Impact of Agricultural Mechanization on Production, Productivity, Cropping Intensity Income Generation and Employment of Labour

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ABSTRACT

Agricultural mechanization implies the use of various power sources and improved farm tools and equipment, with a view to reduce the drudgery of the human beings and draught animals, enhance the cropping intensity, precision and timelines of efficiency of utilisation of various crop inputs and reduce the losses at different stages of crop production. The end objective of farm mechanization is to enhance the overall productivity and production with the lowest cost of production. The contribution of agricultural mechanization has been well recognized in enhancing the production together with irrigation, biological and chemical inputs of high yielding seed varieties, fertilizers, pesticides and mechanical energy. Indian Green Revolution is regarded as one of the greatest achievements of the 20th century. It has been adopted in India on a large scale benefiting both small, medium and large size farms. Some of its aspects such as its impact on human labour employment in a labour abundant economy have always evoked sharp responses from the policy makers. Several studies have been conducted on the impact of agricultural mechanization on production, productivity, cropping intensity, human labour employment as well as income generation.

Different researchers have concluded that farm mechanization enhances the production and productivity of different crops due to timeliness of operations, better quality of operations and precision in the application of the inputs. According to NCAER (1980) survey covering 815 farming households in 85 villages, the increase was 72 per cent in the case of sorghum, and 7 per cent in the case of cotton as compared to traditional bullock farms. ITES, Madras (1975) found that the productivity increase on tractor owning and hiring farms ranged between 4.1 and 54.8 per cent. The per cent increase was comparatively low on custom hiring farms as compared to tractor-owning farms due to higher level of inputs and better control on timeliness of operations. These productivity increases, thus, were attributed to higher doses of fertilizer, irrigation and mechanization.

Several studies have indicated that there was significant increase in cropping intensity due to the use of tractors and irrigation as a consequence of mechanization. The increase in cropping intensity has been reported to be 165, 156 and 149 per cent respectively for tractor-owning, tractor using and bullock operated farms respectively, according to a NCAER (1980) survey. Similar results have been reported in other studies which have concluded that as a consequence of mechanization, the cropping intensity increased significantly. Furthermore, the percent gross cropped area irrigated was positively related to cropping intensity. The facilities of tubewell irrigation and mechanical power helped the farmers in raising the cropping intensity of their farms (Patil & Sirohi, 1987). Singh (2001) concluded that cropping intensity was mainly dependent on annual water availability and the farm power available. He reported that the States like Punjab, Haryana, Uttar Pradesh which had higher percent irrigated area, higher doses of fertilizer and higher power availability per hectare also had higher grain yield per hectare.

The studies regarding effect of agricultural mechanization on human labour employment have shown that agricultural mechanization helped in overall increase in the employment of human labour. The reduction in aggregate labour used on tractor operated farms was quite nominal (1.3 to 12%) as compared to bullock operated farms. The increase in employment of casual male labour was reported to be upto 38.55%. There was slight decline in the employment of casual labour. According to NCAER (1973) survey, the mechanized small farms used 5.7% more labour. IIM, Ahmedabad (1975) reported that mechanization did not lead to decrease in human labour employment. Sidhu & Grewal (1991) reported that there was no significant difference in human labour use on tractor and bullock operated farms. The studies indicated that with mechanization, the demand for hired labour increased while participation of family labour in crop production declined.

Different studies also indicated that net human labour displacement in agricultural operations was non-significant and it was more than compensated by increased demand for human labour due to multiple cropping, greater intensity of cultivation and higher yields. Furthermore the demand for non-farm labour for manufacture, servicing, distribution, repair and maintenance as well as other complementary jobs substantially increased due to mechanization.

The different studies have also brought out that farm mechanization greatly helped the farming community in the overall economic upliftment. NCAER (1980) survey revealed that tractor owners and users derived higher per hectare gross income compared to traditional bullock farms. The gross income per hectare was reported to be about 63% higher on tractor owning farms as compared to the bullock farms. The average net return from a tractor owning farm on per hectare basis was reported to be 152% that of a bullock owning farm.

