The Pakistan Development Review
Vol. XXV, No. 4 (Winter 1986)

Mechanization and Agricultural Development in Pakistan

M. GHAFFAR CHAUDHRY*

1. INTRODUCTION

Recent experience of a number of countries has amply shown that there is a positive relationship between technology and output. A technological change refers to use of either a new input or an improvement in a traditional factor of production [22]. The changes in technology may be biological, chemical, or mechanical. The former two types of technologies, commonly known as "seed-fertilizer revolution", have been thoroughly discussed in the literature on Pakistan, with or without reference to mechanical innovations [2; 3; 5; 7; 10; 11; 13; 15; 18; 19; 20; 25]. The objective of the present paper is to highlight the effects of mechanized cultivation on agricultural development in Pakistan.

In accordance with its objectives, this paper is divided into six sections. Section 2 traces the progress of mechanical technology in Pakistan and thus provides a background to a realistic assessment of its limitations and contributions to the process of agricultural development discussed in the following sections. Attention is centred on the output effects of mechanized cultivation in Section 3. The fundamental question has been addressed in Section 4. The issue of income distribution is the subject of discussion in Section 5. The sixth and final section summarizes the major findings of this study and offers a few policy recommendations.

2. THE NATURE OF MECHANICAL TECHNOLOGY

The use of mechanical power in Pakistan's agriculture first appeared in the early Fifties in the form of private tubewells to tap underground water for irrigation purposes. The progress of tubewell installation in the Fifties, however, was slow, as, despite a full decade of development, their number did not exceed 4200 in 1959-60. After 1959-60, the pace of the development of private tubewells gained momentum and the recorded number of tubewells reached a figure of 25,000 by mid-1964 [23]. Following the advent of the seed-fertilizer revolution and the rapid increase of tubewells in subsequent years, introduction of tractors and tractor-tillage equipment became inevitable in the mid-Sixties. However, like the investment in tubewells,

*Dr Chaudhry is Chief of Research at the Pakistan Institute of Development Economics, Islamabad.

the tractor numbers increased only slowly and did not become significant until the early Seventies. It was this availability of tractor power which induced the introduction of tractor trailers, threshers and corn shellers into Pakistan's agriculture. Alongside these developments, Pakistan's agriculture also witnessed positive changes in the use of bullock-drawn improved implements like furrow-turning ploughs, seed drills, and hand-operated sprayers. It has been only in recent years that the tractor-drawn seed drills and self-operating sprayers have become popular. The progress of appropriation of various mechanical machines in Pakistan's agriculture since 1968 is summarized in Table 1.

Table 1

Number of Machines and Mechanical Equipment used for Agricultural Purposes in 1968, 1975 and 1980

Equipment	Numbers in		
	1968	1975	1980
Tubewells and Lift Pumps	83,702	155,784	205,440
Tractors	18,909	34,583	97,373
Threshers-shellers	–	5,970	35,250
Tractor-driven Blades	–	12,599	41,199
Tractor-driven Drills	–	1,617	17,316
Bullock-driven Drills	–	–	199,188
Bullock-driven Furrow-turning Ploughs	–	2,734	1,162,243
Self-operated Sprayers	–	473	7,676
Hand-operated Sprayers	–	–	36,223

Source: [26; 27].

It is clear from Table 1 that the pace of development of private tubewells far outstripped that of tractors. There were nearly 84,000 tubewells against 19,000 tractors in 1968. The number of tubewells rose to 156,000 by 1975 while, by the same year, the number of tractors had risen to 35,000 only. In 1980, the number of tubewells rose to 205,000 in contrast to the number of tractors which stood at 97,000. Although the figures for other equipment for 1968 are not available, the number of threshers and shellers increased from nearly 6,000 to 35,000 between 1975 and 1980. Over the same period, tractor-driven blades for precision land-levelling went up from 13,000 to 41,000. During the period from 1975 to 1980, the number of tractor-driven drills increased from 1,617 to 17,316. Bullock-driven drills numbered nearly 200,000 in 1980. The number of bullock-driven furrow-turning

ploughs was 3,000 in 1975 but more than one million in 1980. There were nearly 500 self-operated sprayers, but their number went up to 8,000 in 1980. By contrast, the hand-operated sprayers only numbered 36,000 in 1980.

The data in Table 1 also show that over the period under study the rate of the growth of mechanical technology was indeed high. Two questions arise in this context: "Has there been a complete shift to mechanized cultivation in Pakistan?" and "What were the factors responsible for such high growth rates?"

The high growth rate of mechanical technology manifest from Table 1, should, in part, be attributed to the very low statistics relating to that technology in the base year. The facts on the ground indicate that, by Western standards, mechanization in Pakistan has at best been partial or incomplete or in its infancy for a number of reasons. Firstly, except for the large size of tractors, mechanization in Pakistan is completely devoid of large-scale mechanical equipment, like combine harvesters, reapers and cotton pickers. Secondly, against the use of 2.0 horsepower per hectare in some of the advanced countries, the per hectare power input in Pakistan is only 0.2 horsepower [14]. Thirdly, despite the impressive growth of mechanical technology, the users of tubewell, tractor and thresher/sheller technologies are only about 34 percent, 38 percent and 17 percent, respectively, of the total farms. The access to other technologies is even lower; seed drill has ever been used only about 10.0 percent of the farms and a tractor-driven seed drill has been ever used on only 2.0 percent of them. Similarly, tractor-driven blades have been used on only 3.0 percent of the total farms [27].

