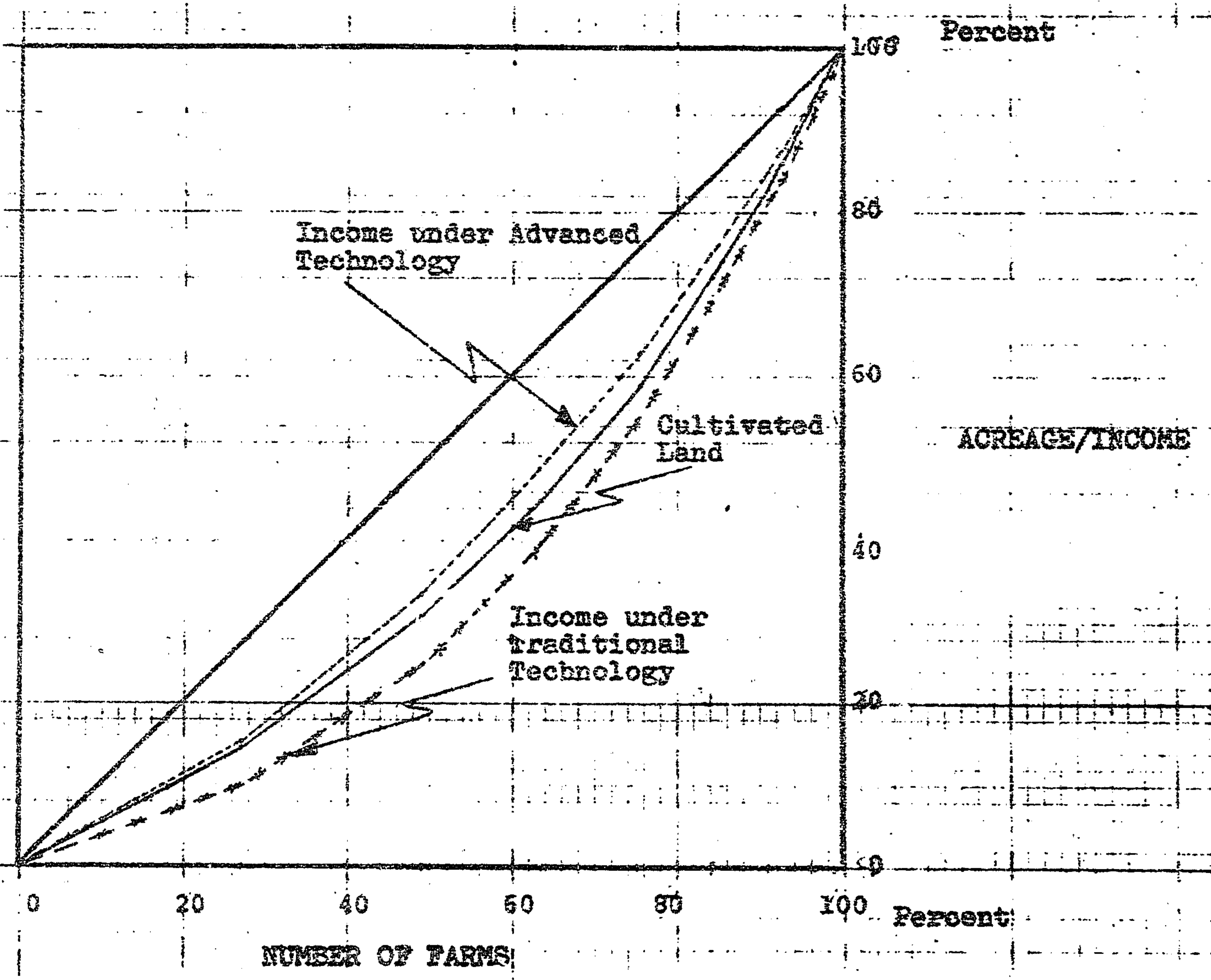
Table B-2 gives the frequency distributions of farms in the 5 to 25-acre category in Sahiwal District. It also shows the total incomes of each class obtained when the income of a particular representative farm is weighted by the number of farms in that category.

Lorenz curves constructed from the data in Table B-2 show that incomes under traditional technology tend to be less equitably distributed than land (Figure 4). The reason for such a result is not difficult to find. Examination of the programming model indicates that under traditional technology, net revenue increases in proportion to the increases in land and its associated surface water over almost the entire 5 to 25-acre rnage. The "dual" of the model indicates that constraints on bullocks and family labor are not binding and thus are not the basis for diminishing returns to land. This Lorenz curve describing net revenue by farm size under traditional technology would be virtually identical with the Lorenz curve of the distribution of land.

