PN-ACN-412
112000

PK
338.16
A286
DRAFT
C.2

Working Paper #7
AID/NESA 527
Preliminary Draft
Not for Quotation
July 11, 1972

THE ECONOMIC AND SOCIAL EFFECTS OF TRACTOR MECHANIZATION IN THE PAKISTAN PUNJAB: RESULTS OF A FIELD SURVEY

by

Bashir Ahmad

A.I.D.
Reference Center
Room 1656 NS

THE ECONOMIC AND SOCIAL EFFECTS OF TRACTOR MECHANIZATION IN THE PAKISTAN PUNJAB: RESULTS OF A FIELD SURVEY

INTRODUCTION

In the spring of 1972, a farm management survey was conducted among 50 of the larger farmers in the Pakistan Punjab. The purpose of the survey was (1) to add additional field evidence to the already existing data on the effects of mechanization, and (2) to provide the empirical basis for a linear programming model that could be used to explore the implications for mechanization of changes in a number of economic parameters whose values are the subject of public policy. Unfortunately, the war with India interrupted the field work and hence the number of respondents in each cell was somewhat less than desired from a purely statistical point of view. Considerable care was taken, however, to standardize as much as possible all aspects of the units sampled save those items that actually bear on the mechanization question. For example, it will be noted that the mean value of farm size is approximately the same for the various technologies investigated. When a tractor farmer was selected for interview, a corresponding traditional bullock farm was also selected to reflect conditions in the same village: the same soil, a similar position on the water course, etc. The result was a sample that was not random in its selection but one in which a good deal of effort was made to isolate tractor mechanization as the major causal difference in the observed data between tractor farms and the traditional bullock farms.

Table 4.1. Farm Management Survey of Tractor and Bullock Farmers in the Pakistan Punjab

	Lyallpur		Sahiwal			Gujranwalla	
	saline groundwater wheat - cotton		sweet groundwater wheat - cotton			sweet groundwater wheat - rice	
	Number	Mean Size	Number	Mean Size	Var	Number	Mean Size
Bullock Farms	7	39.0	7	43.5		5	47.6
Tractor Hire Farms			7	41.6		5	43.0
Tractor Farms	7		7	45.3		5	41.0

The results of the study are presented in two sections. The first analyses of the direct costs and benefits of mechanization; the second is devoted to a discussion of its social implications, i.e. the influence of tractors on farm employment and land tenure relationships.

OUTPUT EFFECTS

The output effects of mechanization can be divided into three parts: (1) its effects on cropping intensity, (2) its effects on yields, and (3) its effects on cropping patterns. Before and after comparisons are based on both a cross-sectional comparison of the mechanized and non-mechanized farms and on recall answers to questions that were addressed to tractor owners regarding their activities before they purchased a tractor.

Cropping Intensities

The most frequent argument advanced in support of tractor mechanization is that mechanical power, by speeding up farm operations, permits multiple cropping and, therefore, higher agricultural production from a given land area than would be possible with the slow moving bullocks.

Sweet and Saline Groundwater: Table 4.2 presents a picture of the cropping intensities on tractor owner, tractor custom hire and bullock farms in the "sweet" and the "saline" groundwater areas. Not surprisingly, tractor mechanization has made

little difference in the cropping intensities in the saline groundwater areas. The intensity in the mechanized farms is 109 percent against 112 percent on the bullock farms. The reason, of course, is that the saline groundwater rules out the possibility of pumping supplementary water with a tubewell. Sole dependence on canal water in a low rainfall area results in a water constrained farming system. The power and the speed provided by the tractor does not help to increase the cropping intensity since timeliness in removing one crop to plant another is of little value.

The situation is markedly different in the sweet water area. Here tubewells provide supplementary water in addition to that available from the canal. Even on the farms having only bullock power, the intensity increases to 143.6 percent. The availability of the tractor power further increases the intensity to 168 percent on the farms having their own tractors and to 161 percent on the farms hiring tractor services.

Table 4.2. Cropping Intensities on Different Types of Farms in Sweet and Saline Groundwater Areas

	Sweet-water Area (Canal plus tubewell)								
	Cotton Zone			Rice Zone			Total		
	Tractor Operated	Tractor Custom	Bullock Operated	Tractor Operated	Tractor Custom	Bullock Operated	Tractor Operated	Tractor Custom	Bullock Operated
Total Cultivated Area (Acres)	317.00	291.00	304.50	205.00	215.00	238.00	522.00	506.00	542.50
Total Cropped Acreage	514.10	418.19	393.25	362.75	396.75	386.12	876.85	814.94	779.37
Intensity[a]	162.2	143.7	129.1	176.9	184.5	162.2	168.0	161.0	143.6
Average Size (Acres)	45.3	41.6	43.5	41.0	43.0	47.6	43.5	42.2	45.2

	Saline-water Area (canal only)			
			Total	
Total Cultivated Area (Acres)	Tractor Operated	Bullock Operated	Tractor Operated	Bullock Operated
Total Cropped Acreage	264.50	273.00	786.50	815.50
Intensity[a]	287.76	307.15	1164.61	1086.52
Average Size (Acres)	108.8	112.5	148.1	133.2
	37.8	39.0	41.4	42.9

These results indicate the importance to the farming system of the water supply in determining the output effects of mechanisation through multiple cropping. With the limited canal supplies in the saline water areas, water rather than power appears to be the constraining factor. Once the water limitation is overcome, then up to a point, the cropping intensities can be increased.

As Table 4.2 indicates, increased intensities occur even with the existing bullock power. In part, the increase in intensity is due to the overall increase in water supplied. However, it is also a response to the removal of the rigidities of canal water deliveries. When water is limited to canal deliveries, temporal rigidities occur in the farm operations that produce a bunching up of activities around canal turns. The flexibility of the tubewell water removes these bottlenecks in the farm operations and produces a more evenly distributed demand for bullock power. This is particularly apparent on the bullock farms in the sweet water cotton zone where, with 29 percent less bullock power, a higher intensity is achieved than on the bullock farms in the saline water area.

The data suggest, however, that where tubewell water is supplementing canal water, power does ultimately become the limiting factor. At least tractor farmers have attained a significantly higher intensity than bullock farmers. (This question will be further explored through the programming model in Chapter VI since one wonders if the bullock/land ratio in the tubewell situation. is currently optimal.

In the sweet-water area, the farms hiring tractor services have also been able to get higher cropped acreage per unit of the cultivated area. With a cropping intensity of 161 percent they are very close the 168 percent found on tractor farms. As might be expected, a widespread tractor hiring market that has developed in the sweet-water area.

In the saline water area; on the other hand, the tractor hiring for crop cultivation purposes was found to be almost non-existant. By implication, this finding suggests that mechanization in the saline groundwater areas is proceeding from other than those involving power constraints. (This point will be investigated further in the programming models where rates of return for the two areas are presented.)

Cotton and rice zones: Within the sweet water area, the influence of mechanization on the cropping intensities differs considerably with the cropping pattern. In the first place, the absolute level of intensities on all types of farms in the cotton zone is lower than in the rice zone. An interesting aspect of this difference is that the bullock farms in the rice zone have achieved a level of cropping intensity equivalent to that of the tractor farms in the cotton zone. Secondly, the difference between the intensities on the mechanised and the non-mechanised farms is greater in the cotton zone than in the rice zone. In the cotton zone, the mechanised farms have an intensity of 162 percent as compared to 129 percent on the bullock farms. The tractor hiring farms lie in-between with an intensity level of 144 percent. In the rice zone, the tractor hiring farms achieve the

highest intensities, i.e. 184 percent, and the tractor farms have 177 percent as compared to 162 percent on the bullock farms.

Why do the intensities differ in the two zones, both before and after mechanization? Answers to this question require a more detailed investigation of the interaction between cropping patterns and intensities as found in the survey data. For example, Table 4.3 gives the cropping pattern as found on the bullock farm in the cotton and rice areas.