To sum up, agricultural mechanization studies had shown that farm mechanization led to increase in inputs due to higher average cropping intensity, larger area and increased the productivity of farm labour. Furthermore, farm mechanization increased agricultural productivity and profitability on account of timeliness of operations, better quality of work and more efficient utilization of crop inputs. Undoubtedly, farm mechanization displaced animal power from 60 to 100% but resulted in less time for farm work. Also mechanization led to increase in the human labour employment for the on-farm and off-farm activities as a result of manufacture, repair, servicing and sales of tractors and improved farm equipment.

1. INTRODUCTION

Indian agriculture is characterised by overwhelmingly small holdings due to higher population density and nearly two-third of its population residing in the rural areas coupled with unabated land fragmentation due to the inheritance laws of the country. Nearly 62 per cent of the estimated 142 m ha area is rainfed. Major sources of farm power include both animate (humans and draught animals) as well as inanimate sources such as diesel engines, tractors and electric motors. India's well-orchestrated Green Revolution began in the mid 60's. It was ushered in through the adoption of higher and balanced doses of the biological, chemical and mechanical inputs together with the timely intervention of the Government. The later ensured the availability of the required inputs of high yielding seed varieties, fertilizers, pesticides water and improved power sources and equipment. The Government provided the minimum support price, easy access to procurement markets, rural roads and other infrastructures which helped to trigger the green revolution in selected areas of the country. Resultantly gross food production increased from 50.8 M tons in 1950-51 to 199.3 M tons in 1996-97 and land productivity rose from 0.58 tons/ha/year to more than 2.14 tons/ha/year. Whereas the quantum jump in production and productivity was brought about by a combination of factors, farm mechanization was often at the centre of controversy due to its impact on employment of human labour in a labour abundant economy. This paper reviews the findings of various researchers on the impact of farm mechanization on agricultural production and productivity, cropping

intensity, human labour employment on the farm, subsidiary and non-farm employment as well as gross farm income and net return.

2. IMPACT OF MECHANIZATION ON AGRICULTURAL PRODUCTION AND PRODUCTIVITY

Farm mechanization is regarded as sine-*qua-non* to reduce the human drudgery and enhance the agricultural productivity. During the post-green revolution period, the impact of farm mechanization on agricultural production and productivity has been well recognised in India. Depending upon the use of other inputs such as irrigation, high yielding seed varieties, chemical fertilizers, herbicides and pesticides, different States in India have attained different levels of mechanization. Consequently the agricultural production & productivity has witnessed three to four fold increase. Studies have been conducted by various organisations & individuals which have highlighted the impact of agricultural mechanization on farm production and productivity.

Singh and Singh (1972) concluded that tractor farms gave higher yields of wheat, paddy and sugarcane and produced a higher overall gross output per hectare than non-tractor farms. NCAER (1973) compared the values of annual farm output per hectare of net sown area under different levels of mechanization. The output per hectare was found to increase as the level of mechanization increased from irrigated non - mechanized farms to tubewell, tractor-thresher farms.

Singh and Chancellor (1974) found that though, tractor and tubewell farms had significantly higher yields than bullock farms in case of wheat, much of the difference was accounted for by difference in other factors such as level of irrigation. The use of tubewell was found to be associated with significantly higher yields compared to the persian wheel irrigation. ITES, Madras (1975) found that tractor - owned farms obtained increased productivity of paddy, sugarcane and groundnut by 4.1 to 28.3 per cent, 13.1 to 34.2 per cent and 9.8 to 54.8 per cent with an average value of 15.8 per cent, 23.2 per cent and 31.8 per cent respectively. Likewise, the average increase of productivity on farms hiring tractors was reported to be 11.8 per cent, 13.0 per cent and 16.0 percent for paddy, sugarcane and groundnut respectively (Table 1).

