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10. Abstract

Tractor mechanization in Pakistan is following a familiar pattern: the larger farmers, especially those located in areas where water is available and possibilities for increasing cropping intensity are favorable, are doing the innovating, often at the expense of displaced tenants. The most feasible policy change to reduce the divergence between net social and net private benefits arising from mechanization could be to increase the direct costs of tractors and equipment by pricing capital at its opportunity cost. Such cost increases would be likely to slow the rate of mechanization to the point where the resulting social dislocations would be of manageable proportions. This policy change would do nothing to improve the distribution of incomes, or to increase employment, but it would allow for continued agricultural growth and a slow rise in farm wages sufficient to give the masses at least a nominal participation in the green revolution. The overall costs and benefits of importing technology require very careful analysis.

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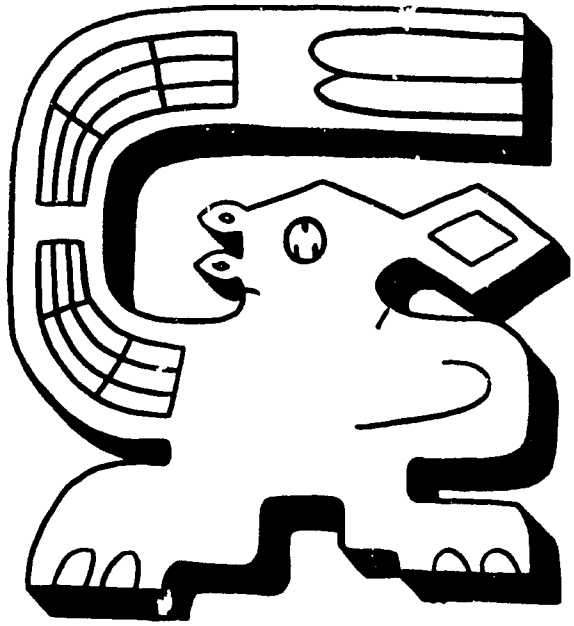

Tractor Mechanisation and Rural Development in Pakistan

by Carl H. Gotsch

LAND TENURE CENTER
University of Wisconsin—Madison
53706

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Tractor Mechanisation and Rural Development in Pakistan

Carl H. GOTSCH [1]

I. Introduction

THE DEVELOPMENT and diffusion of technology occupy a place of critical importance in the development strategy of any economy. For late-developing countries the policy decisions they involve are particularly difficult. Unlike the economically advanced societies—which have found it hard enough to adjust to the sequences of innovations endogenously generated by their own research and development institutions—the third world is constantly having to adjust to techniques borrowed almost entirely from foreigners.

Nowhere is this more evident than in the agricultural sector. To date, nearly all the research and development in respect of agricultural technology have taken place in the developed countries. In some cases, e.g. chemical and biological innovations, the results have been for the most part positive. The so-called seed-fertiliser revolution is a crucial element in the efforts of a number of less developed countries to attain sustained economic growth. While the " new realism " emphasises that the spurt in food output cannot solve all development problems, there is widespread agreement that it can provide a decade or more of breathing space within which to improve the non-farm opportunities for employment, launch effective birth control programmes and in general pursue a more expansionist development policy without running the risk of rampant inflation.

With respect to mechanical innovations, however, the benefits of technology borrowing are less clear. Some items, such as motors, low-lift pumps, tube-wells and small power tillers, seem on the whole to be consistent with the factor endowments and social organisation of most of the less developed countries in which they have been introduced. But other types of equipment, notably tractors and various types of harvesting equipment such as combines and cotton pickers, appear to

[1] Development Adviser, Development Advisory Service, and Lecturer, Department of Economics, Harvard University.

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have the potential for producing significant divergences between net private and net social benefits. In part, these divergences result from government economic policies—e.g. subsidies and licensing procedures biasing the private profitability of technology in socially undesirable directions—that are, in principle, relatively easy to adjust. But they may also be due to institutional conditions—e.g. the distribution of land, the tenure system and biases in individual access to service organisations—that would remain even if resources were valued at their opportunity cost.

Pakistan is a country affected by virtually all the issues described above. Judging from the demand for tractors as measured by applications for import licences and the free market price, the net benefits of mechanisation viewed from a private perspective are quite high. This is partly due to the fact that, ecologically, the Indus Basin is unusually well suited to highly mechanised farming. The land is flat, the soil free from rocks or other foreign materials that would be damaging to equipment. An arid climate plus irrigation permit continuous cropping, a feature that puts a premium on timely cultivating. The size of holdings among the larger farmers is such that medium and even large tractors can be kept busy throughout the agricultural year. In addition, the prices both of inputs such as capital and water and of outputs such as wheat, maize and sugar-cane are distorted in such a way that they enhance the attractiveness of mechanising farming operations.

The net social benefits of mechanisation under these conditions are another matter. Certain social inefficiencies directly associated with the distortions in factor and product prices indicated above are relatively easy to identify. There are also, however, a number of indirect costs that must be taken into account. For example, nearly 50 per cent of the arable area is cultivated by tenants of one sort or another. Some are, of course, fairly large operators and can be expected to take advantage of the opportunities afforded by mechanisation in much the same way as the large landowners do. However, the majority (75 per cent) are small farmers with less than 12.5 acres, who operate their holdings with a single pair of bullocks and the labour of their families. A mechanisation programme that relegated this group to the status of landless labourers would undoubtedly produce a significant and undesirable alteration in the social structure of the rural communities. Moreover, even if the total hours worked in agriculture were to remain the same, the former tenants, many of whom have benefited to some extent from the seed-fertiliser component of the new technology, would in future receive only the wages of day labourers. Mechanisation could therefore be expected to produce a further deterioration in the distribution of rural incomes.

The subsequent analysis will probe the arguments regarding the balance of public and private interests. Superficially, at least, there is

sufficient evidence to suggest that the social costs of policies that encourage present trends outweigh the social benefits. However, this finding, even if it is substantiated by further investigation, will not mark the end of the mechanisation policy debate. To understand the actual context within which decisions are being made requires a fuller investigation of the social and political institutions of the society than has thus far appeared in the various economic analyses.

Section II begins with some facts and interpretations that provide a perspective on the historical process and an overview of past government policies. It closes with a review of selected studies that have been made on the mechanisation question. Sections III and IV contain my own approach to the problem.

II. The present state of mechanisation

Number, use and location of tractors

By the standards of developed countries, mechanisation in Pakistan is of course still in its infancy. Table I shows that at the end of 1968 there were only 19,000 serviceable tractors in a country with nearly 50 million cultivated acres. Since that time, there have been further disbursements of 23.2 million rupees from the International Development Association (IDA) to the Agricultural Development Bank of Pakistan, which has probably led to the acquisition of several thousand new tractors by the end of 1972. In addition, some 6,000 machines have been obtained from Eastern European countries under barter arrangements. From this total, however, must be subtracted a rapidly increasing number of worn-out machines as the tractors purchased in the early 1960s reach the end of their useful lives. Thus, the figure of 27,000 will serve as a rough approximation of the total number currently in operation. Of these, about 25,000 are in private hands.

TABLE I. TRACTORS BY TYPE OF OWNERSHIP, 1968

Type of ownership	No.	%
Individual	14 031	74
Joint ownership	2 256	12
Co-operatives	296	2
Government and semi-official bodies	2 326	12
Total	18 909	100

Source: Government of Pakistan, Ministry of Agriculture and Works: *Report of the Farm Mechanization Committee* (Islamabad, 1970).

The farm mechanisation survey from which table I is derived revealed that the average area per tractor is approximately 200 acres. On the basis of this average figure it would appear that some 10 per cent of the cultivated area is presently being farmed with mechanical power. In reality, the total area affected is considerably less. Various farm management studies have shown that the capacity of a single machine under irrigated conditions is approximately 100 acres. Many of the very large farmers are therefore obviously continuing to farm part of their holdings with tenants and traditional sources of power. The 10 per cent calculation of area under mechanised cultivation is also too high because a number of farmers owning substantially less land let excess capacity lie idle or hire out their tractors for non-farm uses.

Average acreage per tractor is misleading in other ways, too. For instance, it hides a considerable geographical concentration. Thirty per cent of the machines are located in one division (Multan) of the Central Punjab, giving it over 5 tractor horsepower per 100 cropped acres. Fifty-eight per cent are located in three divisions of the same area (Lahore, Multan and Bahawalpur) giving them an index of 3.9 horsepower per 100 cropped acres. Admittedly these divisions are important in terms of agricultural output, but the significance of the two groups as measured by their share of total cropped acreage (18 and 39 per cent respectively) or of the gross value of crop production (24 and 42 per cent respectively) is considerably less than their share of the total tractor force.

There are several reasons for this concentration. As other researchers have pointed out, cropping patterns in the Central Punjab are quite flexible and with adequate irrigation supplies (canals plus tube-wells) double and even triple cropping is agronomically feasible. Under such conditions, the timeliness of tillage, sowing and harvesting operations is particularly important. The significance of the irrigation variable can be seen from table II, which shows that nearly 75 per cent of privately owned tractors are located on farms that also have tube-wells.

A second factor making for concentration relates to farm size. As Alavi has pointed out, the structure of holdings differs considerably among the various agricultural regions of the country.[1] Given the economies associated with the effective utilisation of a technology as "lumpy" (i.e. indivisible) as tractors, it is not surprising that those districts where the machines are concentrated are also districts with above-average holding sizes.

