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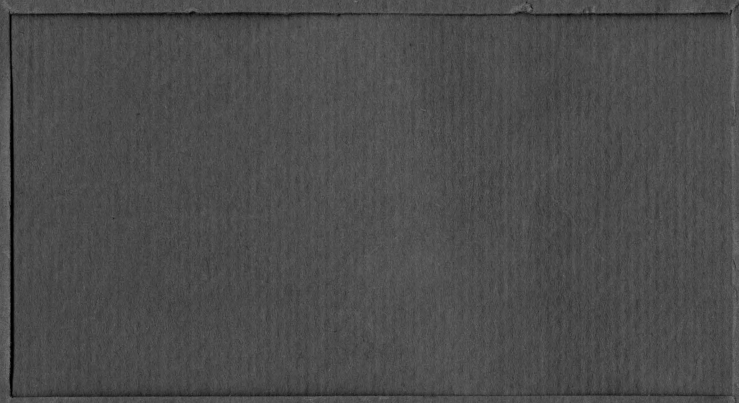

ECONOMIC DEVELOPMENT REPORTS

The Center for International Affairs

HARVARD UNIVERSITY

TECHNICAL CHANGE AND THE DISTRIBUTION OF INCOME IN RURAL AREAS

by

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Economic Development Report No. 205

Presented at the Joint Session of the American Economic Association and the American Agricultural Economics Association, New Orleans, December 1971.

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ABSTRACT

Carl H. Gotsch: Technical Change and the Distribution of Income in Rural Areas

The paper argues that the distributive effects of technical change cannot be predicted except in the context of the institutional and social structure of the rural community, i.e. except in the context of a rural "system." Four kinds of considerations are seen to be fundamental to technology's ultimate impact on such systems: the characteristics of "abstract" technology (efficiency and factor intensity), the absolute magnitude and distribution of productive assets, the type and distribution of institutional services and local social customs and traditions.

Technology, the distribution of assets and the distribution of institutional services are seen to determine the distribution of personal income. When coupled with traditional social customs, the distribution of personal income is transformed into the distribution of power. Three feedback loops complete the system: (1) the asset accumulation mechanism that links the distribution of income in time period t to the distribution of assets in period t + 1, (2) the distribution of power in period t that is assumed to influence the type and distribution of institutional services in period t + 1, and (3) the character of local customs and traditions that are assumed to be influenced by the characteristics of the technology and the distribution of assets with a lag of several periods.

The analysis is made concrete by examining the effects of a particular innovation, the tubewell, on the distribution of income and power in rural

communities of East and West Pakistan. It is concluded that the same technology, highly profitable and labor-using in both areas, will tend to strengthen the position of the dominant agricultural classes in Sahiwal District, West Pakistan and to weaken the position of the large farmer cum moneylender in Comilla, East Pakistan.

The paper concludes with several generalizations about the characteristics of the various development situations that emerge when the weights of the four considerations in the system are varied. It is argued that the effectiveness of rural development policies and programs could be improved if they were based on more disaggregated typologies defined by different combinations of technology, asset distribution, institutional structure and traditional social organization.

Portions of this research were supported by the Development Research Group through funds provided by the Agency for International Development, the National Science Foundation, and the Ford Foundation. However, the views expressed in this report are those of the author and do not necessarily reflect those of the sponsoring agencies.

TECHNICAL CHANGE AND THE DISTRIBUTION OF INCOME IN RURAL AREAS*

> "It took both time and experience before the work people learned to distinguish between machinery and its employment by capital and to direct their attacks not against the material instruments of production but against the mode in which they are used." 1/
>
> Karl Marx - 1867

> "It is not ... the new technology which is the primary cause of the accentuated imbalances in the countryside. It is not the fault of the new technology that the credit service does not serve those for whom it was originally intended; that the extensions services are not living up to expectations; that the panchayats are political rather than development bodies; that security of tenure is a luxury of the few; that rents are exorbitant; that ceiling in agricultural land are national; that for the greater part tenurial legislation is deliberately miscarried; or that wage scales are hardly sufficient to keep soul and body together." 2/
>
> Wolf Ladejinsky - 1969

Introduction

It is hardly a new idea to suggest that the adverse distributive effects of technical change in rural areas must be attributed primarily to the social and institutional context in which it occurs. Indeed many prominent members of the agricultural economics profession have, over the years, pointed out that the characteristics of the social structure within which growth takes place are critical in determining its ultimate effect on the welfare of people, and have insisted that institutions must be treated as variables in any relevant description of the development process. 3/

It is only recently, however, that an increasing number of researchers have begun to heed these pleas for a more intensive investigation of the ways in which technology and institutions interact through time. This turn of events is perhaps less a matter of intellectual persuasion than it is the result of the rapidly accumulating evidence that the character of technical change in the rural areas has important implications for the orderly structural transformation of the entire economy. First, there is the problem of growth per se. A major portion of the agricultural land in a number of Third World countries is divided among small farmers; in such cases sustained increases in output in all sectors of the economy can be achieved only if a broad spectrum of the rural population takes part in the modernization effort. Second, and probably of greater importance in altering people's perception of the distribution question, is the apprehension in these same countries that technical change may produce a good deal of social and political unrest in the countryside. Recent studies have cautioned against the unbounded optimism that accompanied the first projections of the ultimate output effect of the green revolution; they have also stressed that the conditions which limit its output potential are, in part, the basis for severe distributional effects. [4/] Lastly, the outbreak of urban violence in the developed countries has underlined the potential long-run effects of technical change. In the aftermath of the riots in Watts and elsewhere, a number of urbanization studies have underscored what should have been obvious, namely, that an explanation of much of what has happened in U.S. cities is to be found in several decades of

massive structural change in U.S. agriculture.[5]

There are undoubtedly a number of lessons about the distributive effects of technology that can be learned from the existing historical experience. However, most comparative studies -- and the accompanying warnings and admonitions -- continue to have an air of unreality about them; they dwell on the outcome of events (symptoms) rather than on the causes. For example, in the case of the United States, rarely does the analysis confront what ought to be key policy questions: If there were undesirable distributive effects associated with the introduction of a more efficient technology, why did it prove to be virtually impossible to alleviate them? What explains the failure to develop institutional and political instruments for mitigating the negative effects on, say, the welfare of sharecroppers and the small farmers? Why were policies with adverse distributive effects continued long after their cumulative impact was well understood? To stop short of these questions and others like them has tended to produce policy advice to developing countries that is at best politically naive, and, at worst, the basis for development strategies that may be socially disastrous in the long run.

A thorough treatment of the political economy of technical change in agriculture would involve a lengthy consideration of the inter-dependencies between private agricultural interests, the manufacturing and processing sector, various research organizations and general public policy.[6] In this short paper I have tried to focus on a single aspect of the problem, namely, the relationship between technology, institutions

and people at the micro or community level. This necessitates treating the state (and particularly the development of technology) as exogeneous to the system, a formulation that does not exclude the effects of government policy from the analysis, but fails to incorporate the feedback from the aggregate of local communities onto the activities of public institutions. Similarly, the aggregate price effects of technical change are not considered. Nevertheless, the rural community model, and its specific application to East and West Pakistan underscores my main point: namely, that prognoses about the distributive effects of agricultural technology are of little help unless the characteristics of the technology are explicitly related to the social and political institutions of the countryside.