This, then, implies that a large segment of the farms is still dependent on traditional means of production, like canal water and bullocks. Despite the rapid growth of tractors, only about 15 percent of the farms depend solely on tractors for cultivation. Another 22 percent of the total private farms use both tractors and bullocks. The remaining farms – a large majority of 63 percent – wholly depend on bullock and manual labour for cultivation [28].

It has been argued that low interest rates on agricultural credit, overvalued exchange rates, and the high profitability of agriculture due to higher-than-world prices of agricultural commodities and subsidized key agricultural inputs have been responsible for motivating mechanization in Pakistan [12]. Without challenging the significance of these factors, we would, however, submit that they were not the principal factors in bringing about mechanized cultivation in Pakistan. Instead, mechanization of agriculture was the direct result of farm-sector's responses to changing conditions and emerging constraints in agriculture. This follows from the sequence of events. Despite the unconditional government support for tractors during the First Five-Year Plan, tractorization made no headway simply because sufficient cheap labour and animal power were available to maintain the then existing low cropping-intensities. By contrast, tubewells got a head start as irrigation water was a

major constraint on cropping intensities, fertilizer use and agricultural output. Tractorization, after the mid-Sixties, however, proceeded smoothly because of three factors. Firstly, the combined effect of rapid tubewell development and the onset of seed-fertilizer revolution was to double the labour requirements in agriculture, leading to unprecedented labour shortages during peak seasons. Secondly, the two developments also resulted in a considerable increase in cropping intensities, unattainable with the use of bullocks for cultivation. Finally, and as a consequence of the above developments, bullock prices, wages, and the opportunity costs of feeding bullocks rose tremendously. All these factors were sufficient to induce the farmers to resort to the use of tractors and related equipment in order to alleviate power constraint and to keep costs at a low level.

Although in the Sixties ploughing with bullocks was found to be costlier than ploughing with tractors [4], things seem to have changed considerably in recent years. According to the findings of a minor survey of 21 farmers undertaken by the author in the districts of Lahore, Gujranwala, Jhang and Toba Tek Singh, ploughing with bullocks is almost three times as costly as ploughing with a (rented) tractor. According to our estimates, the daily feed cost of a bullock comes to Rs 16.83. The amortization cost per day is Rs 1.15 on the average price of Rs 3,700 per bullock with an average working life of 8.8 years. The daily interest on investment in a bullock at the prevalent bank rate of 13.0 percent per annum amounts to Rs 1.32. Thus the total daily cost of a bullock comes to Rs 19.30. A bullock, however, is made to work for only 210 days in a year. The daily maintenance cost should therefore be raised by a multiple of 1.74 for conversion to ploughing cost of Rs 33.58. Since it takes a pair of bullocks and one day of labour to plough an acre of land, the ploughing cost per acre would come to Rs 92.0 at the going daily wage rate of Rs 25.00 for the ploughman. By contrast, the rental rate of a tractor for ploughing an acre of land is only Rs 35.00, and the time a tractor takes to do so is under one hour.

With these observations on the nature of mechanical technology, we shall now proceed to make an assessment of its impact on the various components of agricultural development.

3. OUTPUT EFFECTS OF FARM MECHANIZATION

As an innovation, mechanized cultivation is expected to have a positive impact on output, in the form of either direct output increases or a saving in cultivation costs, or both. We have already established above that tractorization has been a cost-reducing innovation, it remains for us now to bring out its value as a means of increasing agricultural output.

Mechanized cultivation of land may induce changes in agricultural output in a number of ways. To begin with, mechanization of agriculture, because of

complementarity of inputs, may add to the overall efficiency of resource use in agriculture. For example, tubewell water helps to realize the full yield-potentials of HYVs and added doses of fertilizers [16]. Then, the availability of a large power-source embodied in machines is conducive to a greater precision in agricultural operations. For example, the flexibility of tubewell water could be exploited to match water supplies with crop water requirements for optimal yields. The quick ploughing with tractors allows conservation of soil moisture, and proper and timely preparation of seed-beds. Improved implements like seed drills are useful additions to mechanized equipment for ensuring timely sowing and placement of seed and fertilizer at appropriate depths for better germination. The seed drills also allow line-sowing and better spacing of plants, which promote proper aeration and access to sunlight for the growing crop. The increasing use of threshers reduces dependence on weather, ensures better-quality harvests, and helps to recover threshing-floor losses.

While the above factors enhance agricultural output through increases in crop yields, mechanization may also improve output through enhanced availability of land for cultivation. For example, the additional power obtained from tractors may be brought into use to cultivate barren land. An assured supply of irrigation water from tubewells and speedy performance of agricultural operations with tractors may make it easier to cultivate land more intensively. The lump sum investment in tubewells and tractors may promote commercialization of agriculture and encourage the farmers to grow more valuable cash crops. Then, with the use of tractors, area previously devoted to fodder for bullocks becomes available for cultivation of other crops.

While the above acreage- and yield-increasing factors are potential contributors, it is difficult to empirically estimate the contribution of each of these factors separately. This is especially true of the yield-increasing factors, as evidence is, at best, casual. It is due to this limitation that we would proceed to project total effect of mechanization on aggregate output in agriculture resulting from individual mechanical technologies.