Though there is little information available from field surveys, informal interviews with farmers suggest yet a third reason for the concentration of tractors in the Central Punjab, namely the high degree

[1] Hamza Alavi: "Elite farmer strategy and regional disparities in the agricultural development of West Pakistan", in R. D. Stevens, H. A. Alavi and Peter Bertocci (eds.): *Rural development in Pakistan* (Michigan State University, forthcoming).

TABLE II. DISTRIBUTION OF PRIVATE TRACTORS BY TYPE OF IRRIGATION, 1968

Type of irrigation	No.	%
Mixed irrigation (canals plus tube-wells)	10 281	62
Perennial canals only	3 317	20
Non-perennial canals	663	4
Tube-wells only	1 824	11
Other irrigation	332	2
No irrigation	166	1
Total	16 583	100

Source: *Report of the Farm Mechanization Committee*, op. cit.

of urbanisation. Mohammed Naseem, in a recent study in Sahiwal District, Multan Division, found that the cropping intensity in the proximity of urban areas was quite high—nearly 135 per cent.[1] The average intensity away from the towns, on the other hand, was only 108 per cent. Farmers located closest to city markets grew large amounts of vegetables for human consumption and green fodder for the milk and transport animals that are reared around all cities. Both these types of crop have short growing seasons and where supplementary water is available several crops can be obtained in a single season—provided that old crop residues can be removed, a seed-bed prepared and the new crop planted, all in a matter of days. According to the cultivators themselves, this can only be done with the help of mechanical tillage equipment.

Urbanisation and tractor concentration are also linked through the use of tractors for urban transport. Given the economics of tractor versus truck transport, many farmers have found it profitable to rent out their machines for short-haul work within the environs of the town. For example, forage for horses and milk animals is frequently transported by tractor and trailer. Such rigs are also commonly seen bringing cotton from the warehouse to the mill and carrying grain to the railhead for shipment.

As indicated earlier, one would expect tractorisation to have been largely a response to the demands of the larger farmers. Table III shows just how small the number of tractor-operated farms is in relation to the total. For example, whereas farms under 26 acres in area account for less than 5 per cent of all those possessing tractors, farms in this size group form 92 per cent of the total operator population. Indeed, 80 per cent of the tractors are found on farms containing more than

[1] Mohammed Naseem: *Small farmers and the agricultural transformation of West Pakistan*, unpublished PhD thesis, University of California, Davis, 1971.

TABLE III. APPROXIMATE DISTRIBUTIONS OF FARMS OPERATED WITH TRACTORS AND BULLOCKS

Farm size (acres)	Acres per tractor	Tractor farms				Bullock farms			
		No.	%	Area (acres)	%	No.	%	Area (acres)	%
No area [1]	.	147	1	.	.	.	.	.	.
Under 13	8	179	1	1 520	—	3 743 408	77	15 492 109	34
13-25	21	634	4	13 574	—	728 275	15	12 519 445	27
26-50	42	2 168	15	94 568	3	283 714	6	9 373 073	21
51-150	77	5 860	40	616 375	19	81 764	2	5 922 508	13
Over 150	358 [2]	5 578	39	2 559 322	78	8 403	—	2 337 089	5
All farms	.	14 567	100	3 285 359	100	4 843 593	100	45 644 224	100

[1] Denotes individuals who do not own land but use tractors for non-farm purposes, e.g. provision of transportation services. [2] A number of larger units reporting tractors are obviously not relying fully on mechanical power.

Sources: *Report of the Farm Mechanization Committee*, op. cit., and Government of Pakistan: *Agricultural Census*, 1960.

50 acres, a group that contains slightly more than 2 per cent of the total operators and controls approximately 23 per cent of the total cultivated land.

Although the data presented are not as complete as one might wish, it is obvious that the pattern of mechanisation in Pakistan is typical of that observed in other parts of the world and conforms to *a priori* expectations: it is concentrated in the areas that have complementary inputs, carried out by the larger and more resourceful farmers and associated with a proximity to urban markets and services.

Government policies encouraging mechanisation

The general thrust of government policy has been to promote mechanisation. The First Five-Year Plan, for example, envisaged that mechanical power would be needed for the improvement of cultivable wasteland, development of new areas, erosion control and soil conservation, dryland farming, pest control, lifting water, increasing cropping intensities, and improving yields.

The Second and Third Plans echoed these sentiments albeit with some cautioning against " premature " mechanisation. The latter caveat, however, has not interfered with a set of incentives that directly and indirectly have provided an extremely favourable investment climate. For example, the Agricultural Development Bank (ADB) has heavily subsidised tractor purchases. Instead of the 12 to 15 per cent charged by commercial banks for medium-term credit, the ADB rates have been approximately 7 to 8 per cent. In addition, the foreign exchange used

to purchase the tractors has been sold to farmers at the official rate rather than at its scarcity value to the economy, a figure widely acknowledged to be at least twice the official rate. Until 1969/70, there were also no duties on tractors; only with the budget of that year was a 5 per cent duty imposed plus a 15 per cent sales tax and a defence surcharge amounting to 25 per cent of the sales tax. These taxes increased the price of a tractor by approximately 25 per cent but failed to wipe out the windfall profits produced by selling foreign exchange at the official rate. As evidence of the magnitude of the distortion, the free market price of tractors in 1971 ranged between Rs. 25,000 and 30,000, compared with the Rs. 16,000-18,000 paid by licence recipient.[1]

Indirectly, mechanisation was also encouraged by the generally favourable income position of agriculture during the latter part of the 1960s. The prices of a number of crops were pegged at rates well above the world market ones when calculated at official exchange rates. For example, sugar-cane's domestic price is nearly 200 per cent above its world market value. Similarly, wheat and maize have been supported at prices approximately 50 per cent above those obtaining in world markets. Recently rice and cotton have also been included in Pakistan's export promotion scheme and have significantly increased their domestic prices.

More important to incomes than prices, however, have been the significant improvements in productivity per acre. For example, official data for 1969/70 show that country-wide wheat yields have increased by approximately 35 per cent since 1965. Rice yields have improved even more: by nearly 40 per cent. Even cotton, a crop which has not benefited from extensive varietal improvement, has shown a substantial increase in yields as a result of improved cultural practices and higher rates of fertiliser usage.

With supported output prices and declining unit costs, large income gains have been enjoyed by those who had the resources to take advantage of the new technology. Without an efficient scheme of agricultural taxation, this in turn has permitted the accumulation of substantial surpluses that could be invested in various kinds of mechanical equipment without the purchaser having to encumber his lands in any way.

The over-all impact of these policies has been to encourage mechanisation by (1) distorting factor prices in favour of capital, and (2) producing surpluses which, in the imperfect capital markets of the rural areas, reduced the risks of investing in machines.

The rationale and the resources for the positive incentives to purchase tractors can in part be linked to the availability of various forms of foreign aid. First, the pro-mechanisation point of view was reinforced by an orientation towards technical assistance in agriculture that emphasised the introduction of more advanced systems of farming. The United

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[1] These latter figures do not include expenses incurred in obtaining the licence.

States Agency for International Development's agricultural programme, for example, was influenced by a desire to show that the environment of the Indus Basin was quite capable of producing the same kinds of crops and yields that have been achieved in comparable areas in the south-western part of the United States. Attempts to demonstrate the correctness of this hypothesis were remarkably successful. By putting together a package of carefully prepared soils, proper seeding and spraying, imported seeds and adequate levels of fertilisation, AID technicians showed that it was indeed possible to obtain the results of advanced arid areas in the Pakistan Punjab. This underlying objective resulted, however, in a major part of the technician's total available time being spent with the most advanced farmers in trying to reproduce the technical conditions of an advanced society rather than with the small cultivators trying to develop techniques that were appropriate for the majority of farmers.

A similar approach was adopted by a mechanisation consultant employed by the Ford Foundation. The result was a much publicised report on farm power that advocated a rapid expansion of tractor availability but failed to deal adequately either with alternatives or with the concept of social costs and benefits.[1]

Second, the single most decisive factor in government policy implementation has been financial assistance in the form of foreign exchange made available for tractor imports.[2] Credits have been made available through IDA, the subsidised lending wing of the International Bank for Reconstruction and Development (IBRD), as well as through various bilateral credit and trade arrangements.

Prior to 1952, tractors and agricultural machinery could be freely imported. From that time on commercial imports were placed under restricted licensing, while individuals were permitted to import under an " open general licence ". This practice was continued until 1966 although, in the interests of standardisation, some restrictions were imposed on the makes that could be imported. As a result of the foreign exchange crisis of 1966/67, the practice of freely granting import licences to individuals was halted and in 1969 discontinued entirely. Before 1966/67, imports of tractors and agricultural machinery were financed out of cash and foreign credits; after that year, they were made entirely dependent on foreign credit and barter arrangements. Thus except for a small number of imports that may have come in under cash arrangements in 1965/66 and those imported under barter arrangements, the

[1] G. W. Giles: *Towards a more powerful agriculture*, report prepared for the Government of Pakistan (Lahore, Department of Agriculture, 1968).