A Conceptual Framework for Investigating the Distributive Effects of Technical Change 7/

Predicting the dynamics of technical change at the community level requires an examination of four basic considerations and several important "feedback loops" between them. The first of these considerations involves the nature of the technology in the abstract; the latter three are best thought of under the broad heading of the social relationships of production.

(1) The characteristics of the technology: 8/ Abstract technology, i.e. technology divorced from its institutional context, has two characteristics that are of basic concern. First, there is the question of efficiency. A decade and a half of experience with community development programs has shown that a critical ingredient to any broad-based rural development

effort is a significant improvement in the value-added by agriculture. While the precise order of magnitude needed to induce change is still a matter of debate, examination of a series of situations in which successful projects have been launched, suggests that the increase to resources owned needed to overcome the reticence of traditional farmers to innovate must be on the order of 30 to 50 percent. Anything less than that is not sufficiently remunerative to produce the change in perceptions needed to insure widespread adoption among all classes of farmers.

A second important aspect of the technology that requires examination is its effect on factor intensities. Neo-classical economic analysis makes the important distinction between "neutral" and "non-neutral" technical change. The former may, for present purposes, be defined as a change in which there is a shift in the production function, but for which the capital-labor ratios remain constant. Non-neutral change, on the other hand, may be either capital-using (labor-saving) -- if the ratio of capital to labor employed in production rises -- or labor-using (capital-saving) if the capital-labor ratio falls. The significant point is that if factor prices remain constant, technical change that is labor-using increases the relative income share of labor, and capital-using technical change increases the relative share of capital.

The empirical estimation of the effects of any specific type of technology on factor shares requires a detailed micro analysis of that particular innovation. Although there is a customary equation of mechanical technology with labor-saving change, and biological-chemical

technology with land (capital)- saving change, this is often a matter of expostional simplicity rather than a description of the real world. For example, herbicides and weedicides are among the most labor-saving innovations that have been introduced into agriculture, while the tubewell and other mechanical devices for providing supplementary water are intensely labor-using. Even tractors, which in temperate climates are almost invariably labor-saving, can become labor-using where the environment of the tropics makes double and triple cropping possible. In short, a detailed analysis of the production process -- the farming system -- at the level of the producer unit, is required to put the analysis of an innovation's effects on sound technical grounds.

(2) The absolute magnitude and relative distribution of productive assets (especially land): Both facets of this point are important, the first because it determines the extent to which individuals and firms can take advantage of the technology, the second because it is a first and vital approximation to the social stratification of the rural community.

Fortunately, the divisibility of many of the most important inputs of the green revolution is such that the absolute size of the holding is irrelevant. New seeds, fertilizer and pesticides are all perfectly divisible and, in principle, can be used with equal advantage by small and large cultivators. There are, however, important exceptions. In cases where the control of irrigation water is critical, the investment indivisibility is sometimes borne by the state in the form of massive

public works. But when the source of supplementary water supplies is privately owned tubewells, low-lift pumps or other mechanical devices, the associated economies of the firm may be substantial.

An analogous situation exists with respect to institutional services. Apart from the question of overt discrimination, applications for credit and information take approximately the same time for everyone. However, the effects tend to be proportional to the magnitude of the output, a result that ties the benefit-cost ratio of acquiring services closely to holding size.

Those with a command over land assets are fortunate. For two other groups -- tenants and landless laborers -- opportunities to exercise a claim to a portion of the benefits of technical change of any sort are at best tenuous. The tenant is in a relatively better position to take advantage of the potential for increasing productivity than the landless laborer. First, he is in possession of some material capital (bullocks, equipment, etc.) whose scarcity value may rise as the result of new cropping patterns and increased power requirements generally. Second, the new technology may put a premium on management and thus provide a means for rewarding the human capital embodied in these skills. (The caveat here, of course, is that the technology must not be such that these skills become superfluous, i.e., extremely labor-displacing. In that event, the landlord may decide that the benefits of direct cultivation outweigh the cost of organizing and controlling a reduced day-labor force.)

The landless laborer has as his only asset his own raw labor power and those minimal skills associated with various forms of manual labor.

Even with the introduction of labor-using technology and rise in the share going to that factor, his personal position is unlikely to show significant improvement. For the surplus labor that exists in most rural areas, coupled with its inability to organize, insures that the supply of labor is likely to be quite elastic at close-to-subsistence wage rates.

The distribution of productive assets, especially land, is a pillar of the class structure in rural areas. Though each situation will differ depending on its historical development, it is nearly always possible to identify some variant of (1) the landed aristocracy, (2) the capitalist farmer, (3) the peasant (subsistence) class, and (4) the groups that are economically and politically dependent on landowners, i.e., tenants and landless laborers. Agricultural growth inevitably affects the welfare of each group differently, depending on the characteristics of the technology and the magnitude of the assets they possess. The effect, however, transcends the mere fact that one group is made better off relative to another in terms of material benefits -- the income distribution question. It alters the distribution of <u>power</u> as well. Thus information on the relative distribution of assets is needed to understand how technical change is likely to affect the <u>political</u> relationships between various groups. Without this knowledge, informed speculation about the dynamic effects of growth is virtually impossible.

(3) <u>The types of institutions and organizations that exist at the local level and the distribution of their services</u>: In most developing

countries, the question of institutional services can be divided conveniently between those embedded in the private sector and those that are carried out by some unit of social organization.

It has frequently been pointed out in the literature that the commodity markets of most traditional societies can adjust to rather significant increases in output without great difficulty. But the circumstances of technological change virtually guarantee that well-established, well-stocked, efficiently functioning input markets for new innovations will take considerable time to establish. As Ruttan /37/ argues, this may be due largely to the relatively large amount of technical information that must accompany the sale of the new item, information which is rarely possessed by the traditional shopkeeper. It may also be due to broad government price policies that do not provide sufficient incentives for the private trade to enter the market or to the failure to provide the primary logistical facilities that make it possible to convey the inputs to areas of use at a profit. Whatever the case, these hindrances to the widespread availability of inputs embodying the new innovation tend to have a severe distributional effect. For when local shortages occur, the distribution of new inputs becomes a function of the resources and power that individual farmers possess. Sometimes the ability to obtain access is a function of corruption and coercion; often it is the availability of private means of transportation to circumvent the limitations of the local sources of supply. The result is usually the same -- small farmers go without.

Another aspect of the distribution of institutional services involves the incentives operating within the organizations that are supposed to serve agriculture. Experience has shown that much of the discrimination between large and small cultivators arises out of the motivations and attitudes forced on local officers by the structure and goals of the bureaucracy. For example, in credit institutions, it is important to ask what the real administrative incentives to lending are. Is the reward to the lending officer in terms of amounts of money loaned or in terms of the number of loans made? How serious is a default from the point of view of a career loan officer? Numerous field studies have demonstrated that the criteria of advancement within organizations may be such that self-interested behavior at the local level runs directly against the broadly stated organizational goals.

Lastly, no evaluation of the dynamic potentials of an institutional structure should overlook the extent to which farmers have had experience in organizing and carrying out group activities of one sort or another. Effective cooperation is something that is learned; it does not spring, full-blown, into existence. Where this experience in participation is lacking, or where it has been perverted by inept and biased leadership, it may be exceedingly difficult to create new institutions that represent class interests of the poorer group.