Table 4.3

The Percentage Share of Different Rabi (Winter Season) and Kharif (Summer Season) Crops in the Total Cropped Area on the Bullock Farms in the Cotton and the Rice Zones during 1970-71

					Cotton Zone				
Rabi 1970-1971	Crops	Wheat	Fodder	Gram	Toria	Fruits and Vegetables	Tobacco	Miscellaneous	Total Rabi
	% Share	36.58	8.33	0.46	0.46	0.52	0.52	0.26	47.13
Kharif 1970	Crops	Cotton	Fodder	Maize	Rice	Fruits and Vegetables	Sugar Cane	Miscellaneous	Total Kharif
	% Share	34.37	11.46	1.82	2.60	0.21	2.41	-	52.87
Total									100.00
					Rice Zone				
Rabi 1970-1971	Crops	Wheat	Fodder	Gram	Toria	Fruits and Vegetables	Tobacco	Miscellaneous	Total Rabi
	% Share	35.26	10.65	0.79	1.45	0.13	0.13	0.26	48.67
Karif 1970	Crops	Cotton	Fodder	Maize	Rice	Fruits and Vegetables	Sugar Cane	Miscellaneous	Total Kharif
	% Share	0.39	9.21	-	39.99	0.16	1.58		51.33
Total									100.00

The data in Table 4.3 shows that the cropping pattern in both the zones is dominated by two major crops, one each in the rabi (winter) and the kharif (summer) season. In the cotton zone, wheat and cotton are the major rabi and kharif crops, respectively. Together they contribute about 71 percent of the total cropped acreage during the year (wheat, 36.6 percent; cotton, 34.4 percent). In the rice zone, on the other hand, the major summer crop is rice which together with wheat contributes about 75 percent of the total cropped acreage. (Rice, 40 percent; wheat, 35 percent).

It is clear from these figures that without the introduction of a major new crop or a considerable increase in diversification, increases in cropping intensity depend on the possibility of wheat and cotton following each other in the cotton zone and a wheat--rice sequence in the rice zone. In the sweet-water area where water is no constraint, these possibilities will be determined to a large extent by the sowing and harvesting calender of the two crops in the two areas, their power requirements for these operations and the power that is available. Table 4.4 gives the sowing and the harvesting calendar for wheat, cotton and rice.

Table 4.4

The Sowing and Harvest Calendar for Wheat, Cotton and Rice in the Punjab

CROPS/Months	April	May	June	July	October	November	December
Cotton	Sowing					Harvesting of April Sowing	Completed of May sowing
Wheat	Field Cutting	Processing requiring bullocks or tractors or threshers			Desi Varieties	Improved Varieties	
Rice			Sowing New Variety	Desi Basmati		Harvesting New Desi	

It is clear from the crop calendar that farmers in the rice zone face a different situation with respect to multiple cropping than those located in the cotton area. In the wheat-cotton case, the harvesting of wheat and sowing of cotton overlap. Traditionally the farmers have handled this problem through late sowing of cotton. But the late sowing of cotton (late May or early June) delays the cotton harvest to December and so overlaps with wheat sowing. This clash has been the most serious and historically very little wheat has followed cotton. (However, the new late sowing varieties of wheat have lessened the extent of the overlap and are opening up new possibilities for increasing intensity.)

In the wheat and rice sequence, there is almost no overlapping of the sowing and harvest periods of the two crops. The sowing of the rice starts after the harvesting of the wheat is over. In the fall, the rice harvest time and the wheat sowing are close but the early maturing new rice varieties and the late sowing new wheat varieties have increased significantly the time between the rice harvesting and wheat sowing. Thus in the rice zone, most of the rice and the wheat follow each other. This explains the higher level of cropping intensities on all types of farms in the rice zone compared to those obtained in the cotton zone.

Because the question of overlapping crop sequence is a crucial parameter in efforts to explore the benefits of mechanization, it is instructive to examine the crop rotations prevailing in the two areas in more detail. Tables 4.5 and 4.6 give an account of the crop rotations with respect to the major rabi and kharif crops.

Table 4.5 Crop Rotations in the Rice Zone

Crops	Farm Type	Total Farm Area (Acres)	Area Sown				
			Total (Acres)	After Fallow (%)	Percentage after the preceding season crops		
					Total	After Rice	After Fodder
Wheat Rabi 1970-71	Tractor Farms	205 (200)	154.5 (150.7)	7.8	92.2	85.4	6.8
	Bullock Farms	238 (200)	134.0 (112.6)	12	88	83.5	4.5
					Total	After Wheat	After Fodder
Rice Karif 1971	Tractor Farms	205 (200)	141.5 (138)	-	100	96.5	3.5
	Bullock Farms	238 (200)	152 (127.7)	6.6	93.4	79.6	13.8

H

Table 4.6 Crop Rotations in the Cotton Zone

Crops	Farm Type	Total Farm Area (Acres)	Area Sown				
			Total (Acres)	After Fallow (%)	Percentage after the preceding season crops		
					Total	After Cotton	After Maize, Rice, Fodder, etc.
Wheat Rabi 1970-71	Tractor Farms	317.0 (300.0)	173 (163.7)	54.6	45.4	14.7	30.7
	Bullock Farms	304.5 (300.0)	140.5 (138.4)	62	38	13.5	24.5
					Total	After Wheat	After Fodder
Cotton Karif 1971	Tractor Farms	317.0 (300)	136.75 (129.4)	15	85	71.3	13.7
	Bullock Farms	304.5 (300)	132 (130)	3.8	96.2	86.4	9.8

As is evident, most of the rice and wheat in the rice zone followed each other and the previous season's fodder. The percentage of the two crops following the previous season crops was higher on the mechanized farms which had 92 percent of their wheat and 100 percent of the rice after other crops. Thus the multiple cropping possibilities have been considerably realised in the rice area by the mechanised farms with the bullock farms following closely.

The situation is, however, different in the cotton zone. On both the mechanised and the bullock farms, cotton does mainly follow wheat. But most of the wheat does not follow cotton. About 71 and 86 percent of the cotton on the mechanised and the bullock farms respectively followed wheat but only about 14 percent of the wheat followed cotton. Comparison of the cropping intensities on the mechanised and the bullock farms in the context of their respective crop rotations can be used to examine the extent to which the double cropping potential has been exploited by mechanised and bullock farms. Table 4.7 is an abstract derived from the cotton zone crop rotation data given above. The data show that on a comparable farm size, the tractor

Table 4.7 Crop Rotations on Cotton Zone Farms

	Tractor Farms	Bullock Farms
Winter wheat (1970)	163.7 acres	138.4 acres
Cotton (1971)	129.4 acres	130.0 acres
Percentage of Cotton following fallow	15 percent	3.8 percent
Percentage of Cotton after wheat and other crops	85 percent	96.2 percent

farms had a wheat acreage of about 164 acres as compared to 138 acres on the bullock farms. With this amount of wheat land and availability of tractor power, it would appear that the mechanised farms could have brought in a greater area under cotton. But this was not done. Indeed, the cotton area on two types of farms is the same. The tractor farms are having 85 percent of their cotton after wheat and other crops against 96 percent on the bullock farms. Thus in respect of the summer crop of cotton, the mechanised farms have not exploited the greater potential of double cropping available to them as compared to the bullock farms.

In the case of wheat on tractor farms, 45 percent came after the previous season's crops. This compared with only 38 percent for bullock farms. The higher wheat acreage has made an important contribution to the higher cropping intensities on the mechanised farms. The mechanised farms, however, have not yet achieved any breakthrough in exploiting the multiple cropping potentiality of bringing wheat after cotton. They have 14.7 percent of their wheat following cotton as compared to 13.5 percent in the case of the bullock farms. The higher wheat acreage on the mechanised farms have been achieved mainly through the traditional cropping sequence, i.e. wheat following maize, kharif fodder, rice, etc. rather than using tractor speed and power to bring wheat after cotton.

The realization of the latter possibility will, in most cases, require removing the cotton crop earlier and doing the last picking on the removed stalks. (Most of the tractor owners believed in giving

rest to the land and were not prepared, though capable, to adopt this "unconventional" practice.)

Yields Per Acre

Besides the cropping intensity effects, yield per acre is another variable through which mechanisation could influence agricultural production. In this section, data is presented on yields of the major crops on the mechanised versus bullock farms in the different survey areas. The discussion is again confined largely to the major crops, wheat, rice and cotton.

Table 4.8 Yields on Tractor and Bullock Farms in Various Areas

Crops	Sweet Water Area						Saline Water Area		
	Cotton Zone			Rice Zone			Cotton Zone		
	Tractor (mds.)	Bullock (mds.)	Difference[a] (%)	Tractor (mds.)	Bullock (mds.)	Difference[a] (%)	Tractor (mds.)	Bullock (mds.)	Difference[a] (%)
Wheat	29.2	33.5	12.8	22.9	17.1	33.9	30.0	30.0	-
Cotton	12.2	14.1	13.5	-	-	-	12.3	10.8	13.9
Rice	-	-	-	16.4	19.4	15.5	-	-	-
Sugarcane	40.0	40.0	-	33.6	30.8	9.0	60.7	58.6	3.6
Toria	-	-	-	-	-	-	12.3	13.3	7.5

[a]Difference measured from bullock farmer base.