[2] For a similar view of the source of mechanisation incentives in the Philippines, see Randolph Barker *et al.*: " Employment and technological change in Philippine agriculture ", in *International Labour Review*, Aug.-Sep. 1972, pp. 11-139. Also Carl Eicher, Thomas Zalla, James Kocher and Fred Winch: *Employment generation in African agriculture* (East Lansing, Institute of International Agriculture, Michigan State University, 1970).

15,000 tractors purchased since 1965 were obtained with foreign aid loans. Of the total machinery loans, IDA contributed roughly 65 per cent, the Western Europeans 25 per cent, and the USSR 10 per cent.

As the concluding sections on mechanisation policy will emphasise, the future availability of such funds, earmarked for a specific purpose and not subject to the full scrutiny of the resource allocation process, is likely to determine in large measure the appropriateness of the country's mechanisation programme.

Existing research on the economics of mechanisation

In recent years there have been a growing number of articles and papers devoted to the economics of mechanisation in Pakistan.[1] In the following review of this research I have not attempted to provide a summary of each individual contribution but have tried to highlight only those conclusions and/or differences of opinion that have the most relevance for mechanisation policy.

DIRECT SOCIAL COSTS AND BENEFITS

As International Agricultural Consultants Associated (IACA) pointed out in its extensive study of agriculture in Pakistan, private benefits from mechanisation may accrue because the capital invested in bullocks and labour devoted to their care can be released, land used to provide fodder for work animals can be diverted to alternative crops, labour costs can be reduced, timely planting can be assured, better seed-beds can be prepared, etc.[2] Unfortunately, most of the data required to make a quantitative assessment of the significance of these items are not particularly easy to obtain. First, there is a large element of learning-by-doing involved in such a radical shift in farming practices. Consequently, conclusions about the tractor's ultimate effect based on survey data which do not carefully distinguish between individuals who have had tractors for several years and those who have recently purchased machines may be highly misleading.

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[1] Writers who have dealt with one or more facets of the problem include: S. R. Bose and E. H. Clark II: "Some basic considerations on agricultural mechanization in West Pakistan", in *Pakistan Development Review* (Karachi), Autumn 1969, pp. 273-308; J. Cownie, B. F. Johnston and B. Duff: "The quantitative impact of the seed-fertilizer revolution in West Pakistan: an exploratory study", in *Food Research Institute Studies in Agricultural Economics, Trade and Development* (Stanford), 1970, pp. 57-95; Hiromitsu Kaneda: "Economic implications of the 'Green Revolution' and the strategy of agricultural development in West Pakistan", in *Pakistan Development Review*, Summer 1969, pp. 111-144; Roger Lawrence: *Some economic aspects of mechanization in Pakistan* (Islamabad, AID, 1970), mimeographed; International Agricultural Consultants Associated: *Program for the development of irrigation and agriculture in West Pakistan: comprehensive report*, Vol. 10, Annexure 14 (Watercourse Studies) (Washington, IBRD, 1966); and Leslie Nulty: *The Green Revolution in West Pakistan* (New York, Praeger Publishers, 1972).

[2] Measuring social benefits in this case would obviously require pricing of the factors released and the outputs obtained at their scarcity value.

Second, the last three items in the list are particularly sensitive to the assumptions of cross-sectional analysis. Acquiring a tractor is at least one measure of a progressive farmer and it is very likely that his yields and cropping intensity were higher than those of his non-mechanised neighbours even before the acquisition of the tractor. Attempts to avoid this problem by constructing time series, i.e. by asking the farmer about his yields before and after he acquired the tractor, encounter the well-known problems associated with obtaining answers through recall.

Really accurate answers to these questions will require detailed experimental work by agricultural scientists. However, considerable evidence does exist that the yields of a number of typical crops are significantly affected by deviations from optimal planting dates. Moreover, in the high temperatures of the Punjab, provision of adequate germination moisture means that the operations devoted to tillage, packing for seed-bed firmness, sowing and covering the seed have to be accomplished as quickly as possible. Therefore it seems highly likely that at least some nominal yield effects will accompany tractor tillage.[1]

The more important question regarding the benefits of mechanisation, however, has to do with the intensity effects and cropping pattern, i.e. an improvement in the cropped acreage/cultivated acreage ratio. The basic proposition is that in an area where the agro-environment permits multiple cropping mechanisation of the tillage operations results in a minimum of delay in getting a second crop planted after the standing crop has been harvested. It is easy to see that in terms of both output and the use of other factors such as labour, the relative benefits of increasing and/or altering the cropped acreage, as compared to improving yields, are likely to be substantial. Especially clear are the favourable employment effects. Higher yields may increase the time needed to perform non-mechanical agricultural tasks somewhat; however, the additional labour required will surely be less than proportional to the increase in output per acre. Increases in cropped acreage, on the other hand, produce a roughly proportional increase in employment and could actually result in an increase in the total labour used on the farm.

Two articles that represent opposing points of view in calculating the net social benefits of mechanisation turn for the most part on these points. Bose and Clark contend:

For West Pakistan it has been recommended that mechanization proceed at a rate of 12 per cent annually [the Giles Report]. As an illustration of the implications of

[1] Ahmed argues that one of the reasons there has been so little evidence of yield effects in Pakistan is that tractor owners are still performing tillage operations with a simple cultivator. What they have in effect done is to mechanise the primitive *desi* plough. Bashir Ahmed: *Field survey of large farmers in the Pakistan Punjab*, Working Paper No. 7, Project on Rural Development in Pakistan (Cambridge (Massachusetts), Harvard University, 1972), mimeographed.

TABLE IV. ASSUMPTIONS ON YIELDS AND CROPPING INTENSITY OF THE BOSE-CLARK AND LAWRENCE ANALYSES

Mechanisation effect	Bose and Clark	Lawrence
Yield effects of seed-bed preparation, deep tillage, germination, etc.	None	10-15% increase
Yield effects of optimal planting dates	None	5-10% increase
Ultimate cropping intensity	150%	200%

this recommendation, our analysis indicates that in 1975 the direct costs to society of such a programme would be about 330 million rupees, and the direct benefits would be around 200 million rupees. Thus, the net direct social cash flow in that year would be about minus 130 million rupees. Similarly for other years the direct social benefits would be considerably smaller than direct social costs. Moreover, the indirect social costs, mainly arising from throwing large numbers of farm labourers out of employment, may be considered much greater than the possible indirect benefits. Thus, our cash-flow analysis indicates that mechanization is not socially advantageous.[1]

Roger Lawrence, on the other hand, comes to a significantly different conclusion:

[The analysis] shows a consistent downward trend in both the market and opportunity costs of a unit of production as one moves from techniques involving less mechanization. The techniques of production enumerated in the exercise [bullock power with unimproved implements; bullock power with improved implements; tractor power with wheat drills, cotton planters, etc.; tractor power with threshers; etc.] thus failed to include any that were too capital-intensive for conditions existing in West Pakistan. The persistent downward trend also indicates that emphasis on so-called intermediate technologies involving improved bullock implements and stationary threshers is misplaced. Indeed, the largest single drop in unit costs occurs... when tractors are introduced. There thus appears to be a clear-cut case for mechanization up to and including the use of tractors and pull combines when a wheat-cotton sequence is being formed.[2]

Table IV shows the assumptions about yields and cropping intensity that underlie each of these analyses.

Though there are many other differences in the two studies, it is not surprising, given the assumptions that were made in each case, that Lawrence presents a rather optimistic picture of the harmony between private and social interests in the Government's mechanisation policy while Bose and Clark are extremely critical of that policy.

Both analyses, however, tend to understate the true divergence between net private and net social benefits. Bose and Clark are certainly

[1] Bose and Clark, op. cit., p. 294.

[2] Lawrence, op. cit., p. 13.

correct in maintaining that the over-all water availability in the Indus Basin (surface plus groundwater) will only permit a cropping intensity of approximately 150 per cent; hence this constitutes the appropriate *social* constraint. The IACA data on which they have based their estimates of *private* benefits, however, do not fully reflect the opportunities as seen by individual farmers.[1] So long as Pakistan's authorities do not regulate water withdrawals from the aquifer, cultivators with the resources to install tube-wells will be constrained only by their ability to manage land effectively. Informal conversations with farmers who have had several years of experience with mechanisation suggest that, unlike the IACA sample, they anticipate being able to achieve cropping intensities of between 150 and 200 per cent without great difficulty. Thus the Bose-Clark analysis appears to understate the public-private divergence by understating the potential private benefits to individuals who are able both to mechanise and to obtain access to unlimited supplies of groundwater.

The possibility that, in the presence of unlimited water supplies, mechanisation may be an important element in attaining substantially higher cropping intensities is recognised by Lawrence. He assumes an admittedly rather extreme case in which farmers may reach cropping intensities of 200 per cent, i.e. it is assumed that they can double-crop all their land. Of course, if this increase in intensity above the 130 to 140 per cent level which is demonstrably attainable with present power [2] is attributed entirely to mechanisation, this assumption is sufficient to carry the day with respect to net social benefits. However, attaching scarcity values to land, labour and capital and using world market prices for inputs and outputs do not show the effect on the social desirability of mechanisation if there is only enough water to increase the cropping intensity to 150 per cent. The Lawrence analysis leads to an underestimate of the public-private divergence of the return on investments in mechanisation because it overstates the net social benefits.