Mechanization of agriculture seems to be positively related with farm incomes in Pakistan. In his pioneering study in the early Sixties, Ghulam Muhammad [23] observed that the return to investment in private tubewells was indeed very high. Depending on the location and size of the tubewells installed, the return varied between 30 percent and 100 percent. On the basis of the comparisons of the before and after situations, he concluded that a near doubling of farm incomes occurs after the installation of a private tubewell. His analysis of private tubewells also shows that 32 percent of the total increase is attributable to increases in cropping intensity; 20 to 30 percent to yield increases as a result of improvement in irrigation and associated inputs; and the rest to changes in the cropping pattern in favour of more valuable cash crops like cotton, rice, and fruits and vegetables. The results of a later study

[17], based on 1967 data, largely confirmed the above conclusions. These figures, however, represent an underestimation of the actual impact of tubewells on output, for in the absence of this development, waterlogging and salinity would have been widespread debarring all possibilities of cultivation of crops.

In contrast to the tubewells, tractors seem to have been less effective in raising farm incomes and their utility has been much debated. Bose and Clark held the view that the introduction of tractors would add neither to crop yields nor to intensive cultivation of land, implying a complete absence of output effects of tractors [4]. It was also argued that under Pakistani conditions, cultivation would be far cheaper with bullocks than with tractors. By contrast, Roger Lawrence believed that the introduction of tractors in Pakistan's economy had been instrumental in increasing crop yields by 25 percent and in raising the existing cropping intensities to 200 percent [21]. Nearly one-third of the total yield increase was attributed by him to optimal planting dates to be attained with tractors and the remaining to deep tillage, seed-bed preparation and proper germination of crops. In Ahmad's view, while tractorization does lead to cropping intensity increases, it fails to result in any increase in yield [1]. The study by Gotsch points to rates of return on investment in tractors, which vary between 12 percent and 51 percent, depending on how the tractors, are combined with other available technologies [12]. McInerney and Donaldson estimated the financial and economic rates of return on tractor and associated equipment at 57 percent and 24 percent, respectively [22]. Their analysis also shows that farm incomes witnessed a 200-percent increase after the introduction of a tractor. Of the total increase in farm incomes, nearly 100 percent was the result of farm-size enlargement due to (a) newly purchased land (12 percent), (b) land rented in (24 percent), (c) owner-cultivation of the land previously rented out (42 percent) and (d) cultivation of barren land (22 percent). Of the remaining increase, 14 percent was attributed to increase in productivity, 8 percent to increased cropping intensity and 73 percent to the shift from fodder and other less valuable crops to cash crops [22]. It should, however, be noted that in this study the increases in productivity and cropping intensity were, perhaps, underestimated because both productivity and cropping intensity are inversely related to farm size [8].

Although output increases may also have resulted from the steadily rising use of improved implements and tractor-related equipment, a general lack of appropriate studies and data does not permit us to estimate them quantitatively. A recent study, however, suggested that a threshing machine would recover 5 percent more grain than can be recovered in threshing done by animals and hand [6].

It follows from the above anlaysis that the output effects of mechanization have largely been positive and significant in Pakistan. However, the benefits of enlarged output can be greatly discounted on social grounds if mechanization of agriculture is accompanied by a large-scale displacement of labour, especially in an economy with few, if any, alternative employment opportunities. An attempt, therefore, is made in the following section to explore the effects of mechanization on employment in agriculture and elsewhere.

4. MECHANIZATION AND LABOUR DISPLACEMENT

It is generally assumed in Pakistan that a large-scale displacement of labour is an essential concomitant of the mechanized cultivation of agriculture and that such a displacement in a labour-surplus economy like that of Pakistan is highly undesirable from the point of view of social welfare. This section to explores the nature and extent of labour displacement in Pakistan and derives its implications for the general trends in rural employment.

It is important to note first of all that labour displacement cannot be associated with the use of each and every kind of mechanization. In agriculture, some forms of mechanization may even augment the use of labour while others may be just neutral in their effects [10]. The employment effect of mechanization is, thus, the net result of counteracting effects of various forms of mechanization.

There is universal agreement in Pakistan that the installation of tubewells has tremendously increased the demand for labour in agriculture [17; 23] and at least one study indicates that the input of labour on tubewell farms is, on the average, about 57 percent higher than that on non-tubewell farms [17]. By contrast, the contribution of tractors to employment is highly controversial. Bose and Clark suggested that labour requirements on tractorized farms may be half of those on traditional farms [4]. Mclnerney and Donaldson, estimated that labour input declined by 40 percent when a tractor was introduced in a farm [22]. By contrast, Ahmad [1], Gotsch [12] and Naseem [24], basing their analyses on appropriate combinations of various technologies, found a positive impact of tractors on labour employment. According to Ahmad [1], the use of tractors is unlikely to cause a reduction in permanent labour use; for family labour, which in pre-tractor period was averse to doing menial farm-jobs (e.g. ploughing with bullocks, land preparation, etc.) for which permanently hired labour was employed, readily accepts to do diverse jobs related to maintaining and operation of tractors, and thus easily replaces such permanently hired hands as are rendered unnecessary by the use of tractors. In addition, the casual labour requirement is increased by 5–35 percent (with an average of 20 percent) in major areas of Pakistan. Based on a linear-programming analysis of Pakistani data, Gotsch has shown an 18-percent increase in labour input following the introduction of tubewell-tractor technology [12]. Similar conclusions follow from Naseem's work [2]. His data show that selective mechanization (consisting of tractors, wheat threshers, and tractors used for off-carting of wheat), by removing peak-season power-tillage constraint, is likely to lead to a 19-percent increase in

employment compared with the traditional cultivation with bullocks [24]. We believe that these studies are both balanced and realistic. On the other hand, the studies by Bose and Clark and by Mclnerney and Donaldson seem to be unrealistic, for the 40–50 percent drop in labour requirement suggested by them is a clear impossibility in view of the fact that tractors in Pakistan are used only for preparatory tillage for which labour displacement could not have exceeded 5–10 percent [7; 16]. In addition, while the effects of tractorization on land use and cropping intensities were completely ignored by Bose and Clark, they were under-estimated by Mclnerney and Donaldson because of the tremendous increase in farm size after the purchase of a tractor.

