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## **Dynamics of Labour Demand and its Determinants in Punjab Agriculture<sup>§</sup>**

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### **Abstract**

The study on dynamics of labour demand in Punjab agriculture has revealed that between 1985-86 and 2006-07, the per-hectare labour use has declined by about 23 per cent; more so, in the case of dominant crops like wheat and paddy that have experienced large-scale mechanization. Wheat and paddy had together accounted for about 52 per cent of the gross cropped area in 1985-86, which further increased to 73 per cent in 2006-07. However, increase in labour use in cotton cultivation has been only marginal. The positive effect of agricultural growth on labour use has got neutralized due to the significant displacement of human labour by machines and also due to rising wage rates. The elasticity of labour use in agriculture has fallen drastically during the past two decades indicating little potential for absorption of additional labour in agriculture.

**Key words:** Labour employment, labour demand, agriculture, Punjab

**JEL Classification:** J20, J23, J43

### **Introduction**

Punjab is one of the most agriculturally-developed states of India with high level of agricultural productivity. The state has witnessed a significant increase in agricultural productivity and production due to large-scale adoption of high-yielding seeds, fertilizers and pesticides, and availability of assured irrigation and market for foodgrains. This has resulted in an increase in farm profits, which has encouraged large-scale mechanization of agricultural operations. Initially, farm mechanization, by raising cropping intensity and labour-intensive shifts in the crop mix, led to improvement in the input-use efficiency and also employment. But, after the mid-1980s, further

mechanization, especially in wheat and paddy, and increasing use of inputs like weedicides and herbicides, caused substantial displacement of labour in agriculture (Rangi and Sidhu 2004; Sidhu and Singh, 2004). Despite shifts towards relatively more labour-intensive crops, the total labour-use has either been stagnant or fallen (Bhalla, 1987).

There has been a significant decline in the employment elasticity of agriculture in India with respect to aggregate output, from 0.54 during the early-1970s to 0.36 per cent in the late-1980s (Bhalla, 1993). In Punjab, the employment elasticity of agriculture was reported to be even less than 0.20 during the 1990s (Sidhu, 2002). A number of factors such as increase in cropping intensity, shift in cropping pattern, wider adoption of bio-chemical and mechanical technologies, etc. affected the labour demand significantly (Bardhan, 1977; Parthasarathy, 1990; Sidhu and Grewal, 1990; Acharya, 1992). In this context, it became important to examine the dynamics of labour use in agriculture so as to devise suitable strategies to enhance

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employment growth. The present study has examined the changes in elasticity of agricultural labour demand with respect to some important factors of production.

### Data and Methodology

Data for this study were taken from the "Comprehensive Scheme to Study the Cost of Cultivation of Principal Crops in Punjab" for 1985-86 and 2006-07. Under this scheme, data were collected from a sample of 300 farm households in 30 tehsils spread across three agro-climatic zones of the Punjab state. From each zone, farmers were selected using three-stage stratified sampling technique, with tehsil as stage one, a village or cluster of villages as stage two and operational holdings within the cluster as stage three. From each cluster, a sample of 10 operational holdings, two each from the five size-classes, viz. marginal (< 1 ha), small (1-2 ha), semi-medium (2-4 ha), medium (4-6 ha) and large ( $\geq 6$  ha), were selected randomly. For 1985-86, due to lack of availability of whole set of required data, a sample 150 farm households from 15 tehsils were selected.