Moreover, neither analysis addresses itself to the reality of a good portion of Pakistan agriculture. For in the Punjab several million acres are underlain with saline groundwater which makes it extremely difficult to raise the traditional cropping intensity above 100 to 110 per cent. Where this is so, the social benefits of mechanisation are obviously severely constrained.

In the Province of Sind (10 million cultivated acres), the additional waters from Tarbela Dam will do little to increase the over-all power requirements since they will be mainly used to provide perennial water supplies in areas where canals are currently non-perennial, i.e. where

[1] Bose and Clark, op. cit., p. 279.

[2] For empirical evidence that such cropping intensities are possible with the present bullock/land ratio, see Ghulam Mohammad: " Private tubewell development and cropping patterns in West Pakistan ", in *Pakistan Development Review*, Spring 1965, pp. 1-53.

they contain water in the summer months only. Because the largest part of that area is underlain with saline groundwater, it is not envisaged that over-all cropping intensities will reach levels at which mechanical power becomes a necessary ingredient for increasing cropped acreage.

A second common difficulty with these analyses concerns the valuation of the increases in output attributable to tractors. As Cownie, Johnston and Duff have pointed out, significant increases in the output of particular crops cannot help but trigger off price declines. Given the well-known price inelasticity of agricultural products, the benefits of mechanisation would in turn be adversely affected.[1]

INDIRECT SOCIAL COSTS AND BENEFITS

Some work has also been done on the indirect social costs and benefits of mechanisation. For example, on the benefit side, Bose and Clark have suggested that positive values should be attributed to the fact that increased mechanisation is likely to broaden the range of mechanical skills available in the society. Also, it is argued that the investment in capital-intensive equipment will lead to greater savings in the agricultural sector. They note, however, that for this latter argument to hold, displaced workers must be employed productively elsewhere in the economy.

Set against these benefits are the indirect social costs of resettling the displaced workers. These were worked out in some detail by the above researchers on the basis of data obtained from a resettlement scheme in Karachi. As might be expected, the costs of housing and other services are so high when a large-scale displacement is assumed that they would appear to overwhelm any but the most optimistic estimates of the benefits cited above.

SUMMARY

A careful appraisal of the arguments that have been made regarding the social costs and benefits of the current pattern of mechanisation in Pakistan leads to the conclusion that the net social benefits are indeed negative. It will come as no surprise to students of political economy, however, that this analysis has by no means settled the mechanisation controversy. Indeed, many of the results were available before such documents as the Farm Mechanisation Committee's report discounting the warnings of mechanisation critics was written, and before the latest credit and barter agreements with international aid donors were signed. To understand the issue of mechanisation in Pakistan one clearly has to go beyond social accounting to its institutional and political dimensions. Therefore, in the following sections, the analysis will be both narrowed and broadened. It will be narrowed in the sense that I shall

[1] Cownie, Johnston and Duff, op. cit.. pp. 74-77.

focus only on the nature of the *private* benefits of mechanisation to different groups in the rural community. While a review of past research has established some of the appropriate preoccupations of public policy, it has provided only limited insights into precisely how and why the pressures for mechanisation have arisen.

The perspective is broader than the strictly economic framework in that it attempts to deal more directly with the source and use of economic and political power in formulating mechanisation policy from the standpoint of both rural and urban interest groups. Without this more explicitly political economy approach, little sense can be made of policies that appear to fly in the face of the interests of the society as a whole.

III. Mechanisation in an institutional context

I have argued at length elsewhere that an examination of the impact of new agricultural technology on the rural sector requires an investigation of what might be called a *rural system*.[1] That is, in addition to the conventional farm management analysis required for an understanding of the effects of technical change on individual farms, predicting its ultimate impact necessitates explicit consideration of the interaction of such variables as the absolute size and distribution of holdings, the character of the land tenure system and the nature of the organisations (public and private) that provide services to rural people. In the sections that follow, each of these variables is taken up in turn and examined in the context of the diffusion of mechanical power. The last section summarises the findings and relates the mechanisation process to the general process of growth and change that occurred in Pakistan agriculture during the 1960s.

The benefits of mechanisation to individual farmers

The effect of mechanisation on the farming systems in the Indus Basin has been investigated with the aid of a series of linear programming models, the details of which are reported elsewhere.[2] Table V shows the rates of return on investment in various types of new technology on a 75-acre farm in the Central Punjab. Three kinds of investment were considered: (1) the seed-fertiliser package, (2) a private tube-well for pumping supplementary water, and (3) a mechanisation package

[1] C. H. Gotsch: "Technical change and the distribution of income in rural areas", in *American Journal of Agricultural Economics* (Ithaca (New York)), May 1972, pp. 326-340.

[2] B. Ahmed and C. H. Gotsch: *The economics of mechanization in Pakistan*, Working Paper No. 8, Project on Rural Development in Pakistan (Cambridge (Massachusetts), Harvard University, 1972), mimeographed. Results shown in the Working Paper are based on the analysis presented in B. Ahmed: *Farm mechanization and agricultural development in the Pakistan Punjab*, unpublished PhD thesis, Michigan State University, 1972.

TABLE V. ANNUAL RATES OF RETURN ON AGRICULTURAL INNOVATIONS

Investment	Capitalist standard [1] (75-acre farm) (1)	Landlord standard [1] (75-acre farm) (2)
Improved seeds and fertiliser	200	230
Tube-well [2]	68	74
Mechanisation with tube-well (no bullocks retained) [3]	30	45
Mechanisation with tube-well (bullocks retained) [3]	40	51
Mechanisation without a tube-well	12	32

[1] See text. [2] Assumes that new seeds and fertiliser were being used before the tube-well investment. [3] Assumes that the tube-well was installed prior to the investment in a tractor and equipment.

that makes it technically feasible to do away with part or all of the traditional bullock power.

Some of the results shown are already well known. For example, investments in the highly divisible seed-fertiliser technology are extremely profitable. This is partly due to the increases in yields and partly due to the extremely short time period (3 to 4 months) during which investment funds are tied up.

The calculation of tube-well profitability produces internal rates of return that are somewhat higher than those reported by earlier researchers. This is explained by the assumption that the new seeds and fertiliser are already being used and that the tube-well is an incremental investment. Its rate of return is therefore not only due to increases in cropped acreage but also to shifts in the cropping pattern in which relatively larger amounts of the available acreage are under higher-valued crops.

MECHANISATION—THE CAPITALIST FARMER STANDARD

Column 1 of table V presents the internal rate of return on mechanisation, when the base (" before ") unit is assumed to be a capitalist farmer who cultivates his own land and uses traditional sources of power and wage labour to carry out his tillage, sowing and harvesting operations.[1] No increases in yields due to mechanisation have been

[1] The rate of return has been computed from the optimal solution under the traditional technology, i.e. a bullock pair/acres of land ratio of approximately 1 : 15. Analysis of the model results shows that *under the assumption that there is no qualitative difference between tractor and bullock power*, adding further bullocks as a source of power under tube-well conditions yields a higher rate of return than purchasing a tractor up to a holding size of 50 acres. At that point, at current prices, the optimal solution is to replace all bullocks by a tractor. At 75 acres, 3 of the original complement of 6 pairs of bullocks should be retained and at 100 acres 5 of the original 8 pairs should be retained in addition to the tractor.

In the situation without a tube-well, only in the 100-acre case does the optimal solution yield a positive shadow price for retained bullocks. See table VIII for rates of return on tractors by farm size.

assumed, and to the extent that these are present the estimates understate private returns.

As might be expected, the returns on the tractor and its related equipment are significantly higher when the model incorporates a tubewell (40 per cent) than when it does not (12 per cent). This result stems from the assumption that, if supplementary water is available, a combination of sufficient power (bullock or tractor), the new varieties and some appropriate changes in cultural practices will make it possible to keep the land occupied for most of the year. For example, in the optimal solution for a 75-acre farm, the tractor farmer, aided by several pairs of retained bullocks, reaches an over-all cropping intensity of 190 per cent. In the non-tube-well case, however, the cropping intensity remains at approximately 100 per cent, almost identical to the intensity under the traditional complement of power.

Indeed, given the rates of return on investments elsewhere, especially in the non-farm sector, one may legitimately ask why areas underlain with saline groundwater [1] are mechanising at all. As the following paragraphs indicate, investigating this anomaly leads to a much broader interpretation of the mechanisation process than simply the enhancement of energy available to carry out various cultural practices.

The last three figures in column 1 of table V are computed under the assumption that the owner-operator of a 75-acre farm has supplanted all or part of his bullocks with mechanical power. Historically, however, landowners of this size have not engaged in a capitalist mode of production. Almost without fail, they have leased their land out to tenants. This suggests that further analysis of the private profitability of mechanisation should be based on a " landlord standard ", i.e. on the assumption that mechanisation involves the eviction of tenants and not merely the substitution of mechanical power for animal power.

MECHANISATION—THE LANDLORD-TENANT STANDARD

The estimates in column 2 of table V assume that the investments of the landowner are being made in a typical share-tenancy situation.[2] Though this relationship takes a number of forms in Pakistan, in the Central Punjab it has traditionally meant that (1) the variable costs of purchased inputs are shared more or less evenly, (2) the landlord pays the land taxes, (3) the tenant furnishes equipment, animals and labour (his family's and whatever hired labour is required), and (4) the gross output is shared evenly.[3]

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[1] As mentioned earlier, this situation is rather widespread in the southern Punjab, and the larger part of the Province of Sind.