Subtraction of similar fixed costs for the net revenue of each holding, however, generates a Lorenz curve of income that lies below the curve representing the distribution of land.

The effect of fixed costs is also evident on the distribution of income under advanced technology. However, due

Figure 4. Distribution of Land and Income by Farm Size



to the significant increases in intensity resulting from increased water supplies and the increased labor requirements associated with HYV, bullock and human labor constraints quickly become binding as farm size increases. As a result, the disproportionate impact of fixed costs on the small farm is off-set by a comparative advantage in high value, labor intensive activities.

The results shown in Figure 4 flow directly from production theory. But they are extremely important for they illustrate virtually the only conditions short of land redistribution in which the distributive effect of the green revolution can lead to greater income equality. The assumptions are strong: all new inputs are divisible, either intrinsically or through a competitive market for hired services, and everyone has equal access to the institutional services that dispense the knowledge and credit required for their use.

Recent research suggests that these assumptions are at least in part correct. Work by several authors summarized by Rochin (23) indicates that there is little difference among different farm size groups regarding the percentage of cultivators now using improved seeds. The same is true of fertilizer although here there is some difference between large and small farmers in the level of use. It seems that despite the general lack of concern regarding small farmers that has traditionally been associated with various government agencies, the simplicity, divisibility and profitability of seeds and fertilizers have been such that the diffusion process has penetrated to all size groups.

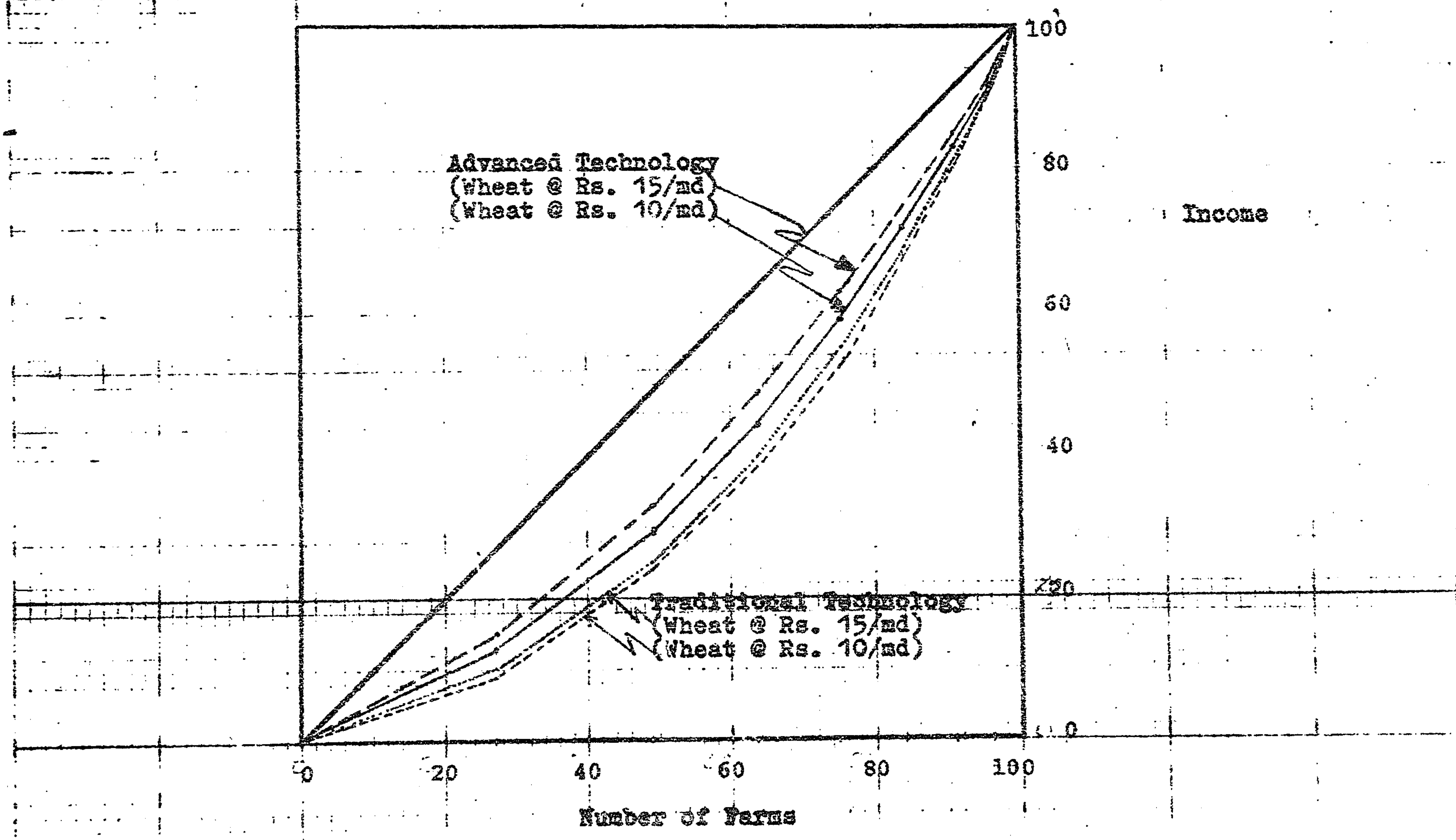
There is, however, one aspect of the research that is crucial and provides considerable cause for concern. According to a recent survey by Mohammad Naseem (17), he too finds little difference between farm sizes in the diffusion of the seed-fertilizer package, but the same cannot be said of access to supplementary water. This is to be expected since the tubewell is a "lumpy" input whose spatial immobility imposes rather severe limitations on the emergence of a competitive market for water.