In order to appreciate the net effect of mechanization on labour market, we, following Gotsch, would assume that a tubewell and a tractor can easily serve 100 and 200 acres respectively [12]. Assuming further that there are 205,000 tubewells and 97,000 tractors in Pakistan at present, the respective areas served by tubewells and tractors would come to 41 percent and 39 percent of the 50 million acres currently under farms. Using these percentages along with a 57-percent increase in labour requirements as a result of tubewells and a 50-percent reduction due to tractors, it is not difficult to project a 4-percent net increase in employment in agriculture induced by the tubewell-tractor technology. By contrast, if tractors are assumed, perhaps more realistically, to result in a 20-percent increase in labour requirements, the overall employment in agriculture would be increased by 33 percent. Thus it follows that the net impact of mechanical technology on employment in agriculture, irrespective of the assumptions involved, has been positive and significant. It is basically this positive impact of mechanical technology plus the heavy labour requirements of HYVs that led to a growth rate of 2.60 percent per annum, in contrast to a much lower growth rate of agricultural labour force, in Pakistan's agriculture between 1964 and 1976 [9].

The above discussion, however, is centred only on the direct employment effects of mechanical technology, ignoring its indirect effects. For example, introduction of mechanical innovations in agriculture has been associated with a rapid development of industrial establishments manufacturing tubewells, tractors, threshers, tractor and bullock drawn improved implements and related equipment. Repair shop business for tubewells and tractors has witnessed an incredible growth. Employment in the supply of spare-parts for tubewells and tractors, the layout and maintenance of electric transmission lines, distribution centres for diesel oil and transportation service has expanded considerably. More significantly, the mechanical technologies have strengthened forward and backward linkages between farm and non-farm sectors. Although the indirect employment effects of the mechanical technologies may not be quantifiable because of a lack of appropriate data, it is only reasonable to assume that these effects may have exceeded the direct employment effects of mechanization [2;30].

5. MECHANIZATION AND INCOME DISTRIBUTION

The trend of income distribution in agriculture is shaped by changes in inter-class and inter-regional disparities of income. The discussion on inter-class disparities is generally based on comparisons of incomes between small and large farmers and those between landowners and the landless agricultural workers, including tenants. The emphasis in regional distribution is on relative incomes of poorer versus the well-to-do regions, such as *barani* areas versus the irrigated areas and the saline and waterlogged areas versus the non-saline areas. Since incomes in agriculture are a function of a complex set of factors, it is difficult to attribute a given change in income to a change in a single factor like mechanization. The analysis of this section, therefore, attempts to indicate the direction of the possible effects of mechanization on the incomes of various classes and regions relative to others without an attempt to quantify the precise magnitude of the changes involved. It may be noted at the outset by way of the finding of this section that mechanization of agriculture has been at least as beneficial to low-income groups and regions as it has been to the relatively rich groups and regions.

There is no doubt that the ownership of tubewells and tractors has been concentrated in the hands of large farmers. But this concentration does not imply that the use of tubewells and tractors is restricted to large farmers alone. In spite of ownership concentration, more than 80.5 percent of the total cropped area of the small farmers, i.e. that under 12.5 acres per farm, in contrast to 72.4 percent of that of large farmers owning farms exceeding 50.0 acres each, had irrigation facilities in 1980 [28]. Similarly, nearly 36 percent of the small farmers in comparison with 46 percent of the large farmers had access to tractors. While the availability of rental services for tubewell water and tractors has been instrumental in promoting the use of mechanical technology on small farms, both tubewells and tractors affect farm incomes through their effects on land use intensity, cropping intensities, and land productivity and also through reduction of production costs. According to the 1980 Census of Agriculture, there is a clear inverse relationship between farm size on the one hand and land use and cropping intensities on the other. While 96 percent of the farm area of the small farmers was cultivated, the corresponding percentage did not exceed 80 for the large farmers. The cropping intensities of the small and large farmers amounted to 140 percent and 111 percent respectively [28]. The small farmers have continued to maintain the lead in farm productivities over the large farmers [8]. One of the implications of this discussion is that the income distribution remained in favour of the small farmers. What is more noteworthy is the fact that the shift from bullock cultivation to tractor cultivation has enabled the small farmers to get rid of the enormous costs of maintaining bullocks. It may be remarked that the smaller the size of the farm is, the greater the savings on the maintenance costs of bullocks would be, for at least two reasons Firstly, there is an

inverse relationship between farm size and the percentage of farmers abandoning bullocks in response to the availability of tractors for ploughing of land. According to the 1980 Census of Agriculture [28], nearly 33 percent of the farms in the under-one-acre category depended on tractors alone for cultivation in contrast to 20 percent of the farms in the largest-size category of 150 acres and above. Secondly, the use of bullocks and farm size are inversely related [23]. The maintenance costs of bullocks being the same on all farms, ploughing costs per acre for the small farmers may run into hundreds of rupees, depending on the extent of the underutilization of bullocks. It may be inferred from experience that the use of bullocks on farms in the under-five-acre category is unlikely to exceed 70 days a year, raising the bullock-ploughing cost from an average of Rs 90 to Rs 270 per ploughing. Farms in the under-one-acre size category, which had to maintain a pair of bullocks for ploughing in the absence of the availability of rental services of tractors would be at a further disadvantage. With a rental rate of tractors not exceeding Rs 35.0 per ploughing, the small farmers are likely to benefit most from tractorization.