[2] According to the Agricultural Census of 1960, approximately 37 per cent of the operated area was farmed under share-cropping arrangements. For Sahiwal District the figure was 35 per cent. Government of Pakistan: *Agricultural Census* (1960), Vol. II, table 9.

[3] Although there is a good deal of debate about what has actually been happening in the countryside, as far as I am aware there is no evidence that, among the landlords seeking

A comparison of the capitalist and landlord standards suggests that the rate of return on " investments " in production costs such as seed, fertiliser and pesticides under these arrangements is slightly higher to the landlord than to the capitalist farmer. This is because the tenants provide all the labour at no expense to the landlord while wages are a major expense for the large capitalist operator. The rate of return on production investments, however, does not portray the landlord's true situation in the face of changing technology. For so long as inputs and outputs are shared evenly, the Green Revolution has made both the landlord and the tenant better off. Thus, while the rate of return on short-term production capital may be virtually the same to the landlord as to the capitalist farmer, the absolute surplus or profit—the rate of return to total capital—is considerably less than it would have been had he cultivated the land himself.

In the case of a tube-well, the installation of the pump and motor is seen by both parties as an investment of the landlord and a clear departure from traditional arrangements. In such a situation, it is a standard practice to adjust output shares from 50:50 to 60:40 in recognition of the landlord's contribution.[1] As a comparison of the estimates in column 2 of table V indicates, this provides a rate of return on the investment that is slightly higher than that earned by the capitalist investor. The landlord has in effect succeeded in capturing for himself part of the returns on the increased labour expended by the tenant.

But the most interesting aspect of a comparison of the capitalist standard and the landlord-tenant standard is the evidence it offers regarding the sources of the pressures for mechanisation. In the case that raised the question of mechanisation's private profitability, i.e. the non-tube-well situation, mechanisation of a 75-acre farm yielded a marginal rate of return of 12 per cent when it was assumed that the " before " and " after " conditions involved a capitalist enterprise. This figure can now be compared with a respectable return of 32 per cent when mechanisation also involves the eviction of tenants. What has happened is that to the savings on land devoted to bullocks, the dismissal of hired labour, etc., has been added almost all the benefits of the former tenant's share of the productivity increases due to the use of high-yielding varieties and fertiliser. The combination of these two sources of returns to mechanisation, the one technical, the other insti-

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to take advantage of the new seed-fertiliser technology, the traditional arrangements have been changed. Naseem's study of small farmers in Sahiwal District indicates that in 1971 these arrangements were still the most common, even when tenants indicated that they were planting the high-yielding varieties and applying substantial amounts of fertiliser to them (Naseem, op. cit.).

[1] Other reported payments for tube-well water include a quarter share of the wheat crop and a third share of the rice crop. This would amount to a 62 : 38 ratio and a 67 : 33 ratio respectively.

tutional, provides a reasonable remuneration to investments in mechanisation in areas where they would otherwise have been questionable.

This argument—that a significant part of the pressure for mechanisation is a response to a contradiction between the introduction of the new seed-fertiliser technology and the historical crop share—resulted initially from an attempt to explain the pressures for mechanisation when its private profitability appeared marginal. The rationale of the above case involving share-tenancy, however, has been analysed rigorously by Cheung and further discussed by Johnston and Kilby.[1] The crucial points made by these writers are (1) that as a result of competition among tenants for the land, share-croppers will be driven to the next best alternative employment (wage labour), and (2) that the landlord has a number of variables that can be manipulated in concert to produce the desired result vis-à-vis the tenant. Chief among these are the rental percentage and the ratio of land to non-land inputs. As Cheung's study shows, if the former is fixed in such a way that it upsets the established equilibrium by raising the tenant's income above what he could earn as a wage labourer, the landlord retaliates by altering the land/non-land input ratio, i.e. by decreasing the size of the tenant holding.

The same general argument holds good for Pakistan. As Alavi has cogently argued, it is a mistake to assume either that peasant societies are so bound by tradition that new opportunities for profit are not seized or that all historical customs can be flouted with impunity.[2] Given the characteristics of technical change embodied in improved seeds and fertilisers, there was no precedent for radically altering the traditional rental share. Hence the evidence suggests that landlords in Pakistan found it more palatable to work on other variables, in particular on the land/non-land input ratio. In the case of the smaller landlord, this meant a complete resumption of the land for personal cultivation, a resumption easily undertaken with the help of tractor mechanisation. For the very large landowner—over 200 acres—it has usually meant only partial resumption. Some tenants have been kept, both as a hedge against the uncertainty of mechanical power and as a source of guaranteed labour for hoeing, cotton picking and the like.[3]

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[1] S. N. S. Cheung: *The theory of share tenancy* (Chicago and London, University of Chicago Press, 1969), and B. F. Johnston and P. Kilby: *Agricultural strategies, rural-urban interactions, and the expansion of income opportunities* (Paris, OECD Development Centre, forthcoming).

[2] H. Alavi: *Political structures and economic development in rural West Pakistan* (Institute of Development Studies, Sussex, n.d.), mimeographed. Sagar Ahmad has also pointed out that the behaviour vis-à-vis their tenants of *village* landlords may be quite different from that of *absentee* landlords because of the social sanctions against certain types of "anti-social" behaviour that accompany village life. Sagir Ahmad: "Economics of agricultural production", in *Alberta Anthropologist* (Edmonton), pp. 8-16.

[3] Alavi: "Elite farmer strategy . . .", op. cit., pp. 5-6. This practice was confirmed in my own informal conversations with a number of landlords in the spring of 1971.

Last but not least, eviction of the tenant also meant that the landlord-turned-capitalist farmer was much less vulnerable to land reform measures. Typically, such reforms take the form of giving land to those who till it—in other words to tenants. As a result, the privately perceived " cost " of having tenants may rise drastically in periods of major social and political change.[1]

EMPLOYMENT EFFECTS

Thus far the analysis of the impact of mechanical power on the farming system has been confined to its effects on profitability. But what are its effects on factor proportions, especially on labour use? Bose and Clark reported that " [In] interviewing farmers in the Punjab who have mechanized, we received a remarkably consistent response that the labour force per acre had been reduced about 50 per cent from the pre-mechanization period." [2] Bashir Ahmed's recent survey, however, does not bear out this contention and suggests that a more complicated process is at work.[3] Both his time series and his cross-sectional data show that while there has been a one-third reduction in the number of permanent labourers, these have been replaced almost entirely by an increase in the number of family members now working on the farm. Apparently the younger members of the family returned to the land when the prospect of farming with tractors presented itself.

The same study also suggests that the effect of mechanisation on casual labour varies significantly by region and with the availability of supplemental water. For example, in the wheat-cotton area where tube-wells have been installed, Ahmed estimates that the employment of casual workers has gone up by approximately 35 per cent. But in the wheat-cotton area underlain with saline groundwater, it has gone down 5 per cent. In the wheat-rice area, on the other hand, casual labour seems to have increased by only about 5 per cent, even where tube-wells have been installed.

The programming models also indicate that it is difficult to generalise about the employment effect of mechanisation.[4] Table VI shows, for example, the employment effects of different types of innovations with and without tube-wells.

Some of the results are as expected. The increase in total labour use due to the introduction of high-yielding varieties (HYV) only—the

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[1] Landlords who operated under this assumption would have predicted correctly the nature of the reforms being undertaken by the present Government.

[2] Bose and Clark, op. cit., p. 289.

[3] Ahmed: *Field survey . . .*, op. cit., p. 30.

[4] This point has been stressed by Ridker. See Ronald Ridker: " Employment and unemployment in Near East and South Asian countries, a review of evidence and issues ", in Ronald Ridker and Harold Lubell (eds.): *Employment and unemployment of the Near East and South Asia* (New Delhi, Vikas Publications, 1971), pp. 6-58.

TABLE VI. PROGRAMMING ESTIMATES OF THE EFFECT OF MECHANISATION ON MAN-HOURS WORKED PER YEAR ON A 75-ACRE FARM

Technology	Without tube-well				With tube-well			
	Family	Hired [1]	Total	Index	Family	Hired [1]	Total	Index
Traditional	6 801	17 201	24 002	100	6 821	24 260	31 081	100
Traditional + HYV	6 896	19 119	26 015	108	6 841	22 356	29 197	94
Mechanisation	5 479	13 081	18 560	77	6 884	29 669	36 553	118

[1] Includes day and permanent labour.

TABLE VII. SIZE DISTRIBUTION OF HOLDINGS IN SAHIWAL DISTRICT BY TYPE OF TENURE

Size of holding (acres)	Operators and area farmed																Owners and area owned			
	Owner				Owner-cum-tenant				Tenant				Total							
	No. ('000)	%	Area ('000 acres)	%	No. ('000)	%	Area ('000 acres)	%	No. ('000)	%	Area ('000 acres)	%	No. ('000)	%	Area ('000 acres)	%	No. ('000)	%	Area ('000 acres)	%
Under 25	80	95	499	67	26	90	266	68	103	93	786	74	209	93	1 551	70	107	95	993	45
25-50	3	4	102	14	3	10	88	22	7	6	214	20	13	6	404	18	5	4	397	18
Over 50	1	1	144	19	—	—	40	10	1	1	67	6	2	1	251	11	1	1	816	37
Total	84	100	745	100	29	100	394	100	111	100	1 067	100	224	100	2 206	100	113	100	2 206	100

Sources: for data on operators, *Agricultural Census*, op. cit.; for data on owners, Government of Pakistan: *Report of the Land Reform Commission for West Pakistan*, op. cit.

yield effect—is nominal. The availability of supplementary water from a tube-well under traditional technology, on the other hand, produces a 30 per cent increase in hours used—the result of increases in cropping intensity.