Imposing constraints on the availability of supplementary water on the small farmers making up the lower portion the holding size frequency curve would undoubtedly produce a Lorenz curve of income distribution that lay below that associated with traditional technology. That is, small farmers would be better off in absolute terms but substantially less well off than their larger neighbors in relative terms.

Thus far the analysis has dealt almost exclusively with the distributive effects of the highly divisible technology associated with the seed-fertilizer revolution. Of interest also, however, are the distributive effects of alternative prices under conditions of changing technology. What would the impact be, for example, of permitting wheat prices to fall to approximately world market levels? The dotted lines in Figure 3 show the results of parametrically varying the land and water constraints in the model under an assumption that wheat prices have been decreased by one third. (Farm income was obtained by subtracting the fixed costs as in the previous exercise.) Lorenz curves were calculated from the income estimated by size of farm class (Table B-2) and compared with those obtained when wheat was set at its prevailing domestic market value. The results are shown in Figure 5.

In the case of both technologies, the decline in the price of wheat has altered the distribution of income in favor of the larger farmers. The familiar fixed cost or "lumpy input" phenomenon--here represented in large part by the family and the bullocks associated with traditional agriculture--again provides the mechanism by which

Figure 5. The Distributive Effects of Alternative Wheat Prices



this increase in the inequality of relative income distribution occurs. Both large and small farmers would suffer a decline in income under the circumstances postulated. However, for those whose income was already small, a further decline would only accentuate the disproportionate impact of fixed costs. The smaller the income relative to a constant fixed cost, the more disparate the income distribution among groups.

Table B-2 also shows, however, that a reduction in the price of wheat would tend to produce greater inequality among size groups under the assumption that advanced rather than traditional technology is being used. An examination of the cropping patterns associated with various farm sizes quickly reveals why this is so. As farm size increases, the additional flexibility associated with advanced technology, especially supplementary water, causes the wheat activities to exit from the model long before they do under traditional conditions. Consequently, the downward change in wheat prices have little effect on the larger farmers with farm sizes above 12.5 acres for they have no wheat in the cropping pattern. Small farmers, who do not feel the pressure of power constraints to the same degree, do not seek to reduce their wheat acreage. The result is a relatively greater decline in incomes when the wheat price falls and an increase in income disparity.

The most significant dis ributive effects of a fall in wheat prices, however, would again be associated with a situation in which the smaller farmers do not have access to the new technology. In this situation the inelasticity of supply, particularly among those without supplementary water, means that falling prices will produce significant declines in income. On the other hand, those whose farming operations have attained a high degree of flexibility through the use of modern inputs can be expected, under the same conditions, to shift out of wheat and into more profitable alternatives. The result would tend to be a marginal decline in incomes and, when compared with the position of those unable to alter their cropping patterns,

an increase in income disparity.

Regional Differences: as Tweeten has pointes out:

"The theory [of stagnation] contains three basic elements that apply to individuals, regions or groups: (a) they are confronted by factors which require adjustments in resources, products and technology, (b) they have identifiable characteristics which give rise to differences in ability to adjust to factors in (a), and finally (c) when the forces requiring adjustments are large relative to the ability to adjust, a liminal level of adjustment in reached at which the environment develops anomie and other dysfunctional syndromes inimical to rapid change. The area environment then becomes less rather than more conducive to satisfactory economic adjustments to changing conditions."10/ (my italics)

This comment is as true of regional development in West Pakistan as anywhere else. Whether one is talking about the "flexibility" of an area or an individual farmer, the lack of alternatives in the face of changing conditions is the essence of increasing disparity.