Debarring the possibility of large-scale labour displacements, as shown earlier, the mechanization of agriculture would be commensurable with the rising productivity of wage labour. This is likely to exert an upward pull on the existing wage rates in proportion to the rise in labour productivity. It may be noted that there will be a tremendous increase in labour productivity and wage rates if mechanization takes place in response to the witnessed scarcities of labour. This being the case in Pakistan, wage rates in agriculture have multiplied at a rate considerably exceeding the rates of growth of per capita income in agriculture [7]. One of the consequences of this trend has been a significant improvement in the welfare of agricultural workers as well as in the pattern of income distribution.

It is sometimes argued that tractorization has been associated with a replacement of tenants by casual workers who are employed on daily wages. With the scarcity of alternative job opportunities, it should result in an enhanced impoverishment of the landless agricultural workers. While the argument has considerable merit in a labour-surplus economy, it can not be upheld for Pakistan because of a growing scarcity of labour in Pakistan's agriculture and also because work done on daily wages may be more rewarding than the work done by a tenant.

According to the 1980 Census of Agriculture, the average size of a tenant's nolding is nearly 9.5 acres. With a gross earning of Rs 2,100 per acre at the 1984-85 factor cost, the total earnings from a tenant's holding would come to Rs 20,000. Based on a 50-percent share in the total produce, the gross income accruing to a tenant would thus come to Rs 10,000 a year as a reward for the entire labour of his family and a pair of bullocks. Deducting his share of production costs, he will be left with an income of Rs 7,000-8,000 per annum. By contrast, a casual worker, working for 300 days a year at the going wage rate of Rs 25 per day, would make Rs 7,500

a year — a figure that compares favourably with a tenant's income, for it does not include the earnings of the rest of his family members, nor the income from bullocks. This, in other words, means that a tenant stands to gain financially if he works as a casual worker rather than as a tenant.

It may be inferred that there are large differences in farm incomes between waterlogged/saline and non-saline areas on the one hand and the *barani* and irrigated regions, on the other. In the waterlogged and saline areas, farm incomes are meagre because of the low productivity of the affected land. In the *barani* tracts, both low productivity and smallness of operational holdings, due largely to the existence of large tracts of barren land, are the major causes of low farm-income. The tubewell-tractor technology seems to be particularly suitable for eradicating the problem of low incomes in both water-logged and *barani* areas and for inducing desirable changes in income distribution among various regions.

In the *barani* areas, where water is a limiting factor, tubewells may be used to provide irrigation water and, thereby, to raise the productivity of the rain-fed land. Large-scale land- levelling of barren land can be undertaken with the help of tractors to enlarge the size of the existing farms. Both levelled fields and timely, quick and deeper ploughing with tractors could greatly increase the water conservation potential of the *barani* areas and thus increase crop yields. In the waterlogged and saline soils, tubewells seem to be essential for lowering the underground water-table, for leaching away the salts accumulated on the top of the soil and for ensuring better yields. How significant these effects would be is discussed below.

Like the differences in output, there are notable differences in agricultural productivity between the irrigated and non-irrigated areas. Since the productivity of agriculture in the *barani* tract is only about one-fourth of that in the irrigated region, a *barani* area farmer should be able to secure a three-fold increase in his income with the installation of a tubewell [7]. This compares favourably with a 100-percent increase in the income of a tubewell farmer in the irrigated areas. Similarly, it has been shown that a four-fold increase in wheat yields in *barani* areas, in contrast with the 10--20 percent increase in the irrigated areas, could be brought about with proper mechanization of tillage operations [29]. Although the adoption of the tubewell-tractor technology in the *barani* areas has been slow by the standards of irrigated areas, the productivity of unirrigated agriculture has risen at a faster pace than that of irrigated agriculture throughout the Sixties, Seventies and the Eighties. As a result, the income gap between the two types of areas has narrowed considerably with the passage of time.

6. CONCLUSIONS AND POLICY RECOMMENDATIONS

The objective of this paper was to study the impact of mechanization on agricultural development in Pakistan. It, first of all, discussed the nature of mechanical

technology to enable the readers to develop a relatively more realistic attitude towards the analysis that followed. One of the most fundamental conclusions of the study has been that the tubewell-tractor technology has been highly rewarding in Pakistan. This conclusion owes its origin to five basic conclusions: (i) continuing investments in the tubewell-tractor technology have added tremendously to Pakistan's productive capacity; (ii) it has basically been a response to the emerging resource constraints such as scarcity of water and labour, especially during the peak-demand periods; (iii) mechanized cultivation has been cost-reducing and output-augmenting; (iv) the technology, far from being labour-displacing, has been employment-creating as scarcities of labour continue to exist in agriculture despite considerable progress in mechanical technology; and (v) mechanical cultivation has had a favourable impact on income distribution as small farmers and landless agricultural workers, as well as *barani* and waterlogged areas, have been major beneficiaries of the technology. In the light of the conclusions of this study, the following policy recommendations may be of crucial importance.