(4) Social Customs and Traditions: There is an important distinction to be made, at least in the short run, between the power of wealth and

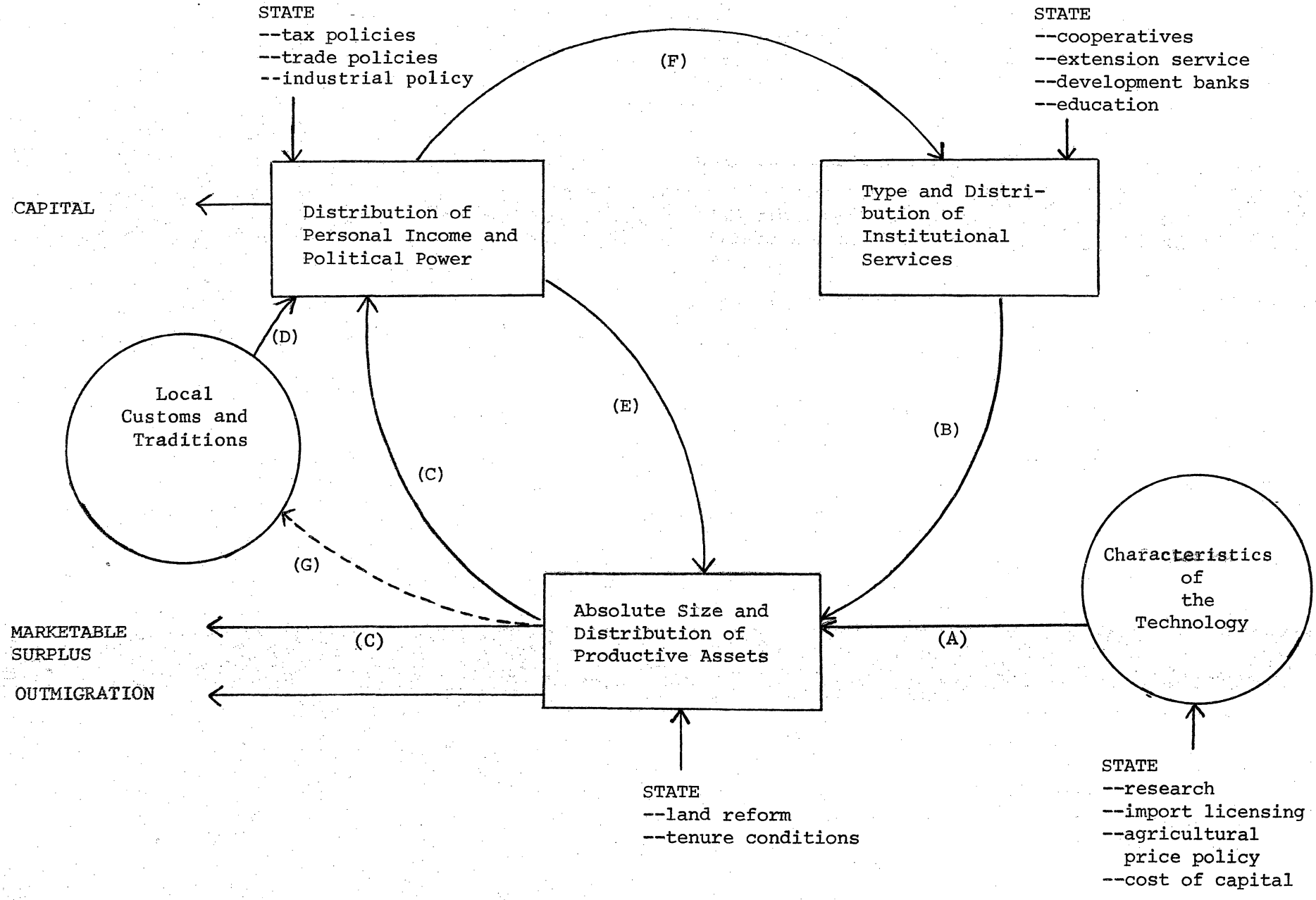
property and the power of role or position.[9] The first three considerations developed in this paper have dealt with the distribution of the former; the latter requires a dimension of analysis in which the perspective of the anthropologist and political scientist is brought into play. Particularly in traditional societies, and for time periods that may last several generations, tribe, caste, kinship and family continue to play an important role in the way in which institutions function locally. Gaining an understanding of the social and cultural framework within which community decisions are made is therefore important in judging the ability of various social classes to organize institutions that would serve their interests.

The Cumulative Effects of the "System"

The second step in developing a broader conceptual framework within which to view the distributive effects of technology at the rural community level is to relate the various analyses described earlier to each other via a general feedback mechanism. Figure 1 suggests, in a purely descriptive fashion, that the characteristics of technology in the agricultural sector, (A), the distribution of institutional services, (B), and the distribution of productive assets, (C), produce an estimate of the marketable surplus available from the rural community and a measure of the personal distribution of income. Taken together with the non-wealth attributes of local customs and traditions, (D), the result is a distribution of personal income and political power.

Three feedback loops complete the structure. The first, (E), involves the familiar process of capital accumulation. Here it is well

Figure 1. Flow Diagram of the Growth and Distribution of Farm Income at the Community Level



to keep in mind that the availability of savings for the acquisition of additional assets is a function of the absolute surplus of the larger farmers and not of their relative position. Therefore one would expect to find that pressure for the acquisition of scarce resources, particularly land, would exist even where technology was perfectly divisible and labor-using.

The second loop relates changes in income and power back to the institutions that serve rural communities. This is the most crucial point in the system for it determines to a large degree the extent to which agricultural growth can become the basis for a broad-based rural development program. Technical changes that affect the distribution of incomes can be expected to create a conflict between (1) those who do not have access to the technology because of institutional constraints, and (2) the current recipients of institutional services who wish to maintain or enhance their current control of rural institutions. In the event that those seeking services try to create new institutions, they will be opposed by those currently in power. For the desire to improve one's access to the services of institutions is, by implication, a desire to participate more effectively in the political decision-making of the community.

Preservation of the status quo could therefore be expected under two types of conditions. The first would arise when the characteristics of the technology were such that mass participation in its benefits did not require social re-organization, e.g. new seeds and fertilizer. The second would occur where there was a definite need for cooperative efforts,

but where political and economic forces of the status quo were sufficiently powerful to prevent the alteration or emergence of any organization dedicated to the interests of the excluded. On the other hand, social change involving increased access to institutional services would imply that some sort of dialectical process was at work in which neither of the polar conditions was a viable resting place. (The extent of the movement that could be expected would obviously be a function of both the intensity of feeling (awareness) of the various groups and the weight that they occupied in the income/power distribution.)

Lastly, there is the feedback from the effects of technology and asset distribution on the social and cultural traditions of the society, (G). As Max Weber [42] remarked: "Property as such is not always recognized as a status qualification, but in the long run it is, and with extraordinary regularity." However, as the dotted line in Figure 1 is meant to suggest, there may be substantial lags in the process. The old ways die hard.

In my view, the need to see that distributive questions involve such a dynamic system deserves special emphasis.[10] Not only does it draw attention to the interdependencies that exist between various facets of life in a rural community, but it forces one to consider explicitly the cumulative effects of the constantly recreated disequilibria that are characteristic of sustained technical change in agriculture.[11]

The possibilities for influencing the tendencies of the system through government policies are numerous, and those shown in Figure 1 are only illustrative. While most of the individual elements have been

widely discussed in the literature on agricultural development, what has been overlooked is that supposedly independent policies also have overall positive or negative cumulative effects. Indeed, in many cases, the presence of "cumulative effects" offers the only chance of making meaningful reforms that in and of themselves mean little. For example, the importance of limited land reform measures rests less on specific economic or social criteria, than on the reform's role in "freeing-up" the system, i.e., in creating new policy options elsewhere in the system which are not immediately related to the initial change. Eliminating some of the larger landlords makes possible rural cooperatives and group equipment pools that would otherwise be difficult to organize. These organizational forms in turn have an effect on the distributive impact of the technology that is introduced -- which in turn affects the distribution of land assets. Too often, these induced effects have gone unrecognized in the static analysis that characterizes most planning exercises. The result has frequently been a series of inherently contradictory programs, each aimed at a different point in the system, whose joint effect has been to frustrate the overall intent of government policy.