The characteristics that are perhaps most relevant in identifying the likely course of regional growth in agriculture have to do with the distinction between (1) areas in which only the yield effects of new technology are available, and (2) areas in which changes in both yields and cropping pattern effects can be anticipated.

An example of the first case is much of the dryland wheat area in the northern portion of the Indus Basin. (Area

I on Figure 2). As Rochin's recent work has shown, there is now reason to believe that at least in the higher rainfall areas (30-50 inches) some benefits can be expected from the seed-fertilizer technology.11/ His field survey, based on a sample of farmers, shows that average yields of 19 maunds per acre were obtained in Hazara District using modern technology. This was an average increase of 103 percent over the control group. Lawrence also reports significant yield increases associated with tractor power cultural practices (deep plowing and fallow) similar to those practiced in the dryland areas of the United States.12/

As a consequence of these findings, the extreme pessimism of earlier years is giving way to a somewhat more optimistic view that yield increases in some parts of the dryland areas will be sufficient to make discernible improvements in the welfare of farm families living there.

An even more optimistic picture for future progress is presented by another traditionally backward area of West Pakistan: the southern portions in the Province of Sind (Areas V, VI, and VII on Figure 2). As indicated elsewhere, the new rice varieties have shown themselves to be unusually adapted to the dry, sunny climate of the area. Although there again appears to be little possibility of crop diversification, farm incomes can be expected to improve significantly through the yield effects alone. The latest report of the rice research stations at Kala Shah Kaku and Dokri indicates, for example, that yields of 60 maunds of rice are now commonplace.13/ Severe institutional and marketing constraints continue to exist, but these are problems that, unlike the basic climatic, soil and water constraints, can in time be solved.

The real beneficiaries of the fruits of technical change, however, are farmers in the more versatile areas of the Central Punjab (Areas II and III on the map). Not only are they able to take advantage of the increased productivity associated with the seed-fertilizer revolution, the water distribution is such that they can respond in cropping pattern terms to the increase in comparative advantage of the new varieties of rice and wheat. Again, if the evidence of more developed agricultures is any guide, this basic flexibility (here demonstrated by the ability to take the ultimate advantage of new technology) will prove to be the central fact in maintaining the dominance of this area in West Pakistan agriculture in the long run.

Thus far, comments on the effects of modernization on regional incomes have focused on the impact of the new technology itself. No attention has been given to the indirect effects produced by the impact of increased output on the prices of such widely grown commodities as wheat and rice. Given the recent gluts on thw world cereal markets, it is probably unrealistic to assume that the government will want to amintain current price relatives in the face of significant by increased domestic supplies. The most reasonable assumption would be that some type of downward adjustment of those cereal prices that are most seriously distorted will take place, at least over the medium and long run.

Not surprisingly, the vulnerability of various areas to price changes is closely linked to their ability to adopt new technology. As in the case of technology alone, flexibility or range of choice is the key. The dryland areas, constrained by the rigidity of the environment from adopting new technology, face exactly the same set of constraining factors as far as price response is concerned. Indeed, the cropping pattern effect, described earlier as an acreage response to the changes in comparative net revenues, is the same phenomenon regardless of whether the alteration in net revenues results from a change in the market price of the output or a change in its unit costs. One would therefore expect the severest effect on incomes of declining wheat prices to occur in these areas which have highly inelastic supply curves for wheat. (The obvious caveat that this only applies to the marketed surplus must be made; however, nearly every farmer sells something, and to that extent he is vulnerable. At best, one could say that sharp declines in wheat prices will make it more difficult to raise living standards above the subsistance level.)

Incomes in the rice areas of the Sind are also affected almost proportionately by declines in the price of rice. Although the supply curve has shifted out, it remains quite inelastic. (Some changes in the level of purchased inputs may occur as variable costs are adjusted to lower output prices. However, given the shape of the production function of the new rice varieties, it is unlikely that this will be a very important phenomenon.)

The ability either to profit from or to minimize the adverse consequences of various price policies is obviously again greatest in the Central Punjab. The reader will by now recognize that the source of <u>both</u> the ability to respond to prices <u>and</u> the ability to adopt the new technology have their origin in the availability and seasonal flexibility of the irrigation water supply.