Table 4.8 presents average yields per acre as reported by the survey respondents. The data show that in the cotton area, the bullock farms have substantially higher yields than tractor farms in both wheat and cotton and similar yields in sugarcane. In the rice zone, bullock farms have higher yields in rice but substantially less in wheat and sugarcane.

In the saline groundwater area, wheat yields exhibit little difference but tractor farms have higher yields in cotton and sugarcane. Bullock farms, on the other hand, have higher yields in toria (oilseeds).

The general conclusion that emerges from the above data is that while yields differ significantly between mechanized and non-mechanized farms, there is no consistency in the direction of the difference. This finding appears to run counter to arguemtns advanced by a number of researchers to the effect that mechanical tillage (1) provides a better seed bed and thus insures higher germination and more vigorous plants, and (2) permits a more optimal planting schedule. However, before declaring these arguments refuted, it should be emphasized that deserved yields per acre are a result of a number of interacting factors: the quality of the land preparation, the sowing date, the sowing method, the seed variety, the quantity of fertilizer, the extent of the hoeing and weeding, the proficiency of water management, etc. Any or all of these could very well account for the differences in observed yields indicated earlier.

The following paragraphs probe deeper into the survey results in an attempt to isolate further the sources of the yield differences noted in Table 4.8.

Tractor implements and equipment: A total of 19 tractor farms were asked about the tractor drawn implements and equipment owned by them. The information received is summarised below:

Tractors and the Equipment on 19 Mechanised Farms in the Pakistan Punjab

Tractors and Equipment	Survey	% of Owners	Agricultural Census Organization	% of Owners
Tractors	19	100	17,123	100
Cultivators	19	100	14,338	84
Disc Harrow	-		2,007	12
Mould board and Disc Plow	-		4,848	28
Row Crop planters	-		169	1
Grain drills	1	5	563	3
Fertilizer distributors	-		88	-
Trailers and Wagons	14	74	6,962	41

From the standpoint of understanding yield differences, it is important to note that none of the tractors in the survey was equipped with the mouldboard or disc plow needed for deep preparatory tillage. All of them use cultivators designed for intertillage for preparatory tillage. The cultivators normally plow 4" - 5" deep, which is also the traditional depth reached by the bullock draw plow (64, p. 82). Regarding sowing equipment, out of the 19 tractor owners, only one had a grain drill. None had row crop planters for rabi crops. Also, there were no fertilizer attachments among any of the 19 farmers. These findings are corroborated by a larger survey conducted by the Pakistan Agriculture Census organization which shows that on the whole the implements and equipment for preparatory tillage and fertilizing were very limited when compared to the number of tractors. To the extent that complementary equipment was purchased, it was purchased by large farmers. Almost none of what would ordinarily be considered necessary elements in a mechanization program are to be found on farms of less than 100 acres.

Given this kind of equipment package, there is little reason to believe that the mechanised farms had better land preparation or sowing methods than the bullock farms. Timeliness of sowing might have been improved somewhat in the areas where supplementary water made a high cropping intensity possible but there was apparently not enough difference to influence yields significantly.

Agricultural inputs and cultural practices: Further understanding regarding yield differences can be obtained studying data on inputs by major crops by area.

Wheat-Cotton Area
(sweet groundwater)

Table 4-10 Level of Inputs and Improved Practices

Inputs and improved practices	Farm Type	Wheat	Cotton
1-Average Plowings per acre	Tractor	8	5.0
	Bullock	8	5.3
2-Percent of the crop on fallow land	Tractor	55	15.0
	Bullock	62	3.8
3-Fertilizer (Nutrient pounds per acre)	Tractor	74	71
	Bullock	64	58
4-Seed Variety (Per cent under improved variety)	Tractor	93	-
	Bullock	94	-
5-Sowing method (Per cent under row sowing)	Tractor	18	12
	Bullock	66	29
6-Hoeing (Per cent of the crop covered)	Tractor	-	66
	Bullock	-	53
7-Water course cleaning (Intensity per acre)	Tractor	1.7	2.5
	Bullock	3.9	3.1
8-Thinning (Intensity per acre)	Tractor	-	1.2
	Bullock	-	1.1

Wheat: As shown earlier (Table 4.8) bullock farms show yields that are 13 per cent higher than those obtained on tractor farms. In terms of inputs they exhibit the following characteristics when compared to tractor farms (Table 4.10):

1) A higher percentage of the crop follows fallow land
2) A higher percentage use the recommended row sowing technique (66 per cent versus 18 per cent)

3) A considerably higher water-course cleaning intensity

4) A lower fertilizer use per acre (64 versus 74 nutrient pounds)

Cotton: Bullock farms with 13.5 per cent higher yield, as compared to the tractor farms, are using a different package of inputs. They had a larger percentage crop area under row sowing (29 versus 12), higher water-course cleaning intensity but less hoeing and a lower quantity of fertilizer per acre (58 versus 71 nutrient pounds).

Wheat-Rice Area
(sweet groundwater)

Table 4.11 Input Level and Improved Practices

Inputs and improved practices	Farm Type	Wheat	Rice
1-Average Plowings per acre	Tractor	6.5	8.9
	Bullock	7.4	9.3
2-Per cent of the crop on fallow land	Tractor	7.8	-
	Bullock	11.9	6.6
3-Fertilizer (Nutrient pounds per acre)	Tractor	64	10.6
	Bullock	48	12.0
4-Seed Variety (Per cent under improved variety)	Tractor	100	16
	Bullock	100	31
5-Sowing method (Per cent under row sowing/ transplant)	Tractor	-	100
	Bullock	1.5	100
6-Weeding (Per cent of the crop covered)	Tractor	-	21
	Bullock	-	23
7-Water-course cleaning (Intensity per acre)	Tractor	1.9	3.5
	Bullock	1.5	3.5

In this area, the tractor farms had 33.9 percent higher yield in wheat and bullock farms had 15.5 percent higher yield in rice. To a great extent, the special characteristics of rice and wheat cultivation explain the difference in yield. The technique of land preparation for rice crop required a number of plowings and plankings in the flooded fields. This practice hardens the soil crust and helps to hold the water and keep it standing longer in the field throughout the crop season. This in turn has a favorable effect on the yield.

The tractor farms do not possess the necessary equipment for land preparation under standing water. The bullock farms with more bullock power[1] and family labor have an advantage in land

[1]See Table 4.16.

preparation for rice. But the hard crust of the soil--which helps to increase the rice yield--becomes a problem for the bullock farmers when they have to prepare that land for wheat. [About 84 percent of the wheat on bullock farms follows rice. See Table 4.5.] Here tractor owners have an advantage and can achieve a better quality of land preparation for wheat which makes an important contribution to increasing wheat yields.[1]

Against this background on some of the special characteristics of the area which favor particular crops, the comparative position of the input use on tractor as compared to bullock farms is as follows:

Wheat: Tractor farms have higher fertilizer input per acre (64 versus 48 nutrient pounds) and somewhat better water-course cleaning. Bullock farms, on the other hand, have somewhat higher crop area on fallow land (11.9 versus 7.8 per cent) and a slightly better sowing method.

Rice: Bullock farms have a higher percentage of the crop following fallow land, have slightly higher fertilizer input per acre, and better weeding operation as compared to tractor farms. The sowing method is comparable on both--each having 100 per cent transplanted rice crop.

1/ The bullocks kept by the tractor owners are not used for wheat but are mainly used for rice cultivation (see Table 4.17).

Wheat-Cotton Area
(saline groundwater)

Table 4.12 Level of Inputs and Improved Practices

Inputs and improved practices	Farm Type	Wheat	Cotton
1-Average plowings per acre	Tractor	9.2	5.4
	Bullock	7.9	7.2
2-Percent of the crop following fallow land	Tractor	81.6	26.7
	Bullock	90.5	9.8
3-Fertilizer (Nutrient pounds per acre)	Tractor	90.0	107
	Bullock	72.5	88
4-Seed Variety (Percent under improved variety)	Tractor	100	-
	Bullock	97	-
5-Sowing method (Percent under row sowing)	Tractor	70	55
	Bullock	69	83
6-Hoeing (Percent of the crop covered)	Tractor	-	49
	Bullock	-	86
7-Water course cleaning (Intensity per acre)	Tractor	2.5	0.5
	Bullock	2.7	1.4
8-Thinning (Intensity per acre)	Tractor	-	1.3
	Bullock	-	0.8

Wheat: Tractor farms showing the same yield per acre as bullock farms have a comparable sowing method, higher fertilizer input (90 versus 73 nutrient pounds per acre) and lesser crop area on fallow land (82 versus 91 per cent) as compared to bullock farms.