Firstly, it should be apparent that the conclusions of this study are, at best, tentative and have been derived from available secondary data supplemented by our own experience of Pakistan's agriculture. There seems to be a need to check their accuracy by undertaking a comprehensive survey of the actual field conditions. Such a survey should be specifically designed to study the impact of varying degrees of mechanization on acreage, output, labour employment in man-hours and inter-class and inter-regional distribution of incomes. Given the significance of farm size in the determination of outcome, it is important that farm size of the adopters and non-adopters is not allowed to be vastly different.

Secondly, mechanization of agriculture seems to be laudable because of its favourable impact on Pakistan's agricultural development, especially in terms of its role in alleviating water, labour and tillage-power constraints. It would, therefore, seem wise to encourage mechanization, especially in the rain-fed and saline areas of Pakistan.

Thirdly, mechanization has gone a long way in reducing tillage costs and has relieved many a small farmer of oppressive maintainence costs of bullocks. The availability of rental services of tractors, tractor equipment and tubewell water has been instrumental in this respect. To provide greater relief to the small farmers, there is a need for expansion of custom/hire services for tractors, tubewells and threshers. This can best be done by setting up corporations, either public or private, to provide such services at pre-specified service rates [24]. One of the alternatives to the above proposal could be a development of small-sized tractors and tubewells for purchase by the small farmers [14]. Apart from being costly, the fractional technology would remain beyond the purchasing power of a large majority of small farmers.

Finally, tractors in Pakistan have thus far been used as a substitute for a *desi* (i.e. indigenous) plough, having little, if any, effect on crop yields. In order to realize the full potential of tractor power, the government should make it compulsory for farmers purchasing tractors also to purchase either a chisel plough, or a furrow-turning plough or a disc plough.

REFERENCES

1. Ahmad, Bashir. "Field Survey of Large Farmers in the Pakistan Punjab". Project on Rural Development in Pakistan. Cambridge, Mass. (USA): Harvard University. 1972. Working Paper No. 7 (Mimeographed)
2. Azam, A. K. "The Future of the Green Revolution in West Pakistan: A Choice of Strategy". *International Journal of Agrarian Affairs.* Vol. 5, No. 6. March 1973.
3. Barkley, Paul W. "Some Non-Farm Effects of Changes in Agricultural Technology". *American Journal of Agricultural Economics.* Vol. 60, No. 2. May 1978. pp. 309–315.
4. Bose, S. R., and E. H. Clark. "Some Basic Considerations on the Agricultural Mechanization in West Pakistan". *Pakistan Development Review.* Vol. IX, No. 3. Autumn 1969.
5. Brown, Lester R. *Seeds of Change: The Green Revolution and Development in the 1970s.* New York, Washington and London: Praeger Publishers. 1970.
6. Canadian International Development Agency. *Agriculture in Pakistan; A Review of Performance and Prospects.* Ottawa. 1985.
7. Chaudhry, M. Ghaffar. "Green Revolution and Redistribution of Rural Incomes; Pakistan's Experience". *Pakistan Development Review.* Vol. XXI, No. 3. Autumn 1982.
8. Chaudhry, M. Ghaffar. "Rural Employment in Pakistan: Magnitude and Some Relevant Strategies". Islamabad: Pakistan Institute of Development Economics. October 1981. (Research Reports Series, No. 131)
9. Chaudhry, M. Ghaffar, Manzoor A. Gill and Ghulam Mustafa Chaudhry. "Size-Productivity Relationship in Pakistan's Agriculture in the Seventies". *Pakistan Development Review.* Vol. XXIV, Nos. 3&4. Autumn-Winter 1985.
10. Falcon, W. P. "The Green Revolution: Second General Problems". *American Journal of Agricultural Economics.* Vol. 52. December 1970.
11. Gotsch, Carl H. "The Green Revolution and Future Developments of Pakistan's Agriculture". In Robert D. Stevens *et al.* (eds.), *Rural Development in Bangladesh and Pakistan.* Honolulu: The University Press of Hawaii. 1976.
12. Gotsch, Carl H. "Tractor Mechanization and Rural Development in Pakistan". *International Labour Review.* Vol. 107. February 1973.
13. Griffin, Keith. *The Political Economic of Agrarian Change.* Cambridge, Mass.: Harvard University Press. 1974.

14. Hamid Javed. "Agricultural Mechanization; A Case for Fractional Technology". In Tan Bock Thiam and Shao-er Ong (eds.), *Readings in Asian Farm Management.* Singapore: Singapore University Press. 1979.
15. Johnston, B. F., and John Cownie. "The Seed-Fertilizer Revolution and Labour Force Absorption". *American Economic Review.* Vol. 59. September 1969.
16. Johnston, B. F., and Peter Kilby. *Agriculture and Structural Transformation: Economic Strategies in Late-Developing Countries.* New York: Oxford University Press. 1975.
17. Kaneda, Hiromitsu. "Economic Implications of the 'Green Revolution' and the Strategy of Agricultural Development in West Pakistan". *Pakistan Development Review.* Vol. IX, No. 2. Summer 1969.
18. Kaneda, H., and M. Ghaffar. "Output Effects of Tubewells on the Agriculture of Punjab". *Pakistan Development Review.* Vol. X, No. 1. Spring 1970.
19. Khan, Dilawar Ali, and H. A. Chaudhari. "Income Impact of the Revolution". *Pakistan Economic and Social Review.* Vol. XI, No. 1. Spring 1973.
20. Khan, M. H. *The Economics of Green Revolution in Pakistan.* New York, Washington and London: Praeger Publishers. 1975.
21. Lawrence, Roger. *Some Economic Aspects of Mechanization in Pakistan.* Islamabad: USAID. 1970. (Mimeographed)
22. McInerney, John P., and Graham F. Donaldson. *The Consequences of Farm Tractors in Pakistan.* Washington, D.C.: World Bank. February 1975. (World Bank Staff Working Paper No. 210)
23. Muhammad, Ghulam. "Private Tubewell Development and Cropping Patterns in West Pakistan". *Readings in Development Economics.* Karachi: Pakistan Institute of Development Economics. February 1970. (Reading No. 3)
24. Naseem, Muhammad. "A Note on the Choice of Technology in Agriculture". *Employment Planning and Basic Needs in Pakistan: Report of a National Conference Held at Islamabad, May 18, 1978.* Islamabad: Pakistan Manpower Institute/Bangkok: Asian Regional Team for Employment Promotion. May 1978.
25. Nulty, Leslie. *The Green Revolution in West Pakistan: Implications of Technical Change.* New York, Washington and London: Praeger Publishers. 1972.
26. Pakistan. Ministry of Food, Agriculture and Cooperatives. Food and Agriculture Division. Planning Unit. *Agricultural Statistics of Pakistan 1980.* Islamabad. October 1981.
27. Pakistan. Ministry of Food, Agriculture and Cooperatives. Food and Agriculture Division. Planning Unit. *Agricultural Statistics of Pakistan 1984.* Islamabad. November 1985.