IV. Technology, Prices and Political Influence

As any student of public policy is aware, Government programs are deeply embedded in the political processes of a country. The decisions surrounding policies regarding agricultural prices and technology in West Pakistan are no exception. (Indeed, there is much about the makeup of that society that permits some fairly convincing analogies to be drawn between the experience of developed countries--particularly the southern portion of the U.S.--and the likely course of agricultural transformation in the Indus Basin.)

The previous section's discussion of the distributive effect of technology took a very narrow, static view of the problem. Even in terms of its focus on farmers with less than 25 acres--perhaps the key group in the process since they make up the majority of the cultivators--the dynamics of the distributive effects have not been examined. Previous studies have shown, however, that the rates of return on the new seed-fertilizer-water combinations are high. Moreover, there is considerable casual evidence that, among the larger farmers (50-100 acres), substantial amounts of these returns are being used to modernize further their already progressive enterprises. Thus, the compound effects of growth among this group are well under way.

At the same time that economic modernization is taking place, however, another process--a political one--is also underway.[14/] As subsequent paragraphs will argue, the wealth of this new class of farmers, partly derived from their use of technology, but equally supported by a distorted set of commodity prices, is reflected in their increasing political influence. This is a matter of fundamental importance. For the history of agricultural policy in virtually every society underscores the fact that this group of better educated, more progressive farmers, owning most of the factors of production but containing a minority of the people will, if permitted, attempt to speak for all of agriculture on matters of technology and prices. Based on the U.S. experience, the following pressures from the commercial sector can be anticipated:

(1) The larger farmers will be strongly opposed to any reduction in the Government's current support of output prices. An example of their waxing power was the recent re-establishment of the wheat support price in the face of the almost unanimous opposition of economists in

the Provincial and Central planning agencies. (The self-serving rationale that will be put forward by the large farmers is also well known from the experience of developed nations: "It will severely affect the income of the small farmers.")

(2) The larger farmers will be against any program of selective mechanization. There is already considerable literature on the premature mechanization of agricultural in Pakistan, particularly since the equipment is being imported at a subsidized exchange rate, and provided under special credit arrangements.[15/] Several authors have argued that this subsidy should be eliminated, and obviously such proposals should be supported. But there is some question as to whether this will greatly retard the rapidity with which the larger land owners will modernize their operations.[16/] First, tractors are likely to be produced soon in Pakistan. It is exceedingly difficult to see how planners or concerned administrators will be able to resist the pressure of an alliance between the industrialists (foreign and private) and the larger farmers for such plants. Second, even if tractors and equipment were imported at the economy's current shadow price of capital, private costs and benefits would still diverge from their social values. So long as

ground water supplies are not under public control, the 150 percent cropping intensity figure for West Pakistan cannot be regarded as an effective constraint. With appropriate equipment and enough tubewell capacity, there is every reason to believe that in the near future, efficient operators will be able to double-crop fully the land they operate. Such an intensive use of land, only feasible if modern equipment is available, provides private rates of return that make agriculture one of the most profitable enterprises in the economy.

(3) The larger farmers will resist public control of the water-bearing acquifer. Currently the water table is within the reach of the centrifugal pumps that even the slightly above average farmer can install on his tubewell. In the long run, however, the water table can be expected to drop below the reach of the pumps currently in use, to depths that require modern turbine pumps. The latter are expensive and necessitate a capital outlay many times that of the centrifugal pump. Obviously, as the water table continues to fall, only those having access to capital for pumps that can tap the deeper layers of the acquifer will be able to continue to expand their operations.

(4) Lastly, the increasingly powerful political posi-

tion of the new agricultural class will make difficult the institutional reforms needed to capture--in a progressive fashion--some of the overall increase in agricultural productivity for development purposes. Pakistan's current mobilization of domestic resources as a percentage of GNP is extremely low, even by developing country standards. With a deteriorating foreign aid picture, it must rely more heavily on internally generated sources. Yet the Fourth Five Year Plan gives no evidence of a willingness to deal with these hard issues; in particular, nothing of significance is proposed for appropriating the windfall gains referred to earlier. If anything, the introduction of the necessary institutional reforms seems as distant now as it was a decade ago.[17]

The preceding description of the forces on the stage in West Pakistan paints a not-unfamiliar picture to students of U.S. agricultural policy. Indeed, some foreign agriculturalists are actually pleased by the prospects outlined above since in the short run at least it will undeniably lead to a continuation of the high rate of agricultural growth. To others, however, the prospect of modernizing agriculture "U.S. style" is distinctly unappetizing.