### Analytical Approach

A simultaneous equation model was used to estimate the labour demand function. This helped in determining both direct and indirect impact of selected economic variables on labour employment. The model was specified as:

#### Labour use equation

$$X_3 = a_0 X_1^{a1} X_2^{a2} X_4^{a4} X_5^{a5} X_7^{a7} X_8^{a8} X_9^{a9} X_{10}^{a10} X_{11}^{a11} \dots(1)$$

#### Output equation

$$X_1 = b_0 X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} X_8^{b8} X_9^{b9} X_{10}^{b10} \dots(2)$$

where,

- $X_1$  = Gross value of agricultural production, including main product and by products of crops (₹)
- $X_2$  = Farm size (ha),
- $X_3$  = Total human labour use (manhours),
- $X_4$  = Bullock labour use (hours),
- $X_5$  = Tractor use (hours),

- $X_6$  = Use of fertilizer and manure (₹),
- $X_7$  = Use of pesticide(₹),
- $X_8$  = Use of weedicide (₹),
- $X_9$  = Irrigation use (hours),
- $X_{10}$  = Combine harvester use (hours), and
- $X_{11}$  = Wage rate (₹/hour).

The 3-stage least square (SLS) method was used to estimate the model. In order to establish the relationship between employment (as dependent variable) and explanatory variables, all possible combinations were tried to select the best fitted labour use equations. The function was estimated for the pooled data for 1985-86 and 2006-07. The marginal effects of different variables on demand for labour in agriculture were estimated by formula (3):

Marginal effect on labour use =

$$a^i \times \frac{\text{Geometric mean of labour use (man hours)}}{\text{Geometric mean of } i^{\text{th}} \text{ variable}} \dots(3)$$

where,  $a^i$  is the elasticity coefficient of labour employment with respect to the  $i^{\text{th}}$  variable.

### Changes in Use of Labour and Other Inputs

The changes in use of human labour, animal labour, machine labour and other inputs along with the value of output of the crop sector per hectare for 1985-86 and 2006-07 are presented in Table 1. The human-labour use in the crop sector declined considerably, by 23 per cent from 1089 man-hours/ha in 1985-86 to 840 man-hours/ha in 2006-07. The use of animal labour declined by 60 per cent, from 68 hours/ha to 27 hours/ha, and the use of tractors increased by 127 per cent, from 14.0 hours/ha to 31.8 hours/ha during 1985-86 to 2006-07.

The use of tractors had a positive impact on labour-use (per unit of net sown area) by facilitating shift towards labour-intensive crops and raising cropping intensity. Despite that, individual jobs in crops did get replaced by increased use of tractors (Binswanger, 1978; NCAER, 1981). The introduction of combine harvesters in the Punjab agriculture during 1980s caused a significant displacement of human labour, especially in harvesting. Note that use of combine

**Table 1. Use of human labour, animal labour, machine labour and material inputs in Punjab agriculture: 1985-86 and 2006-07**

Particulars	1985-86	2006-07	Absolute change	Change, %
(per ha)				
<b>Human labour (man-hours)</b>				
Family	511	319	-192	-37.57
Permanent	193	153	-40	-20.73
Casual	385	368	-17	-4.42
Hired (Permanent + casual)	578	521	-57	-9.86
Total labour	1089	840	-249	-22.87
Bullock labour (hours)	68	27	-41	-60.29
<b>Machine labour (hours)</b>				
Tractor	14.01	31.83	17.82	127.19
Combine harvester	0.13	1.89	1.76	1353.85
Irrigation machines	186.95	281.77	94.82	50.72
<b>Material inputs</b>				
Seed (₹)	442	3572	3130	708.14
Fertilizers (nutrients, kg)	216	393	177	81.94
Weedicides (₹)	73	939	866	1186.30
Insecticides (₹)	108	1058	950	879.63
Output (₹)	11237	81935	70698	629.15
Cropping intensity (%)	183.81	198.52	14.71	14.71

harvesters increased from 0.13 hours/ha in 1985-86 to 1.89 hours/ha in 2006-07. Similarly, the use of irrigation equipment increased by about 51 per cent and of weedicides by a whopping 1186 per cent during this period. The expenditure on other material inputs such as seeds and insecticides also grew 7-8 times. The increased use of weedicides, as expected, led to a reduction in the use of human labour, and the increased use of irrigation equipment enhanced the use of human labour.