Pathak et al. (1978) conducted survey on five different categories of farms in Ludhiana District of Punjab to assess the effect of power sources on production and productivity. The yield of paddy, maize and wheat was

Table 1. Impact of Mechanization on Productivity on Three Categories of Farms in Selected Districts of Tamil Nadu

Sr. No.	Districts	Crops	Average Productivity kg/ha			Percent increase over traditional practices	
			Tractor owned farms	Tractor hired farms	Traditional plough using farms	Tractor owned farms	Tractor hired farms
1.	Chingelpet	Paddy	4076	3815	3403	19.8	12.1
		Sugarcane	104839	99000	86480	21.2	14.5
		Groundnut	1114	956	795	40.1	20.3
2.	South Arcot	Paddy	4121	3893	3746	10.0	3.9
		Sugarcane	108665	105299	94224	15.3	11.8
		Groundnut	1337	1100	1060	26.1	3.8
3.	North Arcot	Paddy	3166	3058	2467	28.3	24.0
		Sugarcane	95161	79067	74011	28.6	6.8
		Groundnut	1464	1300	946	54.8	37.4
4.	Tiruchirapalli	Paddy	4144	4065	3451	20.1	17.0
		Sugarcane	108696	104696	80986	34.2	29.0
		Groundnut	1959	1798	1784	9.8	0.8
5.	Thanjavur	Paddy	2844	2831	2733	4.1	3.6
		Sugarcane	-	-	-	-	-
		Groundnut	-	-	-	-	-
6.	Coimbatore	Paddy	4590	4363	4047	13.4	7.8
		Sugarcane	108050	106210	95510	13.1	11.2
		Groundnut	1567	1578	1218	28.7	29.6
7.	Madurai	Paddy	3664	3619	3191	14.8	13.4
		Sugarcane	109420	90116	86420	26.6	4.3
		Groundnut	1457	1160	1112	31.0	4.3

Source : ITES (1977); Mechanization in Agriculture and Labour Substitution in Tamil Nadu. Report of Institute for Techno-Economic Studies, Madras.

Table 2. Cropping intensity, cropping pattern and yield of different crops at bullock farms and bullock farms hiring tractor

Sr. No.	Index	BF	BFHT	TFOB	TFHB	TF
1.	Cropping Intensity with Fodder					
	a) Paddy region	186.0	182.0	175.3	176.7	175.5
	b) Non-paddy region	168.2	182.5	186.7	154.7	176.5
	c) Average	173.8	182.2	182.2	162.8	171.7
2.	Cropping Intensity without Fodder					
	a) Paddy region	165.6	153.5	148.2	157.5	151.5
	b) Non-paddy region	145.4	153.7	165.1	140.5	149.5
	c) Average	151.7	153.6	158.6	147.0	151.2
3.	Per cent Area Under Paddy					
	a) Paddy region	40.2	31.0	31.8	41.7	42.6
	b) Non-paddy region	4.1	8.2	13.1	5.8	8.0
	c) Average	15.4	23.3	20.5	14.7	30.4
4.	Per cent Area Under Maize					
	a) Paddy region	26.4	18.5	11.6	12.5	4.5
	b) Non-paddy region	40.3	31.6	28.9	30.5	18.3
	c) Average	9.2	7.2	22.4	25.9	7.3
5.	Per cent Area Under Groundnut					
	a) Paddy region	0.0	1.7	2.1	0.0	0.9
	b) Non-paddy region	13.4	15.9	21.0	9.7	23.8
	c) Average	9.2	7.2	13.4	14.3	5.9
6.	Per cent Area Under Wheat After Paddy					
	a) Paddy region	33.9	28.8	24.9	32.3	35.9
	b) Non-paddy region	4.1	8.0	11.8	5.2	7.8
	c) Average	13.4	21.1	17.0	14.0	29.7
7.	Crop Yield (Qt/ha) of Paddy					
	a) Paddy region	57.0	59.5	61.1	63.8	57.9
	b) Non-paddy region	54.3	64.2	67.9	68.3	57.6
	c) Average	56.1	59.8	64.7	65.3	57.8
8.	Crop Yield (Qt/ha) of Maize					
	a) Paddy region	11.1	14.0	16.2	9.9	14.8
	b) Non-paddy region	13.9	12.7	15.6	19.8	14.2
	c) Average	13.1	13.3	15.8	16.5	14.7
9.	Crop Yield (Qt/ha) of Wheat after Paddy					
	a) Paddy region	16.7	27.2	28.9	29.6	28.8
	b) Non-paddy region	27.2	30.8	34.6	32.5	31.6
	c) Average	20.3	28.2	31.6	31.6	29.1
10.	Crop Yield (Qt/ha) of Wheat after Maize					
	a) Paddy region	34.0	29.8	34.6	32.5	31.6
	b) Non-paddy region	31.5	31.8	35.4	34.8	35.8
	c) Average	32.0	31.1	35.1	33.8	33.6