What is somewhat unexpected is the decline in total labour used when high-yielding varieties are combined with a tube-well. *A priori* it would appear that adding the yield and intensity effects together should add still more labour hours. The explanation, however, is simple. The increased yields from the dwarf wheats, a crop requiring relatively little labour, have given it a comparative advantage over cotton, which requires a great deal of labour, and have ousted it from the cropping pattern. Although no one would argue that farm management solutions of the linear programming type are perfect mirrors of reality, this finding points to an important principle; namely that the employment impact of technical change must take into account cropping pattern changes as well as yield and intensity effects. Even more generally, it is a further warning that simplistic calculations of the additional labour required to perform certain operations before and after the introduction of a specific innovation may result in a highly misleading estimate unless its effect on the farming system as a whole is also examined.

The effects of mechanisation in the above situation are as expected. In the absence of a tube-well, the decline in hours of labour used is significant—nearly 30 per cent. Where supplementary water is available, however, labour use has increased by 25 per cent. In this case, the savings in labour due to mechanical power are outweighed by the substantial increase in cropped acreage and a shift in the cropping pattern in favour of rice, a labour-intensive crop.

How reliable these estimates are as a basis for forecasting the effects of mechanisation over the next few years is difficult to say. As indicated earlier, tractor owners themselves are quick to admit that getting rid of animal and human labour involves a good deal of learning-by-doing. Moreover, few of the tractor owners have thus far actually equipped themselves with the implements that would make it possible to carry out mechanically a number of cultural practices that have traditionally involved a good deal of hand labour. Hence the estimates shown in table VI are probably only valid in the short run and surely underestimate substantially the long-run labour-saving potential of mechanical power.

The foregoing farm management analysis has provided a good deal of insight into the sources of private pressures for the diffusion of tractors and tractor-related equipment. I have also pointed out, however, that it is important for an over-all view of the problem to focus on the institutional framework within which mechanisation is taking place. Only then can one arrive at judgements about both the potential effects of tractors on the economy and the practicability of policies designed to produce an agricultural growth process that is socially desirable.

Control of the land

The first and perhaps most important institutional question involves the *absolute size* and the *relative distribution* of land holdings (including rights to their use). Both facets of this question are important, the first because it determines the extent to which advantage can be taken of an innovation, the second because it is vital to any understanding of the social stratification of the rural community.

Precise estimates of the distribution of land ownership are unavailable. The Agricultural Census of 1960 gives size of holding by " operating unit " only, a figure that conceals the most relevant data, namely the distribution of land ownership. However, all tenants have landlords, most of whom are larger than they are. By assigning tenant groups to ownership groups, and by checking these results against the figures given in the Land Reform Commission's report of 1959 [1], it is possible to calculate, at least in a crude way, a distribution of the ownership of land.

When individual operating units are regrouped according to their owners, the unevenness of land distribution is sharply increased. As an example, table VII gives the distribution of farming units by operator size for Sahiwal District in Central Punjab. It shows that approximately 29 per cent of the land is operated in holding sizes of 25 acres and above. However, a *conservative* estimate suggests that approximately 55 per cent, or over half the land, is owned by proprietors whose total holdings are in that size category. Similarly, the 1 per cent or so of cultivators in the over-50-acres category operate 11 per cent of the land; this size category makes up at least 37 per cent of the land owned. It should not be assumed, of course, that all the land owned is in contiguous blocks and thus can be farmed in the units described; the problem of fragmentation exists in Sahiwal District as elsewhere. But table VII does indicate that much of the land is in hands that command the resources necessary to purchase " lumpy " inputs such as tube-wells and tractors. For example, when the size of farm is varied parametrically in the programming models developed in the previous section (table VIII), it suggests that all farms above 50 acres would find the rate of return on an HYV-tube-well-tractor package attractive. This is particularly true of the larger farms since they are the most likely to be farmed currently with share-croppers and thus to reflect the landlord standard. As noted earlier, it also holds good for all areas in the district, even those in which the groundwater is saline. The possibility of appropriating all the benefits of the seed-fertiliser technology turns an otherwise marginal investment into a relatively profitable one.

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[1] Government of Pakistan: *Report of the Land Reform Commission for West Pakistan* (1959).

TABLE VIII. RATES OF RETURN ON MECHANISATION BY SIZE OF HOLDING
(Percentages)

Method of production	Farm size (acres)				
	12.5	25	50	75	100
Capitalist standard:					
Mechanisation with tube-well:					
Bullocks retained	—	7	27	40	44
No bullocks	—	16	37	30	17
Mechanisation without tube-well (no bullocks)	—	—	5	12	15
Landlord standard:					
Mechanisation with tube-well:					
Bullocks retained	6	18	37	51	55
No bullocks	10	27	48	45	35
Mechanisation without tube-well (no bullocks)	—	7	21	32	37

Once the larger farms are mechanised, it could be expected that mechanisation would proceed more slowly. First, the purchase of a tractor by a smaller farmer in the 25-50 acre class, unless he shares the cost with another, would mean that the purchaser would probably need to do custom work in tillage and transportation, especially if he did not have access to supplementary water. There is obviously considerable potential for such work, but the entrepreneurial initiative needed is a good deal greater than if the tractor is purchased for the farmer's own cultivation. Secondly, since many of the farms in the 25-50 acre group are owner-cultivated, the profitability of mechanisation should be measured against the capitalist and not the landlord standard. According to the computations made, this reduces private incentives significantly; indeed, in areas where supplementary groundwater is not available, investment in machines on farms of less than 50 acres appears to be unprofitable. The owners in the 25-50 acre category are unlikely, therefore, even at current factor prices, to pursue the goal of mechanisation very vigorously.

Lastly, small[1] farmers having less than 25 acres, a group that comprises 95 per cent of the owners but controls only about 45 per cent of the land, will mechanise very slowly. Indeed, the rapidity with which mechanical technology is introduced among this group depends almost

[1] Note that they are small only when measured against the standard of a "lumpy" nvestment such as a tractor.

entirely on institutional and organisational considerations. If tractors are to become a part of their farming system, it must be through either a hire service system or the growth of a strong co-operative movement.

Thus far, the analysis of the absolute size of holdings has shown that land is distributed, at least in Sahiwal District, in such a way that mechanisation is likely to proceed rapidly on 30-40 per cent of the area farmed, somewhat more hesitantly on another 20 per cent and may, depending on the evolution of institutional and and organisational structures, be introduced quite slowly on the remaining 40-50 per cent.

But what about the numbers of people involved? Given that the large landholdings are operated by tenants, it is obvious that rapid mechanisation will have an effect on the landless and near landless that will be proportionately much greater than the percentage of the land involved. For example, taking the tenants who are in the 7.5-25-acre categories, size groups that are the most common when a large landowner leases out his lands, it means that nearly 40 per cent of them—44,000 families—would be adversely affected. Since this represents some 20 per cent of all operator families, the potential for a significant worsening in the distribution of income is obvious.

On the other hand, based on the model results, it is my conjecture that in Sahiwal District, largely underlain with sweet groundwater, the adverse employment effects usually associated with mechanisation will, in the short run, be rather muted. As indicated earlier, thus far labour-intensive operations such as harvesting, threshing and hoeing have not been greatly affected. If cropping intensities of the order of 170-180 per cent can be attained on tractor farms, the increased labour needs on the higher cropped acreage and the switch to more labour-intensive crops will probably offset the decline in man-hours required when mechanical power is introduced.

Other regions—the drylands of the Northwest Frontier, the saline groundwater areas of the southern Punjab and the Province of Sind—will be another story. In such areas, mechanisation is likely to produce not only an adverse effect on the distribution of income but result in a significant deterioration of the employment situation as well.

The interests of agricultural organisations

An important element in an institutionally oriented approach to mechanisation is to try to understand the incentives and influences operating within the agencies that deal directly with the problem. Quite apart from the opportunities for private advantage that are bound to exist almost anywhere in this sort of situation, perhaps the major bureaucratic interest of the agricultural organisations in focusing on the larger farmers results from the internal inter-agency bargaining process that underlies the allocation of domestic and foreign resources. For an

organisation to participate aggressively in obtaining funds for its operations and in protecting its own jurisdictional interests, it has to have a constituency base, preferably one whose power also extends well into those groups in which the ultimate decisions regarding proposed programmes and policies are made. This need—and its implications for continued support of a policy of rapid mechanisation—is well captured by Burki's description of the effect of the Basic Democracies [1] in 1959.

> The elections of 1959 to the local [rural] councils created under the system of Basic Democracies brought a large number of middle land-holders into the political area. Once they were there, they exerted their influence on the civil bureaucracy; the civil bureaucracy, in turn, consolidated its position by aligning itself closely with this new social group....
>
> The new [Ayub] régime, mindful of the economic interests of the group it had helped to politically emancipate, was prepared to lend a helping hand. Public policy was geared toward providing this class of landowners with all the inputs they desired at subsidized prices.[2]

These quotations capture in succinct form the link between the support of a political constituency and the types of programme that are most likely to emerge from economic growth-minded organisations. They also explain why agencies such as the Co-operative Department, whose mission is the provision of production and medium-term credit to small farmers, are so devoid of support. For no matter how useful their work may be, they—like the mass of the cultivators they serve—simply do not possess the necessary political power to assert themselves.