This is particularly true when one adds to the previously indicated components of change a three percent rate of population growth. As Johnston and Cownie show, the employment problems that arise with even conservative projections of migration and optimistic increases in non-agricultural employment, are staggering.[18/]

V. Conclusions and Recommendations

It is clear that the green revolution has set in motion a process that will entail significant shifts in the allocation of West Pakistan's agricultural output. It seems equally obvious, that these same forces, working through both the economic and political structure of the society, can be expected to exacerbate an already high degree of income disparity. Given this diagnosis, what sort of technical recommendations could be made that would tend to promote efficiency and to make possible a more humane type of structural change than that which has prevailed in most developed societies?

(1) First, there is a need on efficiency grounds to bring domestic relative prices in line with world market relatives. This is true of cereals; it is even more important in the case of sugarcane. Finding the correct

absolute levels, however, will be no easy task. The terms of trade between agriculture and non-agriculture are badly distorted. Hence, without considering a radical alteration of the overall foreign exchange policy (e.g. devaluation), simply lowering prices to the absolute level of world prices would be inappropriate. The least disruptive (but also perhaps least effective) tactic would be to approach world relatives from both above and below. This would require downward adjustments for sugarcane, maize and wheat, upward adjustments for rice and cotton.

(2) the institutional assumptions that underlay the analysis of income distribution by farm size were optimistic indeed. There is little evidence that the current institutional structure is capable of insuring that all farmers have access to those inputs that are by their nature infinitely divisible. Moreover, the experience of other countries suggests that efforts to provide such a guarantee through national bureaucracies is prohibitively expensive. Eliminating the possibility of a "top-down" strategy leaves no alternative but to accept the political risks of promoting various forms of grass-roots, farmer-dominated organizations. Whether they be in the form of coopera-

tives or communes; small farmers and the landless have no weapon against the system but organization.

(3) West Pakistan must take seriously the problem of regional imbalance. No one program or policy will suffice; what is required is an approach that permits some people to stay on the farm by expanding their holding size, others to be educated for migration to areas of demand for industrial and agricultural labor. Where possible, efforts at decentralization of industrial activity into growth centers close to the affected regions would have a high payoff.

Such efforts at mitigating the growth of regional disparity are, of course, standard recommendations and some observers have cautioned that they may be too expensive in terms of national growth for a country at Pakistan's level of development to afford. The appropriate effort is indeed a matter for calculation. However, the evidence from developed countries is that the downward spiral of poverty that is so prominent a feature of backward regions is difficult to reverse.

(4) The proposals recently made by a number of people regarding the need to capture some of the windfall

gains of technological change must be implemented. Even casual arithmetic shows that the income terms of trade have turned in agriculture's favor during recent years. Rather than capturing some of the surplus associated with the green revolution for the provision of non-agricultural employment, the Government has permitted it to remain in the hands of agriculture.

(5) Lastly, what is needed most is a national policy toward technological change. By investigating further the effects of the economics of mechanization, for example, it should be possible to define more carefully the magnitudes of such parameters as wage rates, interest rates, excise taxes and subsidies, that would create an environment for structural transformation in agriculture that was consistent with the non-agricultural economy's ability to absorb surplus rural labor. Once these have been ascertained, the government should not hesitate to implement a program which might result in significant deviations from that dictated by the unregulated market.

The above technical recommendations are largely the product of simple economic analysis. If they are to have real credibility, however, they should also be accompanied by a description of the political and social mechanisms by by which they are to be implemented. This means, above all else, a description of the nature of the class interests that dominate the various aspects of Pakistan's economic policy, an identification of the extent and potential evolution of the political consciousness of these groups, and porposals for alliances that would move in the right direction.

Such an analysis is beyond the scope of this paper; however, I would argue that one can be anything but optimistic about the ability of West Pakistan's society to develop instruments capable of coping with the country's growing income inequality.

Appendix A
The Programming Model

The objective function of the model contains the elements shown in Equation 1.

$$R = \sum_{i=1}^{n} c_i X_i - \sum_{j=1}^{T} d_j W_j - \sum_{j=1}^{T} e_j L_j \qquad (1)$$

where the parameters are defined as follows:

c_i = the per acre net revenue obtained from the i^{th} crop ac- (gross revenue minus variable costs)

d_j = the cost associated with purchasing a unit of tubewell water in the j^{th} period.

e_j = the wage associated with hiring a unit of human labor in the j^{th} period.