Note : BF = Bullock Farms; BFHT = Bullock Farms Hiring Tractors; TFOB = Tractor Farms Owing Bullocks; TFHB = Tractor Farms Hiring Bullocks; TF = Tractor Farms.
Source : Pathak, B.S. et al. (1978)

reported to be higher on tractor farms than on bullock farms (Table 2). The yield of wheat after paddy or maize was significantly higher on tractor farms than bullock farms. The use of tractors enhanced agricultural productivity due to better seed-bed preparation, timeliness of operations and precision in distribution and placement of seed and fertilizer owing to the use of the seed-cum-fertilizer drills.

NCAER (1980) conducted a survey of farms owning tractors, using tractors on custom-hire and owning bullocks in seven States belonging to three major agro-climatic zones. A sample of 815 farming households was selected randomly from 85 villages. It was reported that an average tractor-owning farm obtained higher yields than a bullock farm, which varied from crop to crop and ranged from 72 per cent in the case of sorghum to 7 per cent in the case of cotton. Tractor users also obtained higher yields compared to bullock farms.

Aggarwal (1983) analysed data of a sample of 240 farms situated in the principal wheat growing areas of Punjab for the crop year 1971-72. The study revealed that the use of tractors instead of bullocks for ploughing

and sowing did not add to the yield of high yielding varieties of wheat. It appeared that the advantage of timeliness of operation of a tractor was nominal, when the crop preceding to wheat could be harvested and threshed sufficiently in advance and the land could be released for timely wheat ploughing and sowing even on bullock farms. Unlike the neutral effect of the tractor use on wheat yield, the use of tubewells in comparison to canals was found to have a significant positive effect on the productivity.

Nandal and Rai (1986) conducted a study by dividing Haryana in three homogenous zones on the basis of intensity of mechanization. In all, 54 farms were selected from each of the three zones making a total sample of 162 farming households. The impact of mechanization on crop yield was studied on three different categories of farms. It was apparent from the study that the tractor-operated farms had higher yield of wheat and paddy. In case of farms using tractors on custom - hire basis, the yield was comparatively low. The study revealed that tractor-owing farms invariably used higher level of agricultural inputs and had better control on timeliness of operations.

Balishter, Gupta and Singh (1991) conducted a study in Mathura district of Uttar Pradesh on the basis of three levels of mechanization, i.e. (i) non-mechanised farms having neither tubewell nor tractor (ii) partially mechanised farms having only tubewell, and (iii) mechanised farms having both tubewell and tractor. The yield was reported to be higher by about 10 to 27 percent in mechanised farms and by about 2 to 26 per cent in partially mechanised farms in comparison with non-mechanised farms for all the major crops grown on the sample farms.

In most of the studies, higher yields on tractorized farms were associated with higher levels of fertilizer and irrigation use, but without statistical testing. An exception was the study conducted in Punjab by Kahlon (1976) which found no statistically significant yield effects. Where wheat yields increased significantly, fertilizer use increased in one area. In the two other areas, the effect did not apply to all farms. No significant differences for high yielding rice varieties were found. Differences were significant for maize in one area and cotton in another.