Alternative Development Patterns: East and West Pakistan

The need to see the distributive effects of technology in terms of the previously cited considerations can best be made concrete by examining related case studies. The following section provides a brief analysis of the introduction of the same innovation into two areas of South Asia that have significantly different relationships between land, institutions

and people.

Technology - The Tubewell: In both regions of Pakistan, the ability of farmers to control an artificial water supply is crucial to the effective use of the improved seed-fertilizer package. In West Pakistan, the need for irrigation is obvious; it is an arid area with the largest part of the region averaging less than 15 inches of rainfall per annum. East Pakistani cultivators however are also interested in irrigation, for although the monsoon delivers vast amounts of rainfall in the summer months, the sunny winters are almost entirely devoid of precipitation. Except for a few low-lying areas, a boro or winter rice crop without supplementary water is impossible.

The water producing technology that has resulted in the most dramatic impact on local farming systems in both areas is the tubewell. In its simplest form, it consists of a 6-8 inch tubular shaft sunk to a depth of 50-150 feet (depending on the characteristics of the soil and the level of the water table) to which a centrifugal pump is attached. The latter may be run by either an electric motor or a 15-20 h.p. one-cylinder diesel engine.

Farm management studies show that there is relatively little difference in many of the engineering and economic aspects of the technology in the two areas. Methods of installation and costs are similar -- something to be expected since East Pakistan essentially borrowed the technique from the West. Rates of return tend to be highest in the non-irrigated arid regions of the Punjab, but where canal water deliveries are on a perennial basis, they are approximately

in line with the more profitable wells in East Pakistan. Studies also show that the potential amount of land irrigated with each well does not vary appreciably. In the rice growing areas of the Central Punjab, on the order of 60-80 acres would be associated with each well: in Comilla District, farm management data suggest the figure would be closer to 50 acres. (The difference results among other things from the fact that all water for the winter rice crop must be supplied by the well.)

Direct estimates of the effect of tubewells on factor shares are not yet available from farm management surveys. However, an examination of the before and after solutions of linear programming models that have been developed for both areas shows that the hours worked annually in the optimal solution increases from 30 to 75 percent, depending upon assumptions about the permissible cropping patterns. [12/] Since the tubewell represents only a very small increase to the total stock of capital represented by the land, bullocks and equipment of the area it irrigates, capital-labor ratios have declined significantly. Thus in both East and West Pakistan, the tubewell must be characterized as a labor-using (capital-saving) type of technological change.

In short, the characteristics of the technology are similar for both areas. However, its impact on the ultimate structure of the rural community is likely to be quite different.

Land Tenure Relationships: As Table 1 and 2 indicate, tenure patterns are quite different in the two regions. The median holding size for Comilla District in East Pakistan is between 1.0 and 2.5 acres, for Sahiwal District in West Pakistan, it is between 7.5 and 12.5 acres.

TABLE 1. SIZE DISTRIBUTION OF HOLDINGS IN COMILLA DISTRICT. EAST PAKISTAN BY TENURE STATUS (1960).

Size (Acres)	Operated				Owned			
	(1) Number (000)	(2) Percent	(3) Area (000)	(4) Percent	(5) Number (000)	(6) Percent	(7) Area (000)	(8) Percent
under 0.5	137	23	35	3	154	26	33	3
015 - 1.0	119	20	87	8	83	14	44	4
1.0 - 2.5	198	33	324	30	154	26	273	25
2.5 - 5.0	99	17	343	31	118	20	371	34
5.0 - 7.5	25	4	149	14	35	6	196	18
7.4 - 12.5	12	2	109	10	47	8	120	11
12.5 - 25.0	2	*	40	4		*	55	5
25.0 - 40.0		*	4	*		*		*
40.0 - over		*	1	*		*		*
	592	100	1092	100	591	100	1092	100

Source: Government of Pakistan [32]. The size distribution of land owned based on my calculation. For details see Gotsch [14].

TABLE 2. SIZE DISTRIBUTION OF HOLDINGS IN SAHIWAL DISTRICT. WEST PAKISTAN BY TENURE STATUS (1969).

Size (Acres)	Operated				Owned			
	(1) Number (000)	(2) Percent	(3) Area (000)	(4) Percent	(5) Number (000)	(6) Percent	(7) Area (000)	(8) Percent
under 5.0	95	43	184	9	48	43	98	5
5.0 - 7.5	19	13	164	8	21	19	200	10
7.5 - 12.5	43	19	399	20	19	17	295	15
12.5 - 25.0	42	19	693	35	17	15	305	16
25.0 - 50.0	12	5	364	19	6	5	782	40
50.0 - over	2	1	149	8	1	1	273	14
	223	100	1953	100	112	100	1953	100

*less than 1 percent.

Source: Government of Pakistan [32]. The size distribution of land owned based on my calculations. For details, see Gotsch [14].