The decision variables are:

X_i = the level (number of acres) at which to employ production activity i $i = 1, 2 \ldots n$

W_j = the level at which to supply tubewell water in period j $j = 1, 2 \ldots T$

L_j = the level (hours) at which to hire labor in period j $j = 1, 2 \ldots T$

Equation 1 is maximized subject to a series of constraints of the following form:

$$\sum_{i=1}^{n} \gamma_{ij} X_i \le W_j + S_j \qquad j = 1,\ldots,T \qquad (2)$$

$$W_j \le P \qquad j = 1, \ldots, T \qquad (3)$$

where i_{ij} is the gross water input (including losses) to the i^{th} activity in the j^{th} period. The γ_{ij}'s are calculated after netting out the effective rainfall. S_j is the amount of surface water available for irrigation in j^{th} period. P is tubewell capacity.

Land Constraints

$$\sum_{i=1}^{n} Q_{ij} \le A \qquad j = 1, 2\ldots,T \qquad (4)$$

where A is the total available acreage, and Q_{ij}, $0 \le Q_{ij} \le 1$, for all ij, is a coefficient of land use specific to the particular crop activity and time period. In general Q_{ij} will be 0 or 1, 0 when the j^{th} interval is wholly in the growing season of crop i. Fractional values would indicate that only part of the month falls in the growing season of crop i.

Labor Constraints

$$\sum_{i=1}^{n} \lambda_{ij} X_i \le \bar{L}_j + L_j \qquad j = 1, 111, T \qquad (5)$$

$$L_j \le \tilde{L}_j \qquad j = 1, 111, T \qquad (6)$$

where $\tilde{L}_j$ is the upper limit of labor fixed to the farm (family) available in the j^{th} period, $\bar{L}_j$ is the upper limit of the labor available for hire in the j^{th} period. The coefficients λ_{ij} are the total units of labor needed in period j for activity i. Equation set 6 states that for each period, labor demand must be less than or equal to total supply.

Bullock Power Constraints

$$\sum_{i=1}^{n} \alpha_{ij} X_i \leq M_j \qquad j = 1,\ldots,T \qquad (7)$$

where M_j is the upper limit of the bullock labor fixed to the farm that is available in the j^{th} period and α_{ij} are the bullock power inputs for the i^{th} crop in the j^{th} period.

Special Crop and Subsistence Constraints

$$i = \sum \Delta k \quad X_i \leq Ak \qquad k = 1,\ldots,\bar{k} \qquad (8)$$

$$X_{is} \geq A_s \qquad s = 1,\ldots,\bar{s} \qquad (9)$$

where A_s and A_k are respectively the lower and upper limits imposed on the production of the particular crop. The set k is the set of all activities which produces crop k. Given current relative prices, there are several significant disequilibria in the cropping pattern (principally sugarcane and fruit) that must be held in check via acreage constraints. The activity indicated by is subscript of the variable x_{is} produces crops for consumption. Minimum acreage of certain crops such as wheat and fodder must be produced to provide subsistence for the family and the bullocks fixed to the farm.

The resulting linear programming model is then of the form:

$$\text{Maximize} \quad R = CZ$$

$$\text{Subject to } AZ \leq B$$

$$B \geq 0$$

where the vector Z is the set of decision variables, C the vector of activity prices, B the vector of resource availabilities and A the activity coefficient matrix.

Table B-1
Calculation of Farm Income at Domestic Prices

Size	Rev-enue	Bullocks*	Equip-ment**	Build-ings	Tube-well***	Total	Income
			Fixed Costs				
			Traditional Technology				
5.0	836	250	136	100	-	486	350
7.5	1361	250	136	100	-	486	875
10.0	1864	250	136	100	-	486	1378
12.5	2337	250	136	100	-	486	1851
15.0	2787	250	136	100	-	486	2301
17.5	3180	250	136	100	-	486	2694
20.0	3543	250	136	100	-	486	3057
22.5	3900	250	136	100	-	486	3414
25.0	4240	250	136	100	-	486	3754
			Advanced Technology				
5.0	1784	250	136	100	62	548	1236
7.5	2939	250	136	100	94	580	2359
10.0	3757	250	136	100	125	611	3146
12.5	4442	250	136	100	156	642	3800
15.0	4943	250	136	100	187	673	4270
17.5	5319	250	136	100	219	705	4614
20.0	5770	250	136	100	250	736	5034
22.5	6250	250	136	100	281	767	5483
25.0	6675	250	136	100	312	798	5877

*One pair bullocks assumed to cost Rs 2000 and have a working lifetime of 8 years.