Cotton: The yield per acre is about 14 per cent higher on tractor as compared to bullock farms. Regarding the use of inputs, tractor farms have a higher percentage of the summer crop following fallow land (27 versus 10 per cent), higher fertilizer input per acre (107 versus 88 nutrient pounds) and higher thinning intensity per acre as compared to bullock farms. Bullock farms, on the

other hand, have a higher percentage under row sowing (87 versus 55) and a higher hoeing intensity.

The major conclusion that emerges from the analysis in the preceding paragraphs is that on the mechanized farms, the tractor has not been accompanied by a simultaneous increase in the bundle of inputs and improved practices. Table 4.13 aggregates the previous area-wise findings and shows that the mechanized farms, on the average, use about 61 nutrient pounds of fertilizer per acre as compared to about 51 pounds used by the bullock farms. In other practices, however, the bullock farms compare favorably. They have as much or more of their wheat and rice in improved varieties, better sowing practices, more weeding and hoeing, etc. This suggests that the tractor has not served as a "catalyst" for modernization as suggested by Johl (36). Tractor farmers use slightly more of the off-farm purchased input of the chemical fertilizers but hardly enough to be significant. Moreover, bullock farmers continue to apply some manure to their lands which of course the tractor farmers no longer have. As a result, the bullock farms have not, on the whole, lagged behind in yields.

The tractor equipment and the agricultural inputs and the practices leads to the conclusion that technological change in the Punjab agriculture is not appearing in the form of a complete "package" of inputs. Farmers have picked up the most outstanding inputs and have either ignored associated inputs and practices or kept them at

Table 4.13

Table 4.13. Aggregate Input Levels and Improved Practices by Crop

Imports	Farm Type	Wheat	Cotton	Rice	All Crops
1. Fertilizer (Pounds of N per acre)	Tractor	69.5	80.5	10.6	61.3
	Bullocks	60.0	64.4	12.0	50.9
2. Seed Variety (Crop Percentage under improved variety)	Tractor	97.2	-	16.0	77.5
	Bullocks	97.1	-	31.0	78.7
3. Sowing Method (Crop percentage under row sowing/transplant	Tractor	25.4	23.7	100.0	38.7
	Bullocks	45.3	40.8	100.0	55.7
4. Weeding/Hoeing (percentage of the crop covered)	Tractor	-	61.5	21.0	44
	Bullocks	-	71.4	23.0	48.4
5. Water-course cleaning (Intensity per acre)	Tractor	2.0	2.6	3.5	2.3
	Bullocks	2.9	2.9	3.5	3.0
6. Thinning (intensity per acre)	Tractor		1.2		1.2
	Bullocks		1.0		1.0

well below recommended levels. The mechanized farms, for example, have purchased the tractor but not the necessary equipment for deep ploughing, row sowing and fertilizing, Similarly, they have adopted the high yielding varieties of wheat but not the associated cultural practices. During the 1970-71 season, the mechanized farms covered 97 per cent of their wheat land with improved varieties but used only 69.5 nutrient pounds per acre against the recommended dose of 140 pounds[1/] and covered only one-fourth with row cropping[2/] (Table 4.14). Some of the results of an earlier study (40) on tubewells lends further support to this hypothesis. It indicates that the methods of cultivation and the type of implements used did not change after the tubewell--the most outstanding input of the package.

Cropping Pattern Effects

Theoretically, in addition to increases in cropping intensity and improvement in yields, mechanization could contribute to value added in agriculture by changing the cropping patterns. First, the replacement of the bullocks by the tractor would release the fodder cropped area for the production of other crops. Second, some high value crops might be substituted for the low value crops if such a substitution was otherwise profitable but was constrained due to lack of power. Table 4.14 gives the comparative cropping patterns of the

---

1/ For an average soil the Department of Agriculture recommends 90 lbs of nitrogen and 50 lbs of phosphorous (64, p. 84). The amount of 69.5 lbs actually used by the farmers contained less than 20 per cent of phosphorous.

2/ This conclusion is corroborated by another study in the Punjab by Lowdermilk (18).

mechanized and the non-mechanized farms in different survey areas.

As would be expected the sweet and the saline groundwater areas differ in the proportion of the annual crop acreage sown in the winter and the summer seasons. The share of the rabi (winter season) crops varies from 47 to 52 percent in the former against 60 to 62 percent in the latter. Due to the water constraint in the saline ground water area, both mechanized and bullock farms grow a higher proportion of their annual crop during the winter season when the water requirements are relatively low. They also have a higher percentage of the cropped area (9-12 percent) under low value but drouth tolerant crops such as gram and toria.

Comparison of the wheat-cotton zones of the saline and the sweet water area shows that both the mechanized and the bullock farms in the latter area have a relatively higher percentage of the total crop acreage under cotton and lower percentage under wheat as compared to the saline water area. The supplementary water supply from the tubewells in the sweet water area has enabled all types of farms to substitute a relatively high value crop of cotton for a relatively low value crop of wheat.

Table 4.14A describes the differences in cropping pattern between mechanized and bullock farms in the cotton zone. In addition to less land under fodder, tractor farms show a significant increase under fruits and vegetables.

In the rice zone, fodder acreage has been reduced

Table 4.14A

Cropping Pattern on Different Types of Farms in Different Areas

A. Cotton Zone
(Sweet Groundwater)

Crops	Tractor Farms Percent of the Total Cropped Area	Bullock Farms Percent of the Total Cropped Area
Rabi (Winter Season)		
Wheat	34.44	36.58
Fodder	5.97	8.33
Gram	0.55	0.46
Toria	1.20	0.46
Fruits & Vegetables	5.08	0.52
Tobacco	1.57	0.52
Miscellaneous	3.19	0.26
Rabi Total	52.00	47.13
Kharif (Summer Season)		
Cotton	27.22	34.37
Fodder	7.81	11.46
Maize	4.18	1.82
Rice	1.14	2.60
Sugar cane	2.34	2.41
Fruits & Vegetables	5.21	0.21
Miscellaneous	0.1	-
Kharif Total	48.00	52.87
Grand Total	100.00	100.00

Table 4.14B

Cropping Pattern on Different Types of Farms in Different Areas

B. Rice Zone
(Sweet Groundwater)

Crops	Tractor Farms Percent of the Total Cropped Area	Bullock Farms Percent of the Total Cropped Area
Rabi (Winter Season)		
Wheat	42.98	35.26
Fodder	7.23	10.65
Gram	0.35	0.79
Toria	0.35	1.45
Fruits & Vegetables	0.12	0.13
Tobacco	0.29	0.13
Miscellaneous		0.26
Rabi Total	51.32	48.67
Kharif (Summer Season)		
Cotton	0.28	0.39
Fodder	7.65	9.21
Maize	-	-
Rice	39.36	39.99
Sugarcane	0.90	1.58
Fruits & Vegetables	0.35	0.16
Miscellaneous	0.14	-
Kharif Total	48.68	51.33
Grand Total	100.00	100.00

Table 4.14C

Cropping Pattern on Different Types of Farms in Different Areas

C. Lyallpur Area
(Saline Groundwater)

Crops	Tractor Farms Percent of the Total Cropped Area	Bullock Farms Percent of the Total Cropped Area
Rabi (Winter Season)		
Wheat	43.31	43.17
Fodder	6.64	5.91
Gram	2.47	3.40
Toria	6.64	8.33
Fruits & Vegetables	0.02	0.02
Tobacco	0.47	0.34
Miscellaneous	0.94	0.54
Rabi Total	60.49	61.71
Kharif (Summer Season)		
Cotton	18.24	12.81
Fodder	6.27	6.63
Maize	4.30	4.83
Rice	-	-
Sugarcane	7.67	10.03
Fruits & Vegetables	0.97	2.20
Miscellaneous	2.06	1.79
Kharif Total	39.51	38.29
Grand Total	100.00	100.00

on tractor farms. Rice acreage, however, is slightly higher on the bullock farms and wheat acreage is considerably less. These differences point towards the relative suitability of the bullock technology for rice cultivation and of the tractor technology for wheat cultivation, a point made earlier in the discussion of yield effects.

In the saline groundwater area, acreage under fodder is practically the same. The tractor farmers have reduced the number of bullocks but increased the number of milk animals. The percentage area under wheat is the same on both but the bullock farms have a relatively higher percentage under low water using crops of gram and toria as compared to the tractor farms. In the summer season crops, the tractor farms have a higher percentage under cotton but less sugarcane reflecting the labor intensity of the latter.