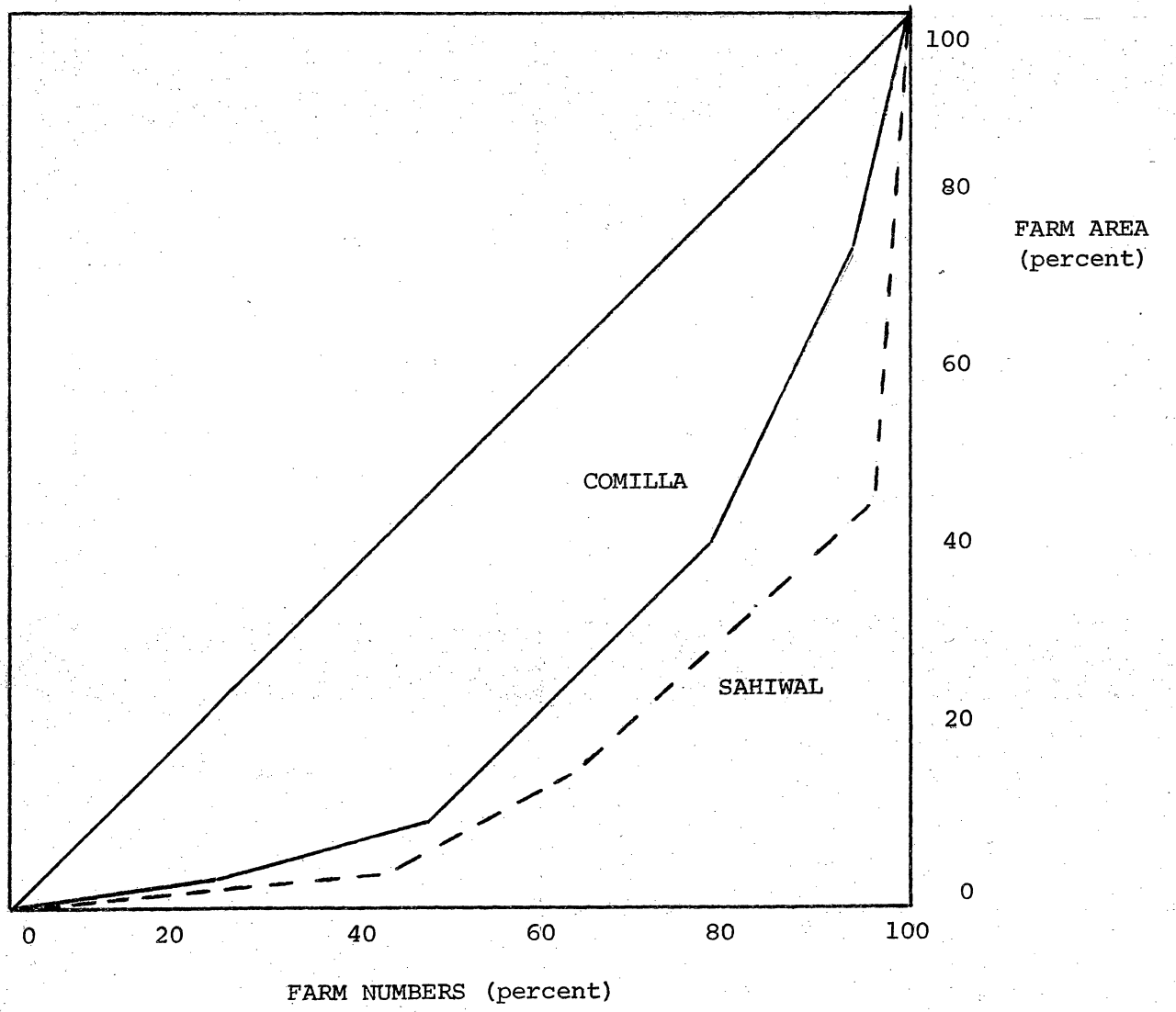
Moreover, there is considerable difference in the distribution of land. As the Lorenz curves in Figure 2 indicate, land is distributed much more equally in Comilla District (less than 1 percent) and the owner cum tenant class comprises less than 25 percent of the total farm population. In Sahiwal District, however, over 50 percent of the units are operated by full tenants.

With respect to the tubewell, the significance of the data on farm size is fairly straightforward. Whereas in West Pakistan nearly 50 percent of the cultivators own sufficient land to purchase and utilize a tubewell either individually or in partnership, less than 1 percent could do so in the East Wing. Even if only the collateral limit were binding, the number of farmers in the East Wing with sufficient resource to finance such an investment is not above 15 percent. The result is a powerful incentive for some type of group activity that will enable individuals to install wells jointly.

Types and Distribution of Institutional Services: For all practical purposes, the institutions serving Pakistani cultivators in Sahiwal District have a strictly top-down style of operation. Even the Cooperative Department relies very little on grass-roots participation. These so-called "nation-building" departments are severely biased against small farmers. Whether it is the transmittal of knowledge through the extension services, access to credit or the sanctioning of additional canal water supplies, the distribution of services is primarily to the larger cultivators.

To some extent, this system has been overcome by the farmers themselves. In areas where input supplies were readily available, virtually everyone

FIGURE 2. DISTRIBUTION OF OWNED LAND IN COMILLA AND SAHIWAL DISTRICTS (1960)



large or small, has adopted the new seeds and has learned to apply fertilizer to them. There is some evidence that small farmers have lagged a year or so behind their larger neighbors and are still applying less-than-optimal dosages of fertilizer. But the difference is not striking. 13/

With respect to the critical question of supplementary water, however, it is a different story. In West Pakistan, subsidized credit available for the purchase of tubewells has gone almost entirely to large farmers. This was due partly to collateral standards and the desire of officials in the lending agencies to insure that as little risk as possible be associated with the transaction, partly because of a greater conversance on the part of large farmers with bureaucratic procedures (both honest and dishonest) and partly because of their influence with other agencies whose duty it was to supply electric connections. The result has been an increase in private wells from 4,000 to 12,000 during the past 5 years, a rate that has substantially surpassed all expectations.

Unfortunately, despite the large increase in wells, small farmers have found that no really satisfactory market for supplementary water exists. It has become apparent, for example, that, depending on the particular distribution system, tubewells have spatial characteristics that tend to give owners a quasi-monopoly position vis-a-vis those who would buy supplementary water. Also, individual tubewell owners may or may not be in a position to extend credit for water sold. Without a ready source of production credit, the result is that small farmers apply less water per acre and, among other things lose the important

physical complementarities that exist in the green revolution package.

Tubewells in East Pakistan were introduced under entirely different institutional circumstances. As indicated earlier, the absolute holding size is such that it was impossible for individuals to sink the bore holes and install the necessary pumping equipment themselves. The result was that in 1965, the Central Cooperative Association of the cooperative system organized initially by the Pakistan Academy for Rural Development at Comilla began its program of helping primary village cooperative societies install the wells.[14/] In each case, wells and pumps were installed only where the village cooperatives had made the request for such equipment and had paid a portion of the rental fee in advance. The rental fee was a flat rate and independent of the acreage irrigated. Digging and maintenance of the irrigation channels and the setting up of a procedure for distributing water among the cooperative's members was the responsibility of the primary village society. They also determined the sale price in the event that water is sold to non-cooperative members.

As one would expect, with the emphasis on village organization, the spread of tubewells in Comilla has been less rapid than in Sahiwal. (The speed has also been affected by the rapid growth in the use of low-lift pumps for lifting the water directly from streams and ponds.) However, the acreage under irrigated winter crops rose from approximately 1000 acres in 1964-65 to 6000 in 1969/70.

The Impact of Tubewells on the Size Distribution of Income

Little direct evidence regarding the distribution of income, either before or after the green revolution, exists for the rural areas of Pakistan. However, knowledge of (1) the incidence of use by farm size, coupled with (2) the effects on synthetic farm management models of incorporating the advanced technology permits a number of judgements to be made regarding the distributive effects that should be expected.

According to a survey conducted in 1968, 70 percent of the tubewells in West Pakistan have been installed by farmers having over 25 acres. Seven percent have been installed by tenants, or, what is more frequently the case, as an investment by businessmen from the city. Only 4 percent have been installed by the size group that incorporates the majority of West Pakistan's cultivators, namely 0-13 acres. (Though these figures are for the region as a whole, they reflect conditions in Sahiwal District quite closely.)

However, as indicated earlier, installation figures do not reflect accurately the extent to which small cultivators have benefitted from improved water supplies. A market in irrigation water does exist, supplied for the most part by owners with less than 50 acres who have excess capacity. Indeed, Naseem's survey of small farmers in Sahiwal District shows that the purchase of water by small farmers is widespread. Unfortunately, the amounts purchased fall well below what would be considered optimal if a competitive market in water prevailed. 15/

The effect of the additional water at competitive prices on the net revenue of the cultivator is substantial. Farm management models

suggest that even without improved seeds and fertilizer, net revenue increases by about 35 percent. This is a function not only of an increase in cropping intensity, but of a shift to higher valued (and more labor intensive crops) such as cotton and sugarcane. When the possibility of utilizing advanced biological and chemical innovations are also introduced, supplementary water produces a 45 percent increase in net revenue. The conclusion is therefore inescapable that so long as small farmers are finding it difficult to gain access to its services, the private tubewell will be a source of increasing income inequity in West Pakistan.