28. Pakistan. Statistics Division. Agricultural Census Organization. *Pakistan Census of Agriculture 1980; All-Pakistan Report.* Lahore: March 1983.
29. Rana Tractors and Equipment Ltd. "Dry Land Farming Project in Pakistan". Islamabad. 1974. (Mimeographed)
30. Turnham, David. *The Employment Problem in Less Developed Countries: A Review of Evidence.* Paris: OECD. 1971.

Comments on "Mechanization and Agricultural Development in Pakistan"

The avowed objective of the paper is to highlight the effects of mechanized cultivation on agricultural dvelopment in Pakistan. The author has very briefly discussed the state of the art in the introduction and presented a bird's-eye view of the nature of the mechanical technology in Pakistan. Towards this end, the author has mainly focused on the output, employment and income distribution aspects of mechanization narrowly defined as tubewell and tractor technologies.

The paper shows that tubewells outnumber the tractors; however, the tractor/tubewell ratio remained constant (0.2) from 1968 to 1975, and it improved to 0.47 in 1980. The irrigated area as a percentage of cultivated land under tubewell witnessed only a marginal (2 percent) increase in the year 1984 as compared with 1975 [11]. The author has stated that the per hectare available power in Pakistan is only 0.2 horse power (hp). But other sources estimate it at 0.34 hp per hectare [10]. Based on his extremely small sample survey, the learned author has also concluded that bullock power was 2-3 times as costly as tractor cost per acre and has strongly supported the widely held belief in the cost-effectiveness of tractor cultivation.

However, there is a need to seriously look into cost estimation of traction power and overcapitalization or underutilization of tractors on certain farms. For instance, based on the power requirement of 0.2 hp per acre [10], a village near Tandlianwala in Faisalabad district having 1400 cultivated acres requires 280 hp which can safely be met from seven tractors (40 hp) and the village in question had 28 tractors (besides 50 pairs of bullocks), generating a surplus of 1036 hp. This clearly reflects overcapitalization, concentration and/or underutilization of a valuable resource. While surplus farm power is partly diverted to custom service on other farms, it is mostly either underutilized or directed towards off-farm activities (e.g. brick haulage) in cities. This in turn defeats the very purpose of the farm-power policy of the Government.

Now I turn to the popular fallacies which the author has reiterated from the previous work on farm mechanization. The protagonists believe that farm mechanization has a positive effect on farm output through increases in yield- and cropping-intensity. The output view of tractors in its extreme forms argues that power is a primary constraint to agricultural production regardless of factor prices. Those who supported the above arguments are [12], which revealed that cropping intensity

increased by 27, 2.2, 12.9 percent on tractor farms (which were previously bullock farms), tractor-hiring farms and bullock-cum-tractor farms, respectively, [3], [4], [6], [7] and [11].

The author has acknowledged the views of antagonists while making reference to Bose and Clark (1969) only, who believed that tractorization had no effect on yield-/or cropping-intensity. Those who hold this contention were Cownie *et al.* [2], Binswanger [1], and ILO-ARTEP [5]. Both sides have based their arguments on certain questionable assumptions. What is really required is to look at the models of all these researchers, compare and contrast them and then derive meaningful policy conclusions. I would only emphasize that the views, when properly specified, may not be all that contradictory.

On the employment issue, the controversy is much deeper. The Green Revolution has certainly created excess demand for farm workers. The Middle East bonanza and migration to urban areas also created labour shortages during peak periods of crop sowing and harvesting. In the debate about labour displacement by tractors, advocates on both sides often confuse potential effects with real effects. The paper does present lively discussion for and against a tractor's labour-displacing effect. I would like to again add evidence to support both views. The PERI [12] study indicates that family labour decreased by 31, 17.8, and 32 percent on tractor farms, tractor-hiring farms and bullock-cum-tractor-hiring farms respectively, while permanent hired labour declined by 21, 31, and 4 percent on the corresponding categories of farms. However, casual labour increased by 105.5 percent on tractor farms and by 18 percent on bullock-cum-tractor-hiring farms but decreased by 16 percent on farms which hired tractors only. Kahlon [8] reported a 24.4 percent increase in labour use on the farms under study.