The extent and pattern of tractor custom work

The results of our survey indicate that the tractor services were hired for the following purposes: (1) crop cultivation, (2) wheat threshing, and (3) transportation of the farm inputs and output.

The major custom work was for crop cultivation. Table 4.15 gives the crop-wise custom work on the farms hiring tractor services in the 'cotton' and the 'rice' zone of the sweet water area.

The data in Table 4.15 indicate that most of the tractor time was hired for land preparation of the two major crops sown in the winter and the summer seasons in the two cropping pattern zones. Tractor hiring is lowest for the rice crop when compared to the other major

crops. This is due to the fact that the technique of land preparation for the rice crop in this area is such that requires a major portion of the plowings to be performed while the water is standing in the field. Tractors in the area do not have the necessary equipment to work in water and therefore the bullocks are used for that purpose. A second point of interest is that the percentage of plowings performed with tractor hiring is highest for the wheat in the rice zone. This results from the difficulty of breaking the hard soil crust of the rice fields in which the wheat follows. The plankings are mostly performed with bullocks and there is very little tractor hiring for this operation.

The number and the use pattern of the bullocks on the tractor farms

Most of the tractor farms have reduced but not eliminated the bullocks. According to the Report of the Farm Mechanization Committee, "Amongst the major problems faced by the tractor owners is the short supply of spare parts and unsatisfactory repairs and servicing facilities" (55, p. 101). Under such a situation it is quite understandable that the tractor farms would continue to keep some of their bullock power to meet any emergencies arising from the tractor breakdown. In addition, the larger farmers may find it economical to keep several pair of bullocks for additional power during the peak power periods. Bullocks on tractor farms, farms hiring tractor services and those using only the bullock power is given in Table 4.16. Tractor farms, as a whole, maintain bullocks equivalent to

a little more than one third of the bullock farms. The reduction in bullocks on the tractor farms has been greatest in the rice area. The farms hiring tractor services maintain about one quarter less bullocks as compared to the bullock farms.

The use pattern of the bullocks on the tractor farms in different areas is given in Table 4.17. It is evident that, by and large, the planking operation is performed by bullocks. Bullocks are also used for plowing operations on a variety of crops in different areas. It is interesting to note that of all the major crops in different areas, the greatest use of bullocks is made for the rice crop in the rice area.

Table 4.15

The Crop-Wise Percentage of the Plowings and the Plankings Performed With Tractor on the Tractor Custom Farms

Crops	Total Acreage	The Average Number of the Per Acre Plowings and Plankings		Percentage Performed by Tractor Hiring	
		Plowings	Plankings	Plowings	Plankings
I. Cotton Zone					
Rabi 1970-71					
Wheat	181.00	8	2.8	50	-
Fodder	24.00	3.9	1.9	-	-
Gram	1.50	4	1	50	-
Toria	5.00	4.5	0.8	13.3	-
Kharif 1971					
Cotton	106.50	4.7	2.3	41.7	-
Fodder	28.75	5	2.8	29.4	14.3
Maize	23.50	6.9	2.6	20.3	-
Rice	13.00	4.4	2.5	-	-
II. Rice Zone					
Rabi 1970-71					
Wheat	125.00	7.4	3.7	59.5	16.2
Fodder	56.00	3.9	2	48.7	-
Gram	7.50	6.4	2.3	65.6	-
Kharif 1971					
Rice	138.00	8.1	4.2	22.2	-
Fodder	54.00	9.8	4.3	44.9	-
Cotton	2.00	8	4.2	-	-
Tobacco	2.00	12.5	2	40	-

Table 4.16

Working Bullock Pairs on Different Types of Farms in Various Survey Areas

	Sweet Groundwater Area						Saline Groundwater Area		All Areas	
	Cotton Zone			Rice Zone			Lyallpur District			
	Tractor	Tractor Hire	Bullocks	Tractor	Tractor Hire	Bullocks	Tractor	Bullocks	Tractor	Bullocks
Pairs of Bullocks per 12½ acre	0.34	0.62	0.75	0.18	0.75	1.05	0.47	1.07	0.34	0.95
Index as a percentage of bullock farms	45	83	100	17	71	100	44	100	36	100

Table 4.17

The Crop-Wise Percentage of Plowings and Plankings Performed With Bullocks on the Tractor Farms in Different Areas

Crops	Total Crop Area	The Average Number of Plowings and Plankings Per Acre of Crop		The Percentage of the Per Acre Plowings and Plankings Performed with Bullocks	
		Plowings (Number)	Plankings (Number)	Plowings (Percent)	Plankings (Percent)
I. Cotton Zone					
Rabi 1970-71					
Wheat	173.00	8.1	3.3	14.8	91
Fodder	34.00	2.4	1.3	16.7	78
Gram	2.00	8	3.0	25	100
Toria	6.00	7	2.0	-	100
Vegetables	15.00	2.5	2.0	-	50
Kharif 1971					
Cotton	136.75	4.9	2.7	2.4	45
Fodder	39.25	6	2.0	21.3	95
Maize	12.00	9.4	5.0	6.4	60.8
Rice	5.75	7	3.5	35.7	71.4
Sugarcane	2.00	11.3	9.5	17.8	100.
II. Rice Zone					
Rabi 1970-71					
Wheat	154.50	6.5	4.0		-
Fodder	24.00	5	2.2		18
Toria	1.25	9.2	7.2		-
Gram	1.75	5.8	4.9		-
Kharif 1971					
Rice	141.50	8.9	6.0	33.7	45
Fodder	44.50	7.0	5.0	-	-
Cotton	1.50	5.3	5.2	-	-
Sugarcane	3.00	14.0	9.0	3.6	3
III. Lyallpur Zone					
Rabi 1970-71					
Wheat	115.75	9.2	3.3	1	79
Fodder	17.25	5.8	2.4	-	88
Toria	13.75	6.2	2.2	6.5	96
Gram	6.50	8.4	3.5	4.8	74
Kharif 1971					
Cotton	48.75	5.4	2.5	3.0	92
Fodder	16.75	5.9	1.9	13.6	95
Maize	11.50	8.2	2.2	20.7	73
Sugarcane	19.50	9.7	5.2	29	83

THE SOCIAL EFFECTS OF TRACTOR MECHANIZATION

This section considers the effect of the tractor mechanization on employment and on the tenant-landlord relationship as it emerges from the survey data. Both cross-sectional data comparing bullock and mechanized farms and time-series data from tractor farms have been utilized.

The Impact of Farm Mechanization on Farm Employment

Farm labor can be divided into family labor--including the operator and the unpaid family labor--and hired labor. The latter can be further divided into permanent and casual labor.

Mechanization clearly affects each group differently. A decrease in hours worked by the family, for example, may simply reflect an increased preference for leisure in the face of rising incomes associated with modern agriculture. Decreases in hours worked by hired labor, on the other hand, is likely to produce economic hardship.

However, even among types of hired labor, the effects are likely to be different. In Pakistan, for example, the casual worker usually has a non-farm job in the village and uses the farm job for his livelihood. The loss of the farm job would, therefore, mean a reduction in income for the former but total deprivation for the latter.

The different categories of the farm labor are also interdependent. One category may substitute for the other, changing the structure of the farm labor force ven where there is no overall change. The change in the structure will have different social implications depending on whether the family labor substitute for the hired or the other way around.

The labor group differences and the structural aspects of the farm labor force discussed above indicate the necessity of a disaggregative analysis in terms of how mechanization influences different groups in the labor force.

Family labor: While pre-testing the questionnaire, the author noticed that the female members of the farm families to be studied were almost wholly confined to the household work and any farm work done by them was insignificant. It was further noticed that the farmers were somewhat reluctant to answer questions about the female members. Under these circumstances, I decided to exclude the female labor and investigate only the male family labor.

The cross-section data show a marked difference in the composition of family labor on bullock and tractor farms. First, the number of acres per adult working male (farm plus non-farm) is lower for tractor farms, it is .092. Second, the rate of participation of the available males is higher. This is largely the result of a larger percentage of the older children on the tractor farm attending school. (The percentage working off the farm is the same in both groups.) The overall result is that the acres per family laborer actually working is ~~approximately~~ lower on the bullock farms than on the tractor farms.