In Comilla District, East Pakistan research on the adoption of highly divisible technology such as new varieties and fertilizer shows a pattern similar to that of Sahawal District. Nearly all farmers, regardless of size of holding or participation in the cooperative scheme, have benefitted absolutely from the green revolution technology. Usually there has been a lag of one to two years between the early adopters (large farmers or cooperative members), and late adopters; however, the diffusion -- if not the same levels of input use -- of simple divisible technology has spread quickly to virtually all members of the farming community.

However, like Sahiwal, the Comilla experience also demonstrates that differences occur between individual farmers when access to a supplementary supply of flexible irrigation water is involved. In this case, among cooperative members farm <u>size</u> has had a relatively small effect on the extent of winter (dry season) cropping. As Table 3 shows,

TABLE 3: Number of Cultivators Growing Winter Crops by Farm Size

Comilla Thana, East Pakistan

(1) Farm size, acres	%	(2) coop-members with given farm size	(3) of members growing winter crop, % with given farm size				%	(4) non-members with given farm size	(5) of non-members growing winter crop, % with given farm size			
			1966	1967	1969	1970			1966	1967	1969	1970
nil		2	--	--	3	2		24	--	2	7	4
0-1		12	22	11	11	18		41	16	23	22	27
1-2		43	36	33	41	32		13	41	42	32	22
2-3		18	19	29	11	11		12	30	20	15	26
3-5		16	19	18	24	19		7	13	10	24	15
over 5		8	3	8	8	18		3	3	2	2	5

Source: Levern Faidley and Merle Esmay, [9]

the proportion of co-op members growing winter crops who farm on less than 2 acres is approximately the same as that size group's representation in the overall sample (52 percent of those growing winter crops; 57 percent membership). Therefore, the probability that any given farmer in the co-op winter crops is independent of his size. The same cannot be said of non-members; the proportion of winter croppers farming on less than 2 acres is about the same but the proportion of non-member farms in that category is much higher. Even more telling with respect to the water variable is the intensity of winter cropping. Table 4 suggests two observations: (1) that when supplementary water supplies are available, small farmers will achieve higher cropping intensities than large farmers, and (2) that cooperative members have a much larger portion of their farm land under irrigation than non-members.

The extent to which farmers have benefitted from the increased water supplies has been investigated by Smith [36]. Using a stochastic programming approach to capture the vagaries of the monsoon-dominated weather, he concludes, for example, that a farmer of the 1.5-2.5 acre class has been able to more than double his income under modern technology. The nature of the Smith analysis make it difficult to determine what part of the increase is related to improved water supplies and what is related to other factors. However, given the fact that the winter crop is entirely dependent on supplementary water, the contribution of tubewells alone is probably even higher than in West Pakistan. One can only conclude from this that the widespread participation of the small and middle peasant group in the Comilla program will tend to maintain the relatively

TABLE 4: Percent of Land Owned by the Farmer which is Winter Cropped

Comilla Thana, East Pakistan

farm size, acres	Coop-members 1966	--% 1967	farm in crop 1966	farm in crop 1970	Non-members 1966	--% 1967	farm in crop 1969	farm in crop 1970
0-1	80	60	195*	208*	--	--	58	77
1-2	53	50	77	79	--	--	53	55
2-3	46	56	75	66	--	--	23	59
3-4	25	65	66	70	--	--	38	23
4-5	--	22	51	47	--	9	25	66
over 5	--	48	60	56	--	--	--	25
average	44	53	68	67	--	9	42	53

* numbers larger than 100 are the result of these persons renting land in addition to the land they owned.

Source: Levern Faidley and Merle Esmay, [9]

equalitarian distribution of income that currently obtains.

The overall conclusion that the first round distributive effects of tubewells in Comilla is equalitarian is not, however, without caveats. As Faidley and Esmay [9] indicate, very small farmers and landless laborers have generally not participated in the co-operative movement. Therefore the benefits from broadening the base of technological diffusion has not taken the same form as it did among those who owned land. However, given the fact that the new seed-fertilizer-water package is labor using and requires 50-70 percent more labor per acre and that the overall demand for labor in the area is a function of the number of acres brought under the new technology, the large increases in acreage brought under winter cropping by cooperative members in the small size classes should have some positive impact on the welfare of landless and near landless laborers.

Traditional Social Organization and the Dynamic Effects of Tubewells

The argument thus far has been a simple illustration of Marx's comment that the distributive effect of machines lies, not in the technology, but in the institutional framework within which they are used. Understanding the ultimate effect of the tubewells, however, also requires an assessment of the second-round effects, i.e. the impact of the technology on the existing institutional and social structure. As indicated previously, it is an important and largely neglected set of policy questions that ask: "Which institutions are strengthened, which are undermined? Which social classes are likely to become more powerful, which will be weakened? Are these changes consistent with the country's overall development strategy?" For it is obvious that new

innovations need not induce desirable institutional change; indeed, they may reinforce the very conditions that stand in the way of broad based participation in the development process. In the extreme case, large short-run gains accruing to certain groups may seriously distort the community's long run growth prospects.

To a considerable extent, the answers to these questions are already implied in the material presented earlier. Wealth is power, and one would expect that the beneficiaries of increased incomes would be strengthened in their conflicts with other classes. Similarly, the institutions that control or provide the profitable inputs will increase in stature and power. However, in the short run, power -- and thereby the ability to influence the course of events -- is also vested in traditional roles and positions. Thus, before going on to a prognosis about the ultimate distributive effects of tubewells, a short digression is necessary on the style of village level politics.

Rural politics in West Pakistan has a distinctively factional flavor.[17/] That is, individuals in the village do not form groups or allegiances because they have a common goal that their cooperation would service. Rather they are "recruited" by one or another of the local political leaders who offers some sort of transactional relationship. "Recruitment" takes two forms: among those who have a choice in the matter and among those who do not. The latter are epitomized by the sharecroppers and landless laborers whose dependence upon the favor of the landlord for their livelihood predetermines their allegiance.

For others, namely the small and medium land owners, there are certain choices to be made. It is around this group that intense

political competition between rival faction leaders takes place. No holds are barred in this struggle: cattle are stolen, women are abducted and buildings are demolished. The use of "goondas" or hoodlums as enforcers is widespread. Frequently when two equally powerful individuals are competing for the allegiance of a particular kinship lineage (biraderi) composed largely of small holders, a virtual state of siege may ensue. In some cases, the pressures are such that the kinship group, which is the basic unit of social interaction in Punjabi Muslim villages, may have to divide against itself politically in order to acquire the "protection" of competing leaders.

Obviously, the vertical alignment of factions is in direct conflict with the horizontal alignment of classes. Where economic dependence is the rule, as in the case of sharecroppers and landless laborers, class alignment is virtually impossible.[18] But from Alavi's [1] description, class alignments needed to produce institutions capable of representing the interests of small farmers would be extremely difficult for small landowners to organize as well. The necessary conditions would appear to be (1) a biraderi or kinship lineage that was composed largely of such small farmers, and (2) the physical proximity of the group in a single village or other contiguous area. (The latter element is necessary in order that they may be able to protect themselves.) Unfortunately, such distributions of holding size and kinship characteristics are not the normal pattern in the Punjab. The result is a domination of village political life by the various faction leaders.

Given the importance of factionalism, the effect of tubewells and other modern technology in West Pakistan has been to further undermine

any possibility of organizing agricultural institutions that could aid small farmers. First, the technology at the disposal of faction leaders has increased considerably their ability to maintain the vertical relationship described earlier. The credibility of eviction or dismissal threats is considerably enhanced by the recent innovations and is proving to be a powerful factor in disciplining the labor force.