**Equipment list and life taken from Singh, Day & Johl (22).

***Tubewell assumed to cost Rs 100,000 and have a life-span of 10 years.

TABLE B-2 DISTRIBUTIVE EFFECT OF ALTERNATIVE WHEAT PRICES

Farm Size			Income							
			Traditional Technology				Advanced Technology			
Size	Number	%	Rs 15/md		Rs 10/md		Rs 15/md		Rs 10/md	
			Total	%	Total	%	Total	%	Total	%
	(thousand)		(million)		(million)		(million)		(million)	
6.25	104	26.9 (26.9)	62.4	10.0 (10.0)	52.0	9.4 (9.4)	187.2	14.7 (14.7)	135.2	12.5 (12.5)
8.75	85	22.0 (48.9)	93.5	15.0 (25.0)	80.8	14.6 (24.0)	233.7	18.3 (33.0)	178.5	16.5 (29.0)
11.25	57	14.7 (63.6)	91.2	14.7 (39.7)	79.8	14.5 (38.5)	199.5	15.6 (48.6)	163.9	15.2 (44.2)
13.75	45	11.6 (75.2)	94.5	15.2 (54.9)	83.2	15.1 (53.6)	182.2	14.3 (62.9)	159.8	14.8 (59.01)
16.25	35	9.0 (84.2)	87.5	14.1 (69.0)	78.8	14.3 (67.9)	156.6	12.3 (75.2)	141.8	13.1 (72.1)
18.75	27	7.0 (91.2)	78.3	12.6 (81.6)	70.2	12.7 (80.6)	131.6	10.3 (85.5)	122.8	11.4 (83.5)
21.25	20	5.2 (96.4)	64.0	10.3 (91.9)	59.5	10.8 (91.4)	105.0	8.2 (93.7)	101.0	9.3 (92.8)
23.75	14	3.6 (100.0)	50.4	8.1 (100.0)	46.9	8.5 (99.9)	79.1	6.2 (100.0)	77.7	7.2 (100.0)
				621.8	551.2			1274.9	1080.7	

NOTES

* This paper is a summary and extension of work carried out under AID/NESA Contract 403. I am grateful to Walter P. Falcon both for coolaboration on the original work and for comments on the specific contents of this paper. I am, of course, resposible for any errors that remain.

1/ The term "green revolution" is taken to include the complex of factors that have led to rapid growth in the agricultural sector: tubewells, seeks, fertilizer, insecticides, etc. It explicitly does not consider the impact of tractor mechanization for, as yet, the latter has had no widespread effect.

2/ A sample of the more recent writings might include: Randolph Barker /2/; Lester Brown /5/; Lowell Hardin /10/; Bruce F. Johnston and John Cownie /12/; Walter P. Falcon /7/; Hiromitsu Kaneda /13/.

3/ My colleague, Mort Grossman, continues to speak of the "green revolution: in describing the Indian situation. As he points out, the increased productivity is thus far confined to a limited number of crops in a limited number of areas. The case for a cautious interpretation of the implications of recent events in India is givenempirical backing on B.S. Minhas /15/.

4/ Clifton Wharton /23/.

5/ Carl H. Gotsch /8/.

6/ Much of this information is contained in the Annual Reports published by the Government of Pakistan. See, for example, Z. A. Munshi et al. /16/.

7/ Net revenue is defined as gross revenue minus variable or out-of-the pocket costs increased during the crop year.

8/ Will Rochin /20/.

9/ Carl Gotsch and Walter Falcon /9/; Sarfraz Khan Qureshi /19/.

10/ Luther G. Tweeten /22/.

11/ Will Rochin /20/.

12/ Roger Lawrence /14/.

13/ Rasul Abbasi, et. al. /1/.

14/ In a recent paper, Birki argues that the political influence of this class was the catalyst to the economic transformation described above. Whatever the direction of causality, there is no disagreement regarding the broadening of the political base of agricultural interests since the middle 60's. Shahid Javed Burki /6/.

15/ An excellent discussion and summary of this whole argument is to be found is S. R. Bose's unpublished paper dissenting from the conclusions of the Government Committee set up to investigate the farm mechanization problem. The latter report does a disservice of those in Pakistan committed to rational policies for structural change in agriculture. Government of Pakistan /18/. See also Hiromitsu Kaneda /13/.

16/ Swadesh R. Bose and Edwin H. Clark /4/; Johnston and Cownie /12/.

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