According to Motilal (1971) in Delhi Territory, yields increased significantly for paddy (13.7%), wheat (15.9%), and sugarcane (29.7%). However, tractor farms used 35% more fertilizer, so these increases could not be entirely, attributed to tractors. In Uttar Pradesh, tractors gave a yield advantage of 17.6% in sugarcane and 41% in wheat, but significance tests and fertilizer inputs were not reported (Singh & Singh, 1972). In the NCAER study (1980), yield increases with tractors accompanied increased fertilizer use, but sample sizes were small. In other areas, large yield increases were reported for summer paddy in Bihar (28.6%), for desi paddy in kharif and high yielding paddy in Andhra Pradesh, and for groundnuts in Coimbatore (23.9%). However, fertilizer applications were also higher (Bihar, 31.8%; Andhra Pradesh, 36.3%; Coimbatore, 28.7%). Finally, Singh and Chancellor's (1974) regression analysis on 26 maize farms in Meerut District showed no significant effect of tractorization on productivity.

Table 3. Output and yield per acre crop wise by Farm size before and after purchase of Tractors (All States)

(Quintals)

Size	Paddy		Wheat		Sugarcane		Oil Seeds		Cotton		Potato	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
0-10	130.0	276.0	294.0	499.0	3250.0	6263.0	9.0	15.0	–	–	130.0	185.0
	(9.22)	(15.33)	(10.98)	(16.10)	(345.74)	(381.89)	(3.0)	(3.33)	–	–	(52.50)	(46.25)
	(14.22)	(17.40)	(10.81)	(13.81)	(195.66)	(234.84)	(5.23)	(5.86)	(5.43)	(5.65)	(74.93)	(85.28)
10-20	11098.0	16622.5	14191.0	21721.5	66131.5	97645.0	730.2	1008.0	269.0	308.0	4758.0	7121.0
	(14.22)	(17.40)	(10.81)	(13.81)	(195.66)	(234.84)	(5.23)	(5.86)	(5.3)	(5.65)	(74.93)	(85.28)
20-30	21572.6	42339.6	30344.3	50044.0	151294.5	206641.0	1625.0	2310.0	906.5	1384.0	3053.0	9248.5
	(15.29)	(19.90)	(10.89)	(13.48)	(223.48)	(270.97)	(4.84)	(5.73)	(5.98)	(6.56)	(62.95)	(83.20)
30-40	25556.0	46094.0	35989.0	55248.5	134005.0	232672.5	1733.0	2641.6	2253.0	3611.0	2794.0	7264.0
	(15.06)	(19.54)	(10.85)	(13.31)	(206.93)	(274.10)	(4.67)	(5.91)	(5.18)	(6.51)	(84.67)	(94.34)
40-50	17991.0	37692.0	53942.0	72225.0	79944.0	141321.0	1805.0	2843.0	3051.0	4727.0	3540.0	7815.0
	(17.38)	(22.18)	(22.10)	(22.95)	(206.09)	(275.05)	(15.29)	(6.32)	(5.42)	(6.86)	(68.08)	(100.19)
50 &	59402.0	122426.0	108079.5	179789.1	276045.0	585522.0	11471.0	21476.5	17262.5	29926.0	9020.0	17924.0
above	(14.34)	(18.26)	(10.39)	(13.40)	(225.62)	(273.81)	(4.61)	(6.95)	(5.41)	(7.34)	(71.02)	(109.29)
All	135749.6	265450.1	242840.6	379527.6	711270.0	1269964.5	17373.2	30294.7	23742.0	39956.0	23295.0	49557.5
classes	(14.95)	(19.15)	(11.97)	(14.58)	(216.43)	(270.46)	(4.72)	(6.63)	(5.41)	(7.15)	(71.02)	(95.49)

Note : Figures in parentheses are yield per acre (in quintals)

Source : Rao, T.R. 1978, Agril. Mechanization in Retrospect and Prospect; Proc. Symp. Farm Mechanization: Problems & Prospects; ISAE North Chapter & ISAE, PAU, Ludhiana, pp 45-56.

According to Binswanger (1978), only 6 out of 118 instances reported, showed large yield differences without large increase in fertilizer input.

Singh and Goswami (1978) noted complex yield effects in Bihar. Early rice yields were slightly higher with tractorization, late rice and maize showed massive yield increases, and wheat yields decreased slightly. No adequate explanation of these results was provided by the authors by studying the input data.