Secondly, while factional feuding continues, there is evidence that efforts are being made by the larger farmers to develop a united front at the highest policy levels (e.g., organizing the Punjab Farmers Association). To the extent that this effort to organize horizontally at the top is successful, the movement has important implications for low-income agriculture. Thus far the energies of the "new" class have been devoted largely to insuring that their prosperities will continue. 19/ Lobbying efforts against land reform and on behalf of a favorable tax policy and the maintenance of price supports have been quite effective. But I would anticipate that if necessary the group would quickly become an instrument of opposition to the establishment of any rural institution that might be effective in dealing with poverty problems. Though they may remain rivals at the village level, large farmers have a common interest in maintaining a factional style of politics, a style to which class-based organizations among the smaller farmers would pose a severe threat.

To some extent, political life in Comilla District also exhibits a good deal of factionalism. But, for a variety of reasons, its impact tends to be relatively muted. First, very little full tenancy exists. As a result, control over the access to the means of production via that

channel is limited. Second, the absolute size of the holdings is such that significant surpluses do not exist except among what might be called the very large farmers. Indeed, the past several decades of increasing population pressure has reduced many individual members of what were historically sadari (dominant) kinship lineages in the village to the subsistence or middle peasant role.

It is this middle peasant group that assumed the crucial leadership role in organizing the village cooperative structure.[20] On the one hand, lineage membership conveyed a status that legitimized their leadership position in whatever form of social change the village undertook. On the other, their immediate economic interests were consistent and best served by the original organizing efforts aimed at making small farmers more independent of the money-lending classes.

The tubewell in turn has been a powerful instrument in (1) solidifying the community organizing activities that began prior to 1965, and (2) providing the middle and small peasant group with sufficient resources to break the economic hold of the very large farmer-trader-moneylender group. Indeed, until the military disruption of recent months, there was considerable evidence that the latter group was being successfully withstood as it made a number of attempts at subverting the village level cooperatives.[21]

In addition to increasing the relative power of the middle peasant class, the green revolution in Comilla has supported -- often indirectly -- a variety of other development programs with positive distributive effects: primary education, health, adult literacy and training for women to mention but a few. Indeed, the list reads somewhat like the community development

programs of a previous decade. The significant difference in the Comilla case, of course, is that these programs are now built on a solid base of increasing productivity in agriculture. 22/

Concluding Comments: Some Generalizations

The theme of this paper has been that a meaningful investigation of the distributive effects of technology must be carried out in the context of a conceptual framework that (1) shows how the characteristics of technology, local institutions and the rural social structures are related to each other at a point in time, and (2) how these relationships can be expected to evolve in a dynamic rural system.

I would hypothesize -- on the basis of alternative combinations of the considerations described earlier - that comparative studies will reveal a number of distinct types of development situations. The four that follow are by no means exclusive but they involve some of the more sensitive parameters in the system.

Type I: New technology: simple, divisible, labor using
Holding size: small, relatively equalitarian
Institutions: top-down, no community participation
Social Organization: individualistic, loosely structured

This type of situation appears to be fairly common in Africa. The highland areas into which new maize varieties were introduced in Kenya offer a specific example. It is also characteristic of a few regions in Latin America, e.g. it seems to fit rather well the description of the Puebla Project sponsored by the Rockefeller Foundation in Mexico.

Output can increase fairly rapidly under such conditions provided that the technology is really profitable; extension efforts required are usually fairly minimal since the technology is simple.

The first round distributive effects of technology in such cases are likely to be minor. However, there is also likely to be little pressure for further community development. Credit would pose severe problems for only the lower third of the population and unless there was a severe marketing problem, as in the case of some sort of cash crop, efforts at organizing cooperatives and other types of communal activities are likely to be slow.

The same holds true for social and political organization. The problem, of course, is not one of the repressive measures of dominant elites; it is simply that the changes in the underlying mode of production do not result in contraditions with the way in which the society is already organized. Without the presence of significant inconsistencies between the nature of the technology and the institutional structure, the demands for any type of rapid social change are likely to be small.

Type II: New technology: complicated, lumpy, labor using
Holding size: small, relatively equilitarian
Institutions: top-down, no community organizations
Social Organizations: individualistic, loosely structured

This situation would be typical of East Pakistan and other areas in South and Southeast Asia that require a mechanical technology for small scale irrigation, but in which labor-displacing mechanization of rice culture is not far advanced.

Such a configuration presents both difficulties and opportunities for broad-based rural development. The difficulty resides in the fact that if no institutional structure exists in the countryside, an outside catalyst is generally needed to introduce and organize people in such a way that the technology can be jointly used. In some cases, this has been done by outside entrepreneurs creating a market for services (pump rental agencies in Malaysia) but more generally, the efforts of a central authority or a political party are necessary. Where these organizational activities are not forthcoming, development is likely to stagnate. However, this situation more than any other has the potential for evolving into a program in which development is something broader than increasing agricultural output. If the "lumpy" technology is truly profitable, it can become the catalyst around which organizations for introducing or creating a variety of additional services for the majority of the farming community can be built.

Type III: New technology: simple, divisible, labor using
Land distribution: relatively unequal
Institutions: top-down, no community organizations
Social Organization: hierarchical

As the research reported here suggests, in those areas of Asia and the Middle East were the seed-fertilizer revolution has found sufficient water control, (artificial or natural), it has spread quickly to farmers of all size groups. Thus, output can be expected to increase fairly rapidly if the technology is clearly superior to traditional practices.

Although there has been some additional delay in the diffusion to the smaller farmers, and they have lagged somewhat in applying the full measure of purchased inputs, the adverse distributive effects in such a situation have not been pronounced. The likely pattern would involve small farmers becoming better off relative to their previous position but worse off relative to their larger neighbors. One would expect relatively little tenant eviction since under this technology the problem of controlling and managing the labor force would remain. However, since it is absolute surplus that determines ability to accumulate additional land, considerable economic power would be wielded by the larger farmers. Insofar as these highly divisible innovations did not involve the type of weedicides and herbicides that seriously reduce the demand for labor, it is possible, indeed likely, that the overall demand for labor would increase.

Type IV: New technology: complicated, lumpy, labor displacing
Land distribution: relatively unequal
Institutions: top down, no community organizations
Social Organization: hierarchical

Obviously, it is this general situation that tends to produce the most serious questions about the distributive effects of technology. An excellent historical example would be the Mississippi Delta; currently, similar conditions exist in most of the Latin American countries. If policies that encourage mechanization are continued, it is also the most

likely prognosis for West Pakistan. As a development situation, it presents a number of difficulties. First, there is the problem of insuring access of the majority of the farmers to the technology. The evidence in both developed and less-developed countries suggests that markets to convert lumpy stocks of mechanical innovations into flows of services may be a less than fully effective diffusion instrument as far as small farmers are concerned. Thus the disparity between those classes having the resources necessary to utilize the technology effectively and those who do not may develop rather rapidly.

Second, the class distinctions that exist in such a situation make it extremely difficult to organize badly needed cooperative institutions. Although the technology produces conflicts in the existing structure that would dictate some sort of group activity, its political threat if organized is such that those who are not in need of the joint service are likely to use their power to render it ineffective. In cases where the lumpy technology is also labor-saving, the existing social stratification may be greatly enhanced.