Table 4.18

Total Male Family Labor on Tractor and Bullock Farms Surveyed in the Punjab, 1971

Labor Force	Tractor Farms			Bullock Farms		
	Number	Participation Rate	Total	Number	Participation Rate	Total
1. Total Adult Males'	72.5	75.6	54.8	93.5	85.5	79.9
2. Total On-Farm Adult Males			45.3			66.0
Percent			(82.6)			(82.6)
3. Total Off-Farm Adult Males			9.5			13.9
Percent			(17.4)			(17.4)
Total Acreage			786.5			815.5
Acreage/Laborer			17.4			12.4

Table 4.19 shows percentage of the labor force in both types of farm households having an educational level of high school and above. In Pakistan, attainment of a high school degree is an important achievement since it is the minimum requirement for most of the white collar jobs in the urban areas. The social status and the level of income of the farm households under study is such that their numbers normally go to the urban areas only for the white collar jobs or business.

Primary and secondary school education have differential effects with respect to the employment problem. According to Ridker ( ) the young, new labor force entrants appear to account for between 40 and 60 percent of the urban unemployed in the Near East and South Asian countries. "They are in the middle groups so far

as education is concerned...Typically the lowest unemployment rates are found among illiterates (and often among literates with less than a matriculate), the next lowest rates among those with college and graduate degrees, and the highest rates among those with matriculate but less than graduate degrees."[1] The evidence from Pakistan corroborates Ridker's general observation. According to the Pakistan Fourth Five Year Plan, "certain international comparisons indicate that Pakistan belongs to a group of countries in which second (matriculates and intermediates) and third (Degree holders) level education has developed faster than education at the first (Grades 5-9) level. This impression is also supported by actual developments in the 1960's ... . The growth of both second and third levels was well above requirements as derived from economic growth during the same period. The excess of availabilities over requirements is reflected in increasing unemployment among the educated youth." (See 11, pp. 108 and 113)

Table 4.19

The level of education of the family labor force in the mechanized and the bullock farm households surveyed in the Punjab, 1971

	Tractor Farm Households			Bullock Farm Households		
	Total Number	High School and Above		Total Number	High School and Above	
		Number	Percent of the total labor force		Number	Percent of the total labor force
On the farm	46.0	21.9 (69.4%)	47.5	61.0	8.8 (42.9%)	14.5
Off the farm	9.7	9.7 (30.6%	100	12.8	11.8 (57.3%)	92.3
Total	55.7	31.6 (100%)	56.7	73.8	20.6 (100%)	27.9

[1] Ridker (31, pp. 9-10)

The data indicate that with respect to education, the labor force in the two types of farm households differs considerably. The tractor farm households have a substantially higher level of formal education when compared to bullock households. Thus a greater proportion (as well as the absolute number) of the labor in the mechanized, as compared to the bullock, farm households is a potential entrant in the urban labor market. Interestingly enough, however, tractor farms have retained a higher portion of their educated labor on the farm. This has both improved the relative educational quality of the tractor farm labor and reduced the migration from the farm to the non-farm labor market. That is, the percentage of the family labor with high school and higher education going for non-farm jobs is considerably higher for bullock as compared to tractor farms.

Our survey also provides time-series data about the tractor farm family labor and its educational levels. The tractor farm operators were asked about the previous occupation of the present farm family labor before the purchase of the tractor. Table 4.20 presents the information based on their answers.

Table 4.20

Previous occupation of the present family labor force on the tractor farms

Previous Occupation	Total		Education level	
	Number	Per Cent	Less than Matric	Matric and Higher
Working on the farm	30	65.2		
Working off the farm	3	6.5	1	2
Students	13	28.2	4	9
Total	46	100	5	11

It will be noticed that before the purchase of the tractor, 6.5 percent of the present family labor on the farm were working on the non-farm jobs and another 28.2 per cent were students. More than two-thirds of these new entrants to the farm labor market have an education level of matric and higher.

The major conclusion that emerge from the analysis of both the cross-section and the time series data on farm family labor appears to be that the presence of the tractor on the farm has led to increased participation in the farm labor by the young educated members of the family who otherwise might have gone to the urban labor market in search of jobs. Answers to the unstructured questions in the survey corrobate this conclusion.[1] Throughout the interviews I noticed that the younger generation especially those having some level of schooling, were reluctant to accept the farm work with its traditional hardship. On the bullock farms, the older people generally complained about the younger

---

[1]The answer of Chaudhry Ali Muhmmad of Chak. No. 311/G.B. in the Lyallpur district was typical. Ali Muhammad had two years of college education and was working on his 45 acre farm with the tractor. When asked about the advantage of the tractor cultivation his answer was, "Without the tractor, you would not have found me on the farm. The tractor has made the farm work acceptable to me and made me stay here instead of going to the city for a job. Without the tractor the farm work day extended from two to three hours before dawn to two to three hours after dusk. With tractor we generally start our daily work after sunrise and are back home before the sun sets."

boys for not taking interest in the farm work.[1] This, however, was not the case on the tractor farms where the older people were mostly appreciative of the younger ones. From the experience of the survey, it appears that Abercrombie ( ) pinpoints an important complexity underlying the whole issue of mechanization and employment when he says "The lightening of agricultural toil is one of the most important effects of mechanization in the context of the employment problem. A major dilemma in determining a mechanization policy to meet employment needs is that, while tractors contribute to driving people out of agriculture, it is nevertheless difficult to see how the younger generation can be persuaded to stay in agriculture without some lightening of the work involved."

---

[1] While interviewing Ch. Mohd. Ali Sahi, a bullock farm operator of village Kotli in the Gujranmala district I noticed a young boy of about 18 in clean clothes and combed hair wandering around the farm. When asked who he was, Ch. Sahi (the boy's father) answered indignantly, "He is our 'Sahib'. He spent eight years in school and now he wants to have good food and clothing but does not like the farm work." Ch. Sahi's answer to the question why the boy does not like the farm work was, "It is not his fault. The younger generation in general does not want to work on the farms, the way we have been doing."

The three elder brothers of Ch. Ali Mohd., the tractor farm operator in the Lyallpur district, sat proudly and appreciatively around him while he answered the author's questions.

Permanent Hired Labor

The permanent farm labor in the Punjab is generally hired for a period of one year though in some areas the practice of hiring by the month also exists. Laborers are usually supposed to be present on the farm round-the-clock for twenty-four hours. Besides taking care of the draught and milk animals on the farm, their major assignment on the farm is land cultivation. Thus when tractor replaces the bullock plow for the cultivation of land, the permanently hired labor is the most likely to subject to immediate displacement.

The influence of the tractor mechanization on permanent labor on the surveyed farms has been examined both by comparing bullock and tractor farms and by asking tractor farmers about practices before they acquired the tractor. As the demand for the permanent hired labor is likely to be influenced by the supply of the family labor, the family farm labor situation is also presented to serve as a background for the discussion. Table 4.21 gives a picture of the permanent labor force (hired plus family) based on cross-sectional data.

Table 4.21

Total Family and Permanent Hired Male Labor Working on the Tractor and the Bullock Farms Surveyed in the Punjab, 1971

	Tractor Farms				Bullock Farms			
	Total Area under own cultivation 1970-71 (Acres)	Family Labor (Number)	Permanent Hired Male Labor (Number)	Total	Total Area under own cultivation 1970-71 (Acres)	Family Labor (Number)	Permanent Hired Male Labor (Number)	Total
1. Cotton Area	317	14	17	31	304.5	17.75	15	32.75
2. Rice Area	205	9	7.5	16.5	238	12.50	17	29.50
3. Lyallpur Area	266.50	22.25	14.50	36.75	273	33	10	43
4. All Areas	786.50	45.25	39	84.25	815.5	62.25	42	105.25
		17.4	20.2	9.3		13.1	19.4	7.7

The data show that there is not much difference in the number of the permanent laborers hired on the two types of farms. The tractor farms hire only 3.6 percent fewer laborers as compared to the bullock farms. But the bullock farms have considerably larger supply of the family labor which tends to depress their demand for the hired labor. Considering both the family and the hired labor, the tractor farms have a potential acres per laborer that is approximately 21 percent higher than that found on bullock farms.[1]

[1] Insofar as the preference for leisure on the part of family members shortens their working day or reduces the number of days work, the switch from permanent to family labor may produce a decline in total hours worked. The data also excludes an adjustment for participation rates by type of household. (See Table 4.18)

Table 4.22

The Number of Permanent Hired and the Family Labor Before and After the Tractor on the Mechanized Farms Surveyed in the Punjab 1971

Survey area	Permanent Hired Labor (Number)					Family Farm Labor (Number)				
	Before the tractor		After the tractor[1]		Per Cent	Before the tractor		After the tractor[1]		Per Cent
	Labor (number)	Farm area (acres	Labor (number)	Farm area (acres)	Change	Labor (number)	Farm area (acres)	Labor (number)	Farm area (acres)	Change
1. Cotton Area	20	292.5	17	317.0		15.8	292.5	22.3	317.0	
2. Rice Area	11	192.5	7.5	205.0		6.0	192.5	9.0	205.0	
3. Lyallpur Area	11	199.5	14.5	264.5		8.0	199.5	14.0	264.5	
4. All Areas	42	684.5	39.0	786.5		29.8	684.5	45.3	786.5	
Acres/Laborer		16.3		20.2	+24		23.0		17.4	-24

1 After the tractor labor force and farm area refers to the crop year 1970-71.

After the tractor, the acres per permanent hired labor increased by 24 percent. But at the same time the acres per family laborer decreased by about the same ount. In absolute numbers, the tractor appears to have displaced nine permanent hired laborers off the farm, but attracted eleven family members back from non-farm occupations to work on the land. Thus it would appear from these figures that on the mechanized farms surveyed, the introduction of the tractor has not reduced significantly the total number of permanent laborer (hired plus family) associated with the farm.