The human-labour use was further examined by classifying into family labour and hired labour. It was found that the use of family labour declined by about 38 per cent (from 511 man-hours/ha to 319 man-hours/ha), and of hired labour declined by only about 10 per cent, from 578 man-hours/ha to 521 man-hours/ha during 1985-86 to 2006-07. The further classification of hired labour into casual and permanent labour revealed that the decline was sharper (by 20.73%) in the use of permanent labour (from 193 man-hours/ha to 153 man-hours/ha) than in the use of causal labour (by 4.42%, from 385 man-hours/ha to 368 man-hours/ha) during this period.

These changes point towards the structural shift in the pattern of labour-use in Punjab agriculture during the period 1985-86 to 2006-07. The dominance of family labour in agriculture declined sharply. Family labour dominated the total labour-use in 1985-86. But, it was the casual labour which accounted for the largest share of total labour-use in 2006-07. The successful adoption of yield enhancing technologies in the state resulted in an increase in the value of output (main product and by-product) from ₹ 11237/ha in 1985-86 to ₹ 81935/ha in 2006-07 (more than 6-times increase).

The change in labour-use was further examined for major crops (Table 2). The total area under these crops increased from about 64 per cent to more than 83 per cent of the gross cropped area on the sample farms between 1985-86 and 2006-07. There was no significant change in area shares of wheat and cotton. But, there was a significant increase in the area share of rice, from 14.52 per cent in 1985-86 to 32.74 per cent in 2006-07. The use of human labour (per ha) in wheat and paddy declined to almost half during this period, mainly owing to large-scale mechanization of farm operations and widespread use of weedicides.

**Table 2. Use of human labour, animal labour and machine labour and material inputs in wheat, paddy and cotton crops in Punjab: 1985-86 and 2006-07**

Particulars	Wheat			Paddy			Cotton		
	1985-86	2006-07	Change	1985-86	2006-07	Change	1985-86	2006-07	Change
(per ha)									
<b>Human labour (man-hours)</b>									
Family	218.99	69.81	-149.18 (-68.12)	308.09	136.98	-171.11 (-55.54)	439.87	255.80	-184.07 (-41.85)
Permanent	44.83	28.17	-16.66 (-37.16)	75.70	63.71	-11.99 (-15.84)	72.85	102.00	29.15 (40.01)
Casual	164.24	85.74	-78.50 (-47.80)	434.59	209.72	-224.87 (-51.74)	299.27	463.40	164.13 (54.84)
Hired (Permanent + casual)	209.07	113.91	-95.16 (-45.52)	510.29	273.43	-236.86 (-46.42)	372.12	565.40	193.28 (51.94)
Total labour	428.06	183.72	-244.34 (-57.08)	818.38	410.41	-407.97 (-49.85)	811.99	821.20	9.21 (1.13)
Bullock labour (hours)	28.60	0.87	-27.73 (-96.96)	31.61	1.08	-30.53 (-96.58)	46.10	3.97	-42.13 (-91.39)
<b>Machine labour (hours)</b>									
Tractor	11.72	15.64	3.92 (33.45)	10.14	15.94	5.80 (57.20)	6.64	18.71	12.07 (181.78)
Combine harvester	0.09	1.16	1.07 (1188.89)	0.33	1.50	1.17 (354.55)	-	-	-
Irrigation machines	47.52	52.04	4.52 (9.51)	337.47	365.97	28.50 (8.45)	10.76	35.66	24.90 (231.41)
<b>Material inputs</b>									
Seed (kg)	103.08	103.30	0.22 (0.21)	NA*	NA*	-	16.09	3.75	-12.34 (-76.69)
Fertilizers (nutrients, kg)	169.10	225.33	56.23 (33.25)	164.83	185.60	20.77 (12.60)	58.59	114.08	55.49 (94.71)
Weedicides (₹)	44.73	792.41	747.68 (1671.54)	127.86	406.62	278.76 (218.02)	0	76.62	76.62 (-)
Insecticides (₹)	15.37	157.02	141.65 (921.60)	19.18	819.95	800.77 (4175.03)	334.48	1542.75	1208.27 (361.24)
Output (q)	36.62	41.86	5.24 (14.31)	54.64	62.60	7.96 (14.57)	12.82	22.18	9.36 (73.01)
Area under crop (% of GCA)	37.07	39.99	2.92	14.52	32.74	18.22	12.22	10.74	-1.48

Note: Figures within the parentheses indicate per cent change over time.