Third, it is under such conditions that technical change may become associated with overt social conflict to produce a rate of innovation and diffusion that is quite inconsistent with prevailing factor endowments. Strikes and social movements such as the recent threat of Punjabi sharecroppers to withhold their rents and the Freedom Summer in Mississippi may raise the wages of labor as <u>perceived</u> by the farm operator to a point well above their social cost. Where this is also accompanied by an undervaluation of capital, labor displacing technology may be introduced

with extraordinary rapidity.

The foregoing generalizations are obviously in the nature of hypotheses that require extensive empirical investigation. However, it is my impression that, insofar as designing rural development programs and projects is concerned, the general principles of "integrated rural development" would benefit from further disaggregation along the lines suggested by the foregoing typology. Too few studies confront explicitly the feasibility of their proposals in the context of a particular system. Where institutional experimentation is highly constrained - as is frequently the case - research is badly needed that would relate quantitative changes in system parameters to qualitative changes in the system's behavior. The latter is frequently a pre-requisite to the implementation of programs and policies that benefit a majority of the residents of the rural community.

FOOTNOTES

* I am especially indebted to Walter Falcon and Peter Warr for discussions of an earlier draft of this paper. Helpful comments were also received from Arthur Mosher and William Thiesenhusen. Errors that remain are mine.

Portions of this research were supported by AID Contract CSD-1543 and AID/NESA Contract No. 527. The views expressed, however, do not necessarily reflect those of AID.

1. Karl Marx, [27, p. 468]. Chapters XIII, XIV, and XV of Capital contain a variety of insights on the relationship between technology and social organization and deserve to be read in their entirety.
2. Wolf Ladejinsky, [24].
3. See, for example, Dorner [9], Schaffer [38] and Schultz [39].
4. For some recent writings that underscore this theme, see Lester Brown, [6]; Lowell Hardin, [17]; Bruce F. Johnston and John Crownie, [20]; Walter P. Falcon, [11]; and Hiromitsu Kaneda, [22].
5. See particularly, John Kain and Joseph Persky, [21].
6. For an important contribution to the development of such a framework, see Yujiro Hayami and Vernon Ruttan, [18]. Their notion of "induced innovations" (akin to the "feedback" concept used in this paper) serves two important functions: (1) it sets the issue of technological change in an appropriately dynamic context, and (2) it provides a mechanism by which certain types of institutional change become endogenous to the model.

While there is a similarity in perspective between their macro framework and the micro approach presented here, our views on the development of technology diverge somewhat when assessing the role of conflict between various groups in determining the direction of technological change. One need "not accept the Marxian perspective regarding the monolithic sequences of evolution based on clear-cut conflicts" to argue that the struggle by various social classes over the economic surplus is an important element in determining the characteristics of the technology that actually get produced and diffused. For a discussion pertinent to this latter view, see Stephen A. Marglin, [26].

7. The proposed framework is complementary to the system developed by A. T. Mosher [30]. In some ways, it can be viewed as an institutional elaboration of his general perspective, i.e., any effective agricultural development strategy inevitability requires significant regional disaggregation.

8. Elements of neo-classical production theory relevant to the subject of technical change and income distribution may be found in Murray Brown [7] and Robert Solow [41]. An earlier treatment of the material is in J. R. Hicks [19].

9. For an extensive discussion of the role that these two sources of power play in the social stratification of societies at different stages of technological development (hunting and gathering, horticultural, agrarian and industrial), see Gerhard E. Lenski, [25].

10. I have benefitted greatly from discussions about the behavior of such systems from Dennis Meadows and members of the Systems Dynamics Group at the Massachusetts Institute of Technology. A brief description of the Group's work that has relevance for the question of agricultural transformation can be found in Dennis Meadows [28]. For a theoretical treatment of dynamic systems, see Jay Forrester [12].

11. Bruce Gardner has recently examined the extent to which rural poverty in the United States is a result of the distribution of assets and to what extent it is a function of disequilibrium payments to factors. Using 1965 data, he concludes that in the West, approximately 40 percent of the relative poverty is due to the former, 60 percent to the latter. The findings are reversed in the South with 90 percent due to asset distribution and only 10 percent due to factor market disequilibria. Bruce Gardner [13].

12. For a programming analysis of the effect of technology on farm operations in West Pakistan, see Carl H. Gotsch, [15, 16]. A similar analysis for East Pakistan farms using a stochastic programming approach can be found in Douglas Smith [40].

13. The broad based participation of small farmers in the first stages of the seed-fertilizer revolution has now been widely documented. For example, for West Pakistan the relevant studies by Eckert, Hussain, the Punjab Planning and Development Department's Survey Unit, Rochin and Loudermilk have been summarized in Refugio I. Rochin, [36]. These results have been reinforced by survey

material presented in Muhammad Naseem, [31].

For Comilla District in East Pakistan, similar evidence is found in Levern Faidley and Merle Esmay, [10].

14. The literature on the Comilla program has become extensive. For a summary statement, see Arthur Raper, et al., [35].

15. For example, in Sahiwal District, West Pakistan, small farmers purchased approximately 10 hours of supplementary tubewell water annually per acre. Naseem, [31], Ghulam Mohammad's earlier study of the same area shows larger farmers with wells applying nearly 20 hours of water per acre. Ghulam Mohammad, [29]. Both results are consistent with estimates based on the parametric variation of water prices in linear programming models of the area. See Gotsch, [15, 16].

16. The interaction of a flexible supply of supplementary water and improved seeds and fertilizer 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 increase produced when both are introduced simultaneously (85). 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 supplementary irrigation water is available.

17. Hamza A. Alavi, [1].

18. This description of the political aspects of economic dependence might as easily have been written about Mississippi. For example, Holmes County has a highly sophisticated network of black organizations and blacks play an important role in the country's political life. In neighboring Sunflower County, with a higher percentage of black voters, there is relatively little black communal and political activity. Observers have traced much of this difference between the two areas to the large number of small, economically independent black farmers in Holmes. Their presence is a result of several pilot programs initiated by the Farm Security Administration during the late 1930's in which black sharecroppers were helped to purchase the land they tilled. For a brief description of these projects, see Ben H. Bagdikian, [2].

19. For an extensive discussion of the political implications of the concentration of benefits from the green revolution, see Shahid Javed Burki, [8].

20. Peter Bertocci, [4] and [5].

21. A favorite trick of the large farmer cum moneylender has been to join the co-op, take out the maximum possible loan, and then refuse to repay, hoping that this would drive the organization into insolvency. See Akhter Hamid Khan, [23].

22. There is reason to believe that the Comilla program could be replicated in most parts of East Pakistan; what is not clear is that it would have been permitted to do so. For the increase in

the economic well-being of the small and medium farmer must ultimately pose a direct threat to the national political position of the surplus farmer-contractor, a class that continued to exercise significant influence in the post-Ayub governments. As Solon Barraclough has observed:

> The paths of development history are strewn with the debris of well-intentioned and often well-planned and executed projects that have failed to have a wider impact because they were not in harmony with the course of events in the national society. These experiences are almost always useful, for research and training -- for learning more about the real problems and possibilities. But they may not have much direct impact on the character of rural development outside their own limited areas. Nor are they usually reliable indicators of the types of institutional change that would be feasible on a national basis.

In other words, even if the rural system that exists at the level of an agricultural community is such that the adverse consequences of technical change can be minimized, its ultimate distributive effects cannot be detached from the economic and social structure of the society as a whole. Solon Barrachlough, /3/.

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