In addition to obtaining data on the hiring of permanent laborers in the with and without tractor situation, an effort was also made to elicit from tractor owners information on the use of hired labor before they purchased a tractor. Table 4.22 gives the number of permanent hired labor along with family labor on these farms before and after the tractor.

Certain results obtained from the time series questions are obviously at variance with the results of the cross-sectional analysis. In particular, there seems to be little decline in the number of permanent laborers on the farm as a result of mechanization. Although the with and without case does not suggest the drastic decline (20%) that has been found by other researchers, the difference is enough to suggest that further investigation is needed.

Casual Labor

In the Punjab, casual labor is usually associated with a series of specific operations on specific crops. Major examples include wheat harvesting, rice transplanting and cotton picking. Consequently, it is possible to obtain a relatively accurate picture of shifts in the demand for such labor by examining the changes in the yields and cropped acreage associated with the switch to tractors.

The use of casual labor on tractor and bullock farms in the different survey areas are shown in Table 4.23.[1]

---

[1]The calculations underlying these estimates are shown in Appendix 4A.

Table 4.23

Casual Labor Used Per Cultivated Acre on Tractor and Bullock Farms

	Tractor Farms	Bullock Farms	Percentage Difference between 1 and 2 (1-2)
	(Manhours of the Casual Labor Used Per Cultivated Acre)		
The Cotton Zone	167	121	+38
The Rice Zone	110	103	+ 6.8
The Lyallpur Zone	91	95	- 4.2
Total all zones	127	107	+18.7

On the whole tractor farms use 18.7 percent more casual labor per cultivated acre as compared to the bullock farms. There are however substantial zonal differences. The amount of labor used was comparatively greatest on both types of farms in the cotton zone of the sweet-water area. Moreover the difference in the labor use between the tractor and the bullock farms in this area is also greatest. The detail given in Table 4.23A shows that wheat and cotton, the two main crops, balance out in their use of the casual labor on the two types of farms. It is the relatively greater area under the minor but mostly labor intensive crops like tobacco, maize, sugarcane and vegetables on the tractor farms that accounts for the relatively higher use of casual labor.

It will be interesting to note that in the rice zone both types of farms had considerably higher cropping intensity (see Table 4.2) but lower use of the casual labor per cultivated areas compared to the cotton area

This is due to difference in the labor intensity of the crops grown

Table 4.23-A Total Use of Casual Labor on Tractor and Bullock Farms in the Punjab - 1970-1971 .

Crops	Tractor Farms	Bullock Farms	Tractor-Bullocks
		(Man Hours)	
	I. Cotton Area		
Wheat	12,456	10,116	+2,340
Toria	192	56	+136
Gram	44	28	+16
Tobacco	1,440	366	+1,074
Cotton	19,282	21,648	-2,366
Maize	1,050	364	+686
Rice	299	520	-231
Sugarcane	3,725	2,932	+793
Vegetables	14,484	778	+13,706
All Crops	52,972	36,808	+16,164
Per Cultivated Acre	167	121	+46
	II. Rice Area		
Wheat	11,124	7,906	+328
Toria	40	176	-136
Gram	20	48	-28
Cotton	138	207	-69
Rice	10,613	14,896	-4,283
Sugarcane	689	1,272	-583
All Crops	22,624	24,505	-1,881
Per Cultivated Acre	110	103	+7
	III. Lyallpur Area (Saline Water)		
Wheat	8,334	8,676	-342
Toria	568	744	-176
Gram	106	152	-46
Cotton	6,727	4,397	+2,330
Maize	575	702	-127
Sugarcane	7,113	9,716	-2,603
Vegetables	728	1,719	-991
All Crops	24,151	26,106	-1,955
Per Cultivated Acre	91	95	-4

in the two zones. Wheat is common to both areas but the second major crop of cotton is much more labor intensive than rice. Moreover, the minor but highly labor intensive crops grown in the cotton area are relatively unimportant in the rice area. The casual labor used per cultivated area on the tractor farms is only 6.8 per cent higher as compared to that of the bullock farms in the rice area. The small difference in the labor use is explained by the correspondingly small difference in the level of their cropping intensities, no significant difference in their cropping pattern in terms of the labor intensity of the crops grown and that the higher yield per acre of rice on the bulloch farms counterbalance the labor effext of higher wheat yield on the tractor farms (See table in Appendix 4). In the Lyallpur zone of the saline-water area the tractor farms use less casual labor as compared to the bullock farms. The relatively higher labor use on the bullock farms appears to be mainly due to their higher cropping intensity and relatively more area under the labor intensive crops of sugarcane and vegetables.

<u>The Influence of Farm Mechanization on Tenurial Relationships and the Size of the Farm:</u> The impact of mechanization on landlord-tenant relationships can be examined in two stages. The first is identified with the use of the machine power for lifting groundwater. The second involves the introduction of tractors for crop cultivation purposes. In both cases, the analysis will focus on the impact of the new technology on the tenant class.

Table 4.24 shows the number of tenants and the land area cultivated by them after the owner-operators surveyed in the Punjab installed the tubewells.

Table 4.24

The Effect of the Tubewell on the Operational holding of the Tubewell Owners and on their Tenants

	Total Area Under Cultivation in the Village of Residence	Own Cultivation		Tenant Cultivation			
		Area		Area under Cultivation		Tenants	
		Percentage of the total	Average holding size	Percentage of the total	Average holding size	Number	Percentage displaced
			I - The Cotton Area				
Before the tubewell	670.5	72	34.5	28	13.4	14	
After the tubewell	677.5[a]	83	40.3	17	14.2	8	43
			II - The Rice Area				
Before the tubewell	429	63	26.9	37	9.4	17	
After the tubewell	455.5[b]	95	43.0	5	25.0	1	94
			III - Both Cotton and Rice Areas				
Before the tubewell	1099.5	68	31.3	32	11.2	31	
After the tubewell	1133.0	88	41.4	12	15.4	9	71

[a] The increase in the area all due to land renting.

[b] The increase in the area due 3.5 acre of land purchase and 23 acres of land renting.

The data shows that in total, 71 per cent of the tenants were ejected after the tubewells were installed by the land owner. The percentage of the tenants ejected was higher in the wee area than the cotton area although the average size of the land holding under the remaining tenants increased in both areas.

Tubewell farm owners increased the area under their own cultivation after they installed the tubewell. As indicated in Table 4.24 there were three sources of the pressures that contributed to increase the own cultivation land holding. Tenant displacement, as already discussed, was the major source of the additional land. The second major source was the land renting by the tubewell farm operators. The third source was land purchase.

The effect of the tractor on tenant displacement and the size of the operational holding of the tractor owners is indicated in Table 4.25.

Table 4.25

The Influence of the Tractor on the Operational Holding of the Tractor Owners and on their Tenants

	Total Area Under Cultivation in the Village of Residence (acres)	Own Cultivation		Tenant Cultivation			
		Area		Area under Cultivation		Tenants	
		Percentage of the total	Average holding size (acres)	Percentage of the total	Average holding size (acres)	Number	Percentage Displaced
I - The Cotton Area (Sweet groundwater)							
Before the tractor	340	86	41.8	14	11.9	4	
Winter 1971-72	415[a]	92	54.6	8	16.2	2	50
II - The Rice Area (Sweet groundwater)							
Before the tractor	217.5	89	38.5	11	25	1	
Winter 1971-72	230.0[b]	100	46.0	-	-	-	100
III - The Lyallpur Area (Saline groundwater)							
Before the tractor	343.0	58	28.5	42	12.0	12	
Winter 1971-72	390.5[a]	98	54.8	2	7	1	92
IV. All Areas							
Before the tractor	900.5	76	36.0	24	12.7	17	
Winter 1971-72	1035.5	96	52.4	4	13.2	3	82

[a] Increase in the area all due to land purchase.