\*Quantitative data not available

Except transplantation of paddy, almost all other operations for these crops have been completely mechanized. There was a tremendous increase in the use of combine harvester in wheat and paddy, by about 1189 per cent and 355 per cent, respectively. The use of tractor went up by about 33 per cent in wheat and

by 57 per cent in paddy. Such a mechanization extent led to the almost disappearance of the use of bullock labour in these crops during this period.

In cotton, the use of human labour increased marginally despite tremendous increase in the use of

tractor (181.78%) and a decline in the use of bullock labour. Increase in cotton yield by about 73 per cent resulted into a significant increase in the demand for labour, which compensated for the decline in demand for human labour due to mechanization. However, the increase in productivity of wheat as well as paddy could not arrest the decline in labour-use. Unlike paddy and wheat crops, where almost all farm operations are mechanized (except transplanting of paddy), the most labour-intensive operations of picking and hoeing in cotton are still out of purview of mechanization.

In nutshell, despite tremendous increase in productivity, the use of human labour in Punjab agriculture has decreased significantly. The dominance of family labour has disappeared and casual labour has emerged as a major component of human-labour use in agriculture. Almost all the major operations in the cultivation of wheat and paddy have been mechanized and the use of bullock labour has almost disappeared on Punjab farms.

### Determinants of Labour Employment in Agriculture

A two-equation simultaneous model was used to establish the relationship between labour use and some of its important determinants, such as farm size, productivity, use of bullocks, tractors, combine harvesters, fertilizers, weedicides, irrigation machinery and wage rate. The labour employment elasticities (along with marginal effects) were estimated for the years 1985-86 and 2006-07 and are presented in Table 3. Almost 63 per cent of the variation in labour use in 1985-86 and 72 per cent in 2006-07 could be explained by these variables.

The productivity level is assumed to have a positive impact on labour-use in agriculture. The elasticity of labour demand with respect to productivity was significantly positive in 1985-86, indicating a 0.62 per cent increase in labour demand with one per cent increase in productivity. The elasticity turned out to

**Table 3. Elasticity coefficients of human labour demand function in Punjab agriculture: 1985-86 and 2006-07**

Variable	1985-86		2006-07	
	Elasticity	Marginal effect	Elasticity	Marginal effect
Constant	1.31*** (0.76)		5.23* (1.44)	
Value of agricultural output	0.62* (0.09)	0.059	0.18 <sup>NS</sup> (0.14)	0.0019
Farm size	-0.11* (0.02)	-30.26	-0.23** (0.02)	-49.65
Bullock labour	0.048* (0.01)	0.77	0.026* (0.01)	0.84
Tractor	-0.011 <sup>NS</sup> (0.02)	-0.77	0.19* (0.05)	5.17
Insecticide	0.00047 <sup>NS</sup> (0.01)	0.004	0.013*** (0.01)	0.01
Weedicide	-0.031* (0.01)	-0.46	-0.020** (0.01)	-0.017
Irrigation	0.025** (0.01)	0.15	0.036* (0.01)	0.11
Combine harvester	-0.048 <sup>NS</sup> (0.05)	-347.64	-0.39* (0.02)	-172.94
Wage rate	-0.059*** (0.04)	-32.59	-0.39* (0.08)	-27.11
R <sup>2</sup>	0.63		0.72	

Note: \*, \*\*, \*\*\* denote significance at 1 per cent, 5 per cent and 10 per cent levels, respectively. NS means non-significant. Figures within the parentheses indicate the standard error

be non-significant in 2006-07, highlighting that the potential of enhancing employment opportunities in Punjab agriculture seems to have been fully exploited with the current crop production technology. The negative elasticity of labour-use with respect to farm size at -0.11 in 1985-86 and -0.23 in 2006-07, indicates the doubling of labour displacing effect of farm size. A faster increase in mechanization on large farms was the main reason behind the decline in elasticity.