Krishna estimates that between 1968-69 and 1973-74 labour use in wheat alone declined to the extent of 16.5 percent. ILO-ARTEP [5] study reveals that the labour-displacement effect of a tractor has been positive and considerable. Of the total labour force in Pakistan, agriculture labour accounted for 52.33 percent in the year 1983, showing a marginal decrease of only 2 percent from that in 1968. The share of farm labour in the rural labour force was 68.59 percent, 72 percent, and 67.80 percent in 1968, 1975 and 1983 respectively [11]. This shows an increase of 3.41 percent in 1975 over that in 1968 but, later on, decreased by 4.20 percent in 1983. Based on the available evidence in Pakistan and elsewhere in Asia, if labour-displacement effects of tractorization are positive and pronounced, its yield and output effects are doubtful, and at best nominal. The employment and income opportunities that the tractor technology has generated by bringing in some of the culturable waste lands under crop production have greatly reduced the labour-displacing effect of tractor mechanization. The effect of mechanization on income distribution is hard to quantify and the available evidence is sketchy and the author has made few assertions to establish income distribution favouring small farmers.

The 'mechanical-engineering' technologies, viz. tractor and tubewell, are 'lumpy' and scale-non-neutral. As such, prima facie, it seems that only large farmers would have used this technology. However, the actual situation reveals different results. As regards tubewell technology, wherever the needed type of water base, the bigger ones have the major share in this technology. Some empirical studies [9] indicate that whereas tubewell owners applied at least 20 hours of tubewell irrigation per acre, the purchasers were only giving 10 hours per acre on an average. As regards tractor technology, this is not a constraining factor for the small farmers. In case they failed to acquire this technology, they were not put in that disadvantageous position with regard to the income-generating effect of recent farm transformation. It may, however, be pointed out that many a small and medium farmer and non-agriculturist who had the needed liquidity was in a position to acquire tractor and use it as an additional source of income by hiring it out both for farming and for transportation use. A study by PERI [12] shows that the income of rural landless workers was increased up to 25 percent. In summary, the evidene on income distribution is inconclusive and needs more empirical support to arrive at any firm conclusion. In the end, my humble submission is that the foregoing controversial issues have hotly been debated for the past two decades. Why can't we accept a three-tier pattern of draught power in our agriculture (manual, animal and mechanical), rather than shed "crocodile tears" on the lot of the small farmers. They have to be given due attention but the programme for them has to be more meaningful and the solution may not lie in technology alone. The engineering-mechanical technology is picking up to bridge power-input gap and farmers are becoming conscious of this technology. Let us not pull our strings on these; rather we should strive to address more attendant problems of farm power and technology. The problem areas are: research and development in agricultural engineering; training of operators; non-availability of appropriate raw material; and divestiture of inefficient public tubewells, etc.

Finally, I tend to agree with most of the author's policy implications and add a few to them.

– We should adopt a selective approach to mechanization. Search is needed for appropriate, viable and possibly scale-neutral technology suited to our conditions.

– Mechanical innovation must be dovetailed with better seed varieties, proper mix and dose of fertilizer, effective plant protection and ensured water supply. This entails far-sighted planning, sound programming and sagacious project identification.

– Estimation of demand functions to derive power-input elasticities.

USAID
Islamabad

Zakir Hussain

REFERENCES

1. Binswanger, Hans P. *The Economics of Tractors in South Aisa: An Analytical Review.* New York: Agricultural Development Council. 1978.
2. Cownie, J., B.F. Johnson and Bert Durff. "The Quantitative Impact of the Seed Fertilizer Revolution in West Pakistan. An Exploratory Study". *Food Research Institute Studies.* Vol. 11, No. 2. 1970.
3. Giles, G. W. "The Reorientation of Agricultural Mechanization for Developing Countries". *Agricultural Mechanization in Asia, Africa and Latin America.* Vol. VI. Autumn 1975.
4. Gotch, C. H., B. Ahmed, W. P. Falcon, M. Nasim and S. Yusuf. "Linear Programming and Agricultural Policy: Macro Studies of Pakistan Punjab". *Food Research Institute Studies.* Vol. 14, No. 1. 1975.
5. International Labour Organization – Asian Regional Team for Employment Promotion. *Employment and Structural Changes in Pakistan – Issues for the Eighties.* Bangkok. 1983.
6. Jain, B. K. S., and Associates. "Tractors in Indian Agriculture – Their Place and Problems". *Agricultural Mechanization in Asia, Africa and Latin America.* Vol. 9. Winter 1979.
7. Johl, S. S. "Mechanization, Labour Use and Productivity in Agriculture". *Agricultural Studies in India.* Vol. 28, No. 1. 1979.
8. Kahlon, A. S. "Impact of Mechanization on Punjab Agriculture with Special Reference to Tractorization. *Indian Journal of Agriculture Economics".* Vol. 31, No. 4. October-December 1976.
9. Khan, D. A., and H. A. Chaudhary. *Income Impact from New Farm Innovations – Implication for Planning.* Lyallpur: West Pakistan Agricultural University. 1972.
10. Khokhar, A. H., A Rehman and A. S. Khan. *Country Report: Pakistan.* Agricultural Machinery Division, Pakistan Agricultural Research Council. 1982.
11. Pakistan. Ministry of Food, Agriculture and Cooperatives (Planning Unit). *Agricultural Statistics of Pakistan.* Islamabad. 1985.
12. Punjab Economic Research Institute. *Socio-Economic Impact of Tractorization in Pakistan.* Lahore. May 1986.