[b] Increase in the area all due to land renting.

Table 4.25 also suggests that the influence of tractor mechanization on the tenurial relationship and the size of the farm cultivated by the tractor owners and their tenants has been very similar to that of the tubewell mechanization. When all areas taken together 82 per cent of the tenants were displaced, reducing their number from 17 to only 3. Eviction was greatest in the saline groundwater area where the tractors were not preceded by tubewells. In the cotton and the rice areas, tubewells displaced most of the tenants (6 out of 14 in the cotton and 16 out of 17 in the rice area) and did not leave much to be displaced by the tractors.

By reducing the land cultivated by tenants, tractor owners increased the size of their operational holdings. Like the tubewells, the tractors also led to "indirect" tenant ejection when the tractor owners increased their cultivated area through land renting. The third source of increase in the area under the cultivation of the tractor owners was the purchase of the land.

While emphasizing the favorable output and the employment effects of the tubewell mechanization, the previous studies (40, 42, 43) have ignored its impact on the tenant displacement. The present survey suggests that insofar as the displacement of tenants is concerned, the impact of tubewells has been comparable to that of tractor mechanization.

The theoretical explanation of the tenant displacement by the owner operator acquiring a tractor are well known. Tractors being a lumpy input, it pays him to increase the area under own cultivation in order to reduce unit costs. Economic theory also provides explanation of why an operator

installing his tubewell may displace his tenant to increase his operational holding. Assuming that the landlord and his tenant were in equilibrium with respect to their tenurial arrangement, the tubewell, by raising the agricultural productivity of other factors injects an element of disequilibrium into their relationship. The equilibrium might be restored by increasing the rental share But if these shares are legally fixed, as was the case in Pakistan, then taking over the land for self-cultivation is one of the predictable causes of action that the tubewell owner might take.[1/]

It became apparent during the course of the survey that in an environment of rising agricultural productivity, any arrangement that increases the land handling capability of the owner operator could lead to tenant displacement. For example, in a number of cases, land consolidation enabled the tubewell farmers to reduce fragmentation and increase the ability of the larger cultivators to bring their entire holdings under self-cultivation. The result was to further increase the rate of tenant evictions. It was also noticed that because of its mobility, tractors can be used to farm several pieces of land as a unit that had heretofore been farmed separately. As Chaudry Ali Mohammed, a sample farmer, said "In addition to my 45 acre farm in this village, I own an area of 45 acres in the village of Noorpur at a distance of 1½ miles from here. With the tractor I can handle that land myself and am therefore going to take over self-cultivation next year."

---

[1] For an elaborated explanation of the theory and its empirical verification in Taiwa see, "The Theory of Share Tenancy" by Steven N. S. Cheung.

APPENDIX TO CHAPTER IV

Table A-1 gives the details of the casual labor estimates shown in the text. The per-acre labor used has been derived on the basis of both structured and unstructured questions. The information on the amount of total labor (casual and permanent) used for the different crop operations was obtained from the survey questionnaire. Different operations, however, differ in the casual component of the total labor used. Information on the crop operations using casual labor was obtained through informal discussions with a selected number of farmers in different areas. Local officials of the Department of Agriculture were also interviewed.

In general, the use of the casual labor will vary with the size of the holding. With an increase in the size of the holding, the use of casual labor tends to increase due to the family labor limitations and the higher level of income and the social status of the farm operator. Since this study deals with farms having an average size of around 45 acres, these results may differ from other studies dealing with different farm sizes.

In the table, the use of the casual labor is concentrated on the harvest operations. It is only for rice, sugarcane and tobacco crops that some casual labor is also used for the sowing operations. The pattern of the casual labor use indicated here is confirmed by a study by the World Bank in 1966 (49) and a more recent study by Eckert. According to Eckert, "of all the possible agricultural operations, farmers most often engage temporary labor for those associated with harvesting." (68, p. v-1).

Given the overall pattern of casual labor use, the underlying factors that determined the casual labor used per acre of different major crops are explained below.

1. Wheat: Of the three harvest operations of cutting, threshing and winnowing, the cutting and winnowing is performed entirely by the casual labor. The survey shows that in most cases the permanent hired labor which constitutes 40 to 45 percent of the total permanent farm labor (see Table 4.20) was not available for the farm work during the wheat cutting season. According to the terms of the contract they can hire out their services for wheat cutting and if the farm operator wants to detain them he has to pay the inflated harvest season wages. As a result, the farm operators mostly allow them to go and the family labor manages to take care of the routine farm work with wheat cutting left entirely to the casual labor. In case they are detained by paying the harvest wages, this is done for the regular farm work rather than for the harvest. Moreover, the nature of the work is such that the prevailing custom expect that to maintain their social status the family do not engage themselves in operation like wheat-cutting and winnowing. The winnowing is also entirely performed by the casual labor having specialised skill.

2. Cotton: The cotton picking involves female labor. Five women working for an 8 hour day can pick an acre of fully mature cotton. The female members of the farm household under study, except the old lady, do not go out for the field work. The old lady or the eldest female member in the family does the supervision and also picking along with the four casual female workers. The number of picking will vary depending on the yield.

3. Rice: Rice is the only major crop which uses casual labor for both the sowing and all of the harvest operations. As already mentioned, the rice

sowing technology in the Punjab requires intensive land preparation plowings and plankings in the standing water. Moreover, most of the rice follows wheat and 100 percent of the crop is transplanted. Under this situation the permanent labor remains busy in preparing the field after field and mostly the casual labor follows with transplanting the rice. The harvest operations are also performed by the casual labor and the permanent labor undertake the land preparation for wheat, most of which follows rice. Moreover, at the rice harvest as well as the sowing time, the permanent hired will either leave the farm work or will have to be paid the higher peak season wages.

4. Sugarcane: The sowing of the sugarcane is short-term but very labor intensive operation. Specific labor teams by bringing in a lot of casual labor are organized for the sowing operation. The cutting and processing of the sugarcane, on the other hand, are performed over a period of three to four weeks per acre. This is why the family labor mostly handles these operations with casual labor accounting for about one fourth of the total.

5. Vegetables: The vegetables, in general, were grown on very small area for the domestic consumption. The musk melon is a special vegetable--rather half fruit, half vegetable--which was grown on a substantial area by a small number of farmers. All post-sowing operations were performed by hired labor paid in the form of the share of the crop.

6. Toria and Gram: Their winnowing requires special skills and was generally performed by the casual labor. Toria cutting which falls in the sugarcane harvest and the processing peak also engages about 50 percent casual labor.

Table A.1: The Casual Labor Used Per Acre of Different Crops on Bullock and Tractor Farms Surveyed in the Punjab

Crop	Casual Labor Use Per Crop Operation							Total per acre (Man Hours)
	Sowing	Hoeing	Harvest Cutting	Threshing	Winnowing	Picking	Processing	
	(Man Hours Per Operation Per Acre)							
1. Wheat								
a) Rice Area - Tractor			40.0		32.0			72.0
Bullock			35.0		24.0			59.0
b) Other Areas - Tractor			40.0		32.0			72.0
Bullock			40.0		32.0			72.0
2. Toria			16.0		16.0			32.0
3. Gram					16.0			16.0
4. Tobacco	17.5	32.0	20.0				113.0	183.0
5. Rice								
a) Rice Area - Tractor	21.0	2.0	26.0	26.0				75.0
Bullock	26.0	2.0	35.0	35.0				98.0
b) Other Areas- Tractor	20.0	-	16.0	16.0				52.0
Bullock								
6. Cotton								
a) Cotton Area - Tractor		7.0				134.0		141.0
Bullock		4.0				160.0		164.0
b) Lyallpur - Tractor		4.0				134.0		138.0
Bullock		11.0				112.0		123.0
7. Maize - Tractor		12.0					38.0	50.0
Bullock		14.0					38.0	52.0
8. Sugarcane								
a) Lyallpur Area	48.0	29.0	120.0				150.0	347.0
b) Cotton Area	48.0	29.0	100.0				140.0	317.0
c) Rice Area	48.0	29.0	60.0				75.0	212.0
9. Vegetables (Musk Melons)		64.0				216.0		280.0