Due to complementarity between the use of bullock and the human labour, elasticity coefficients of bullock labour were significant and positive at 0.048 in 1985-86 and 0.026 in 2006-07. A significant reduction in the use of bullock labour was the main reason for decline in its elasticity coefficient. The elasticity of human-labour use with respect to tractor use turned out to be positive and significant in 2006-07; one per cent increase in tractor use in 2006-07 resulted in an increase in human-labour-use by 0.19 per cent. Increased tractorization leading to intensification of agriculture together with increase in area under more labour-intensive crops (e.g. paddy) resulted in a marginal increase in labour use. The increased use of pesticides is postulated to be labour enhancing in nature. However, its impact on labour use was non-significant in 1985-86, and positive and significant in 2006-07.

The employment elasticity with respect to weedicid use was negative and significant, the elasticity coefficients being -0.03 in 1985-86 and -0.02 in 2006-07. The elasticity coefficient of irrigation was 0.25 in 1985-86 and 0.36 in 2006-07. The higher elasticity was due to the shift in cropping pattern in favour of paddy, a highly water-intensive crop. Though the employment elasticity of the use of combine harvester, which is a major labour-displacing machine, was non-significant in 1985-86, it was estimated to be -0.39 in 2006-07. The use of combine harvester for one hour was estimated to reduce the use of human labour by 173 man-hours in 2006-07. In nutshell, most of the labour displacement in the Punjab agriculture may be attributed to the large-scale use of combine harvesters.

Lastly, employment elasticity of wage, as expected, was negative and significant; -0.06 in 1985-86 and -0.39 in 2006-07. The significant negative elasticity of labour demand with respect to wages indicates that

a rise in wage rate has a negative effect on labour use. Its marginal effect on labour demand indicated that with an increase in wage rate by one rupee, the demand for human labour declined by 32.6 man-hours/ha in 1985-86 and by 27.1 man-hours/ha in 2006-07. These results highlight that while the positive and significant effect of agricultural output on labour demand in 1985-86 had turned out to be insignificant in 2006-07, the negative impact of farm size, combine harvester and wage rate had further aggravated during this period.

### Conclusions and Policy Implications

The study on dynamics of labour demand has revealed that the use of human labour on Punjab farms has declined by about 23 per cent; from 1089 man-hours/ha in 1985-86 to 840 man-hours/ha in 2006-07. A decline has been observed in the use of family labour (~38%), total hired labour (10%) and permanent labour (21%). This has primarily been due to a significant increase in the use of tractors. The most labour-intensive operations of harvesting of paddy and wheat have been completely mechanized. In 1985-86, the value of agricultural output, farm size, use of bullock labour and irrigation as well as the use of weedicides have been found to be the significant determinants of human-labour use. While an increase in the farm size and expenditure on weedicides have depicted a negative impact on human labour demand, it is positively influenced by the increase in value of output, use of bullock labour and irrigation. In 2006-07, the value of output has turned out to be non-significant, but all other variables have depicted a significant effect on human-labour use in crop production. While the demand for human labour in 2006-07 increased with the increase in the use of bullock labour, tractor, pesticide and irrigation machinery, it declined significantly with the increase in farm size, expenditure on weedicides, use of combine harvester and wage rate.

During the past two decades, the positive effect of increasing productivity on human labour employment has got neutralized; while the negative effects of farm size and mechanization have further strengthened. The technological changes in crop production have favoured an increase in the cropping intensity and shift in cropping pattern and thus increase in the human-labour use, but have not been able to compensate the labour-displacing effect of mechanization in Punjab agriculture. This implies that the labour absorption

potential of agriculture has been fully exploited in Punjab.

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