Summary—the dynamics of the mechanisation process

Having focused only on the private profitability of mechanisation, the control of land and water resources and the interests of agricultural organisations as explanatory variables for the rate of mechanisation, it is important to emphasise that the forces that produced a high rate of tractor diffusion were also interwoven with the more general economic and political changes that were taking place in the rural areas in the 1960s.

First, there was what might be called the economic dimension of change. As several writers have pointed out, the origins of the so-called Green Revolution in Pakistan can actually be dated somewhere around 1960. Undoubtedly aided by several good-weather years, the early period nevertheless saw the use of discernible quantities of fertiliser and the spread of privately installed tube-wells. This initial impetus was checked by two drought years, 1965/66 and 1966/67, but was regained

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[1] The Basic Democracies consisted of representative bodies at five levels designed to reinvigorate local government.

[2] Shahid Javed Burki: *Development of West Pakistan agriculture : an interdisciplinary explanation*, paper presented to the Workshop on Rural Development in Pakistan, Michigan State University, East Lansing, July 1971, pp. 24-27.

when the full impact of the new dwarf wheats was felt in 1967/68. Good weather, a record off-take of fertiliser and water from 60,000 tube-wells boosted wheat output from an average of 3.8 million tons during the first part of the decade to 6.3 million tons, an increase of 65 per cent. In the most recent period, rice, sugar-cane and cotton have emerged as the crops on which the 5-6 per cent annual trend rate of growth is dependent.

Against this backdrop of economic growth there were also fundamental changes in the political system that produced a new power base in the rural areas. While one may disagree with Burki's contention that the development of the Basic Democracies system at the turn of the decade was actually the catalyst of the growth process witnessed during the 1960s, he is certainly correct in stating that by the time the Third Plan was being formulated in the mid-1960s the ability of the rural areas to develop a more cohesive political representation was being widely felt.

The general process of economic and political change can be related more specifically to mechanisation by the facts that (1) the increase in water availability created new demands for power, (2) the presence of a new, completely divisible technology led to a conflict between the traditional form of share tenancy and the maximisation of returns to landowners, (3) increased incomes generated by the new technology made it possible to purchase machines with cash surpluses, (4) foreign agencies attracted by the potential for increasing agricultural output were willing to finance tractor imports, (5) there were no rural organisational forces working against mechanisation and a number that were working for it, and (6) the new political structure that developed in the rural areas of Pakistan during the 1960s provided a broad-based constituency for the organisations that had mechanisation as part of their development programmes.

The second-round effects of this process are now under way. Unfortunately, little empirical information regarding the aggregate effects of the tractors that are currently in operation is as yet available. While Burki has shown, for example, that there has been considerable land consolidation during the past decade, this is undoubtedly due to the seed-fertiliser-water revolution as well as to the advent of tractors.[1] Similarly, it is difficult to assess the full extent of tenant eviction. However, the subject was referred to frequently in the election campaign of 1970, which suggests that it has been more than an isolated phenomenon.

The dynamics of this development process are characterised in part by technology that is capital-intensive and relatively indivisible. Accumulation among the larger farmers is fairly rapid and their surpluses are used to establish operations of a size commensurate with the " lum-

[1] Burki, op. cit., pp. 27-28.

piness " of the equipment. At the same time, organisations that provide information and other services to farmers, that do research on agricultural technology and that represent the agricultural sector politically tend to come increasingly under the control of that portion of the agricultural sector that is already highly commercialised.

As a number of writers have pointed out, however, the difficulty with this model in Pakistan and elsewhere in the third world is that the presence of the general historical conditions needed for the successful structural transformation in agriculture are not in evidence. For example, there is the problem of high rates of growth in the rural labour force. Currently, best estimates place the increases in the rural areas of Pakistan at approximately 3.0 per cent per annum. This is well above the rates that existed in any advanced country at the time that its agricultural sector began to grow fairly regularly. In addition, there is the problem of creating off-farm employment for those displaced by the rapid introduction of exogenous technology. Few developing countries—and Pakistan is no exception—have attained growth rates in the industrial sector that would permit the current additions to the labour force to be absorbed without significant increases in the man/land ratios of the rural areas.

If my description of the social stratification in the rural areas is correct, however, there is little reason to expect that the policies needed to ameliorate the dynamics described above will be forthcoming as a result of pressures within the rural areas. The tenants and the landless who are adversely affected by the process are no match for the convergence of economic and political power that favours rapid increases in the availability of mechanical power. It follows from this that any programmes for a rationalisation of the transformation process will find their support largely in groups outside the agricultural sector. In the following section I shall try to assess briefly the nature of these urban interests and the extent to which their conflicting objectives may tend to produce a mechanisation policy that would reduce the gap between net private and net social benefits.

IV. Towards a more rational mechanisation policy

A variety of policy instruments are available to Pakistan's planners for making the agricultural transformation process more rational and humane. With respect to mechanisation, these can be divided into economic policies that directly affect the cost of tractors and related equipment, economic policies that indirectly affect the profitability of mechanisation (e.g. supports on output prices), and institutional policies that either affect the existence and focus of a variety of rural organisations or affect the distribution of resources, particularly land and water.

Mechanisation and the urban interests

To examine in detail the question of the " realism " or " feasibility " of each of the various policy options would require a rather extensive discussion of the governmental decision-making process. Such an analysis is clearly a major undertaking and outside the scope of this article. However, the issue must be faced, even if crudely, since my examination of the rural sector suggested that little effective support for altering public policy could be expected from that quarter. The following comments are based therefore on the notion that basic resource allocation decisions are made in some sort of bargaining process between various governmental agencies. Under Pakistan's parliamentary system this process is, of course, somewhat different from the budgetary process found in the United States, for example. But it is no less political and the role of interest groups emerges as a fundamental variable in both cases.

In order to make my main points, I shall lump together a number of rural and urban groups that could perhaps usefully be further disaggregated to reflect numbers and the extent of their political organisation. Under the rural groups I include (1) large farmers, (2) tenants, and (3) landless labourers; the urban groups are composed of (1) industrialists, (2) the military, (3) the agricultural bureaucracy, (4) the non-agricultural bureaucracy, and (5) urban consumers. The groups are in turn linked to the various policies that could be used to affect the rate of mechanisation, in order to evaluate the intensity of their feelings toward certain types of proposal. Judgements about how these interest groups will react cannot, of course, reflect fully the complexity of the actual political (human) process in which decisions about mechanisation will be made. Nevertheless, it is important that the assumptions about the political and economic goals of various contending groups be made as explicit as possible when addressing the over-all question of the extent to which the behaviour of the rural system is likely to be modified.

In relating the likely actions of the various interest groups to the indicated policies, there is little reason to delve at length into their long-run objectives. Despite some efforts at perspective planning, in socio-economic systems like that of Pakistan a substantial lag inevitably exists between the actual introduction of a technology by private individuals and the identification of its side-effects by the political process. Thus if one had to rely heavily on the creation of an awareness among town dwellers of the ultimately detrimental effects of rural-urban migration on their own lives, it would be hard to be at all optimistic about a more rational policy towards tractors. Consequently, in assessing the strengths and weaknesses of various policy proposals, the perspective will be reasonably short-run: at the very outside, the span of a single Five-Year Plan.

Bearing in mind the interests of the groups listed above, it will be apparent that the various types of policies indicated at the beginning of this section are ranked roughly in order of their political feasibility. That is, the most likely first step in any programme to develop a more rational approach to mechanisation would involve the use of scarcity values to price capital. The result would be a significant increase in tractor prices. This would obviously be fought vigorously by the large farmers and the agricultural bureaucracy. However, arrayed against these groups in the struggle over the allocation of scarce foreign exchange would be the industrialists, the military and other elements of the national bureaucracy interested in preserving resources for their own projects.[1]

The notion that any rationalisation of price policies involving mechanisation will be due to conflicts between domestic groups over scarce foreign exchange illustrates again the crucial role of foreign aid donors. So long as grants and loans are earmarked for projects whose specific purpose is to finance machinery imports, it will obviously be much more difficult to correct the distortions in factor prices.

Price policies that offset the benefits of mechanisation on the output side will probably be more difficult to implement. Although there will be support for change by a large urban consumer group (everybody is against high food prices), support for maintaining output subsidies will be forthcoming from the entire agricultural sector. Typically, the large farmers will speak for the industry, claiming that removal of supports (subsidies) will do irreparable damage to the small cultivators. Because of the unity of the rural areas on this issue, support prices are likely to be harder to alter than those price policies that affect mechanisation directly.

Attempts to dampen the impact of mechanisation through organisational activity are unlikely to be effective. The problem is not one of securing the benefits of mechanisation for small farmers and tenants through commercial rental establishments or even through co-operative ownership. Indeed, if the net social benefits of tractors are negative, their joint use by small farmers is undesirable also.[2] The appropriate organisational activity in this case would be something analogous to the bargaining over job security between trade unions and managements.

[1] This is not to deny that in Pakistan as in other countries individuals may very well belong to more than one camp, which can make the outcome of policy struggles between various groups extremely difficult to predict. Indeed, it would be interesting to study the social and political implications of the classical " two-sector landlord " who creates a surplus in the agricultural sector and invests it in the industrial sector. For a discussion of this " straddle " phenomenon in Latin America, see A. Eugene Havens and William L. Flinn: " Introduction: internal colonialism, structural change, and national development ", in Havens and Flinn (eds.): *Internal colonialism and structural change in Colombia* (New York, Praeger Publishers, 1970), pp. 3-18.

[2] Even medium-sized farmers with 15-20 acres hire a good deal of labour under traditional methods of cultivation.

Of course, there is no need to insist on the difficulty of creating effective unions among the landless adversely affected by mechanical technology.

If there is little hope of rationalising the mechanisation process by organising those it hits, are there not organisational responses possible by way of developing intermediate technology that would provide an alternative to mechanisation? This is an activity in which research stations, universities and government agencies could engage, an activity that would have the support of a large segment of the rural sector. As Johnston and Kilby have pointed out, there is considerable evidence that better harnessing of bullocks and more sophisticated animal-drawn ploughs and drills could cut into the profitability of mechanisation appreciably.[1] Moreover, the implements required by intermediate technology have the virtue of being simple to manufacture locally, thus creating important new areas of growth for small-scale industry.

Unfortunately, the problems associated with orienting the production of technology are the same as those associated with controlling its diffusion. As Hayami and Ruttan have pointed out, one of the chief mechanisms by which a new technology is generated in the agricultural sector is the exchange of ideas between farmers and agricultural researchers.[2] In their model, this is a highly desirable phenomenon since the demands of farmers on institutions are assumed to reflect—at least approximately—real factor scarcities. However, given the distribution of power and the distortions that have been mentioned above, it seems unlikely that demands generated from *within* agriculture can be counted on to improve matters.

Lastly, except under unusual conditions, the most difficult policy to put into effect is the actual redistribution of resources. This is because the group that would be affected—the larger landowners—though to a certain extent isolated, would feel very intensely about the issue. To alter the price of tractors is something that alters the size of the income flow; to take away land is to destroy the basis of political power and social status within the community. One should not be surprised therefore that land reforms carried out under the banner of general domestic reforms have been disappointing. In some cases, as in Pakistan, certain of the most obvious feudal excesses have been eliminated.[3] However, under such conditions the result of land reform has generally been the

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[1] Johnston and Kilby, op. cit.

[2] Y. Hayami and V. Ruttan: *Agricultural development* (Baltimore, Johns Hopkins Press, 1971).

[3] At this point it is still unclear what the effects of the present Government's land reforms will be. In so far as land in excess of 150 acres is actually transferred to tenants, it will improve the distribution of income and reduce the number of potential evictions. For tenants on holdings below that size, some additional tenure security has been provided for. Whether these legal sanctions can withstand the pressures of modernisation remains to be seen. If they do, it will be an interesting case, for it will run counter to the historical experience of most countries which have sought to legislate tenancy rights.

creation of a capitalist agricultural sector rather than the creation of true equity in landholdings. Indeed, these reforms have frequently left large numbers of the landless worse off than before.

Reform and the maintenance of the social structure

The question that now arises is whether the economic reforms that have been identified as the most likely to be implemented would really work. That is, suppose the Government were to charge (1) the scarcity value of capital exchange and (2) the domestic scarcity value of rupees for interest—policy changes that would significantly increase the cost of tractors—would this alter their profitability sufficiently to have much effect on their diffusion? These reforms would obviously not produce a true social rate of return since (1) water is not treated as a scarce resource where tube-wells are available, (2) hired labour continues to be paid market wages, (3) output prices continue to be supported above world prices, (4) fuel taxes are continued, etc. However, they have the virtue of being feasible policy changes and ones that have been widely recommended for years.

Table IX shows a recalculation of the rate of return when an estimate of the scarcity value of capital to the economy is used to price tractors. This suggests that, although the profitability of mechanisation would be affected significantly, using the opportunity cost of capital alone to price tractors would not save the institution of tenancy. For despite the new equipment costs, the rate of return on tractors, when calculated on the landlord standard, is still high enough to make them an attractive investment. (This is particularly true if the perceived cost of having tenants includes possible future claims to the land.)

For government price policies to halt the transformation of the landlord-tenant relationship into one of capitalist-wage labour, a transformation that would have undesirable effects on income distribution and, frequently, employment, additional disincentives to mechanisation would be necessary. The most obvious possibility would be to tax tractors in addition to the increased sale price resulting from the opportunity cost pricing of capital. From a social point of view, such a policy—aimed at making tractor owners pay for the adverse externalities of their actions—would be entirely appropriate. From the viewpoint of political feasibility, however, the practice of levying taxes to compensate for long-run indirect social costs seems highly dubious. Again, on the basis of a generally conflict-oriented view of policy implementation, only if it were evident that the distributive effects described earlier were of a magnitude that would result in serious, immediate social tensions would arguments that in effect banned tractors have real force.

Obviously, one can only offer conjectures about these matters, but in my judgement the economic reforms suggested would go a long

TABLE IX. RATES OF RETURN ON MECHANISATION UNDER ALTERNATIVE ASSUMPTIONS OF THE COST OF CAPITAL

(Percentages)

Method of production	Farm size (acres)					
	12.5	25	50	75	100	125
Capitalist standard:						
With tube-well:						
Current cost	—	7	27	40	44	45
Market cost	—	—	10	24	27	28
Without tube-well:						
Current cost	—	—	5	12	15	16
Market cost	—	—	—	—	1	2
Landlord standard:						
With tube-well:						
Current cost	6	18	37	51	55	58
Market cost	—	—	15	31	34	36
Without tube-well:						
Current cost	—	7	21	32	37	8
Market cost	—	—	2	12	16	17

" Current cost " is the cost of the tractor and equipment when foreign exchange is sold at the official rate of approximately Rs. 4.75 = $1 and the interest charged on capital is 8 per cent plus current excise taxes and duties. " Market cost " is the cost of the tractor and equipment when foreign exchange is sold at Rs. 10 = $1 and the interest charged on capital is 15 per cent. No excise taxes or duties are included.

way towards creating a pattern of agricultural transformation that the country could live with. This is not to say, of course, that they would bring about the creation of a just or equitable rural society. But failure to apply brakes of any kind to the current mechanisation process could lead to a rate of social dislocation with which it might be extremely difficult to cope. The problem is the familiar one of the need for change by the ruling élites if they wish to preserve the existing stratification of society.

V. Summary and conclusions

The major points made in the preceding argument are the following:

(1) Tractor mechanisation in Pakistan is still in its infancy but it is following a familiar pattern. The larger farmers are doing the innovating, primarily those located in areas where additional groundwater

supplies are available and the possibilities for increasing the cropping intensity are favourable.

(2) Government policies have provided several different kinds of incentive to mechanise: *(a)* capital used in purchasing tractors has been undervalued, *(b)* the income terms of trade between agriculture and non-agriculture have been favourable to agriculture in recent years, and *(c)* the Government has supplied a good deal of " free " technical advice on the virtues of increasing mechanical power.

(3) Because there is not enough water for all farms to achieve a high cropping intensity (some saline groundwater areas have no such prospects) and because the effects of mechanisation on yields appear to be nominal in a labour-surplus economy, replacement of bullock power alone is not sufficient to produce net social benefits.

(4) The above findings give no sign of having settled the issue of mechanisation in Pakistan. Private benefits, while varying considerably between areas, continue to outweigh private costs by substantial margins. Such benefits derive in part from the effect of the incentives mentioned above. However, they are also in large measure the result of using tractors to get rid of tenants, thereby permitting landlords to capture the full benefits of the recent increases in productivity stemming from improved seeds, water supplies and fertilisers.

(5) Bearing in mind the class structure of Pakistan society, the most feasible policy change to reduce the divergence between net social and net private benefits arising from mechanisation could be to increase the direct costs of tractors and equipment by pricing capital at its opportunity cost. Institutional changes—changes in the distribution of political power and/or material assets—that would lessen the incentives to mechanise are unlikely to have the support necessary to overcome the political resistance of the larger farmers.

(6) Even if the costs of tractors and equipment reflected the scarcity of capital, the private benefits of getting rid of tenants remain such that most of the larger landlords would go ahead and introduce mechanical power. However, the increase in costs would most likely slow the rate of diffusion significantly, particularly in areas without access to supplementary groundwater. Indeed, it is probable that the rate of introduction would be reduced to the point where the resulting social dislocations would be of manageable proportions.

This does not in any way imply that the reforms proposed—or any others that may appear to be feasible, either now or in the near future—would improve the distribution of incomes or increase employment. Indeed, the presumption must be otherwise for, if anything, mechanisation will tend to further concentrate political power and capital assets.

However, under the economic reform scenario there will be continued agricultural growth and a slow rise in farm wages sufficient to give the masses at least a nominal participation in the Green Revolution.

(7) Lastly, it is imperative to consider not only the direct effects of mechanisation on social stability but the feedbacks that this kind of technology usually brings in its wake (reapers, threshers, etc.). Without a policy much more sensitive to the long-run effects of importing technology than is currently the case, Pakistan may simply be jumping out of the frying-pan into the fire.