Rao (1978) conducted a study to investigate the effect of the use of tractors on yield, employment of labour and cropping pattern. The methodology employed was on recall basis i.e. data obtained before and after tractor acquisition. As many as 4000 tractor-owning farmers were contacted through a mailed questionnaire but only 1500 responded. The results pertaining to the yield differences for six important crops are presented in Table 3. As evident, of all the crops raised on different sizes of farms, tractor owning farms obtained higher yields per acre and the increase was more for the larger sizes of tractor owning farms.

Binswanger (1978) adopted value of crop production per ha per year as a proxy to determine any cropping effects attributable to tractorization. Production value was considered as a function of cropping intensity, yields, cropping patterns, and a residual interactive effect. Since tractorization had increased the first two only slightly, it was reasonable to suppose that the increase in production value was attributable to a tractor-based cropping pattern or to factors such as irrigation, credit, and/ or managerial capacity.

Laxaminarayan et al. (1981) reported 6% grain loss in harvesting and threshing with traditional methods, and 2-4% with combines. A multiple regression analysis indicated that greater fertilizer use mainly explained combine users' higher yields.

Singh and Chandra (1999) used the linear regression function to examine the effect of important inputs on crop productivity for the State of Punjab. Standardized regression coefficients were calculated for relative efficiency of different inputs. The elasticity of productivity for fertilizer, irrigation and farm power was reported to be significant in the production function. Relative efficiency of farm power was higher followed by fertilizer and irrigation. The coefficient for relative efficiency and standardized regression coefficient for fertilizer was reported to be 0.23, irrigation, 0.35 and farm power 0.45. The effect of farm power, however, showed decreasing effect beyond 3.24 kW/ha.

The best fit mathematical relationship for growth of food grain yield and use of fertilizer could be expressed, with statistically significant value of $R^2 = 0.96$ at 1 per cent level by:

$y = 1160.4 + 13.972 X_f$; ($R^2 = 0.96$)

Where, y = state average food grain yield, kg/ha and X_f = state average fertilizer consumption, kg/ha

The best fit mathematical relationship between yield and per cent area irrigated was reported to be as follows:

$y = 278.32\ e^{0.0262\ X_i}$; ($R^2 = 0.98$)

Where X_i = average food grain area under irrigation,%. The value of coefficient of determination ($R^2 = 0.98$) was reported to be the maximum and significant at 1 percent level.

Best mathematical relationship between yield and unit power could be represented by quadratic function and was given as,

$y = 534.41 + 1924.9 X_p - 297.53\ X_p^2$; ($R^2 = 0.99$)

Where, X_p = state average availability of power, kW/ha. The coefficient of determination ($R^2 = 0.99$) was statistically significant at 1 per cent level.

Singh (2000) suggested an analytical approach to study the growth dynamics of agricultural inputs and their effect on productivity in Madhya Pradesh. He found that the impact of farm power upto 1kW/ha was not significant. Standardized regression coefficients estimated values based on time series data, exhibited that fertilizer (0.42) was the most important input followed by irrigation (0.38) and power (0.18) but from the spatial data for the year 1996-1997 it emerged that irrigation (0.52) played the most vital role followed by fertilizer (0.38) and power (0.05) in increasing the crop productivity. Input-grain yield relationship computed on the basis of equations of time series and spatial data also revealed identical trends, and therefore either of the regression equation could be used for planning input requirements for higher yield.

3. IMPACT OF MECHANIZATION ON CROPPING INTENSITY

Agricultural mechanization has made significant contribution in enhancing cropping intensity. The growth in irrigated areas and tractor density has had direct bearing on the cropping intensity. Findings of the studies conducted in the past are briefly presented to highlight the contribution of mechanization in enhancing the cropping intensity.

Chopra (1974) carried out a study on a sample of Punjab farms. He made a comparison of tractor-owning farms in terms of the situation before and after the introduction of tractors. The cropping intensity was reported to be higher after the introduction of tractors.

NCAER (1974) conducted a study of tractorised and non-tractorised farms in nine States of India. The study revealed that tractor-owning farms had a higher cropping intensity of 137.5 per cent as compared to 131.8 per cent in the case of those without a tractor. Cropping

Table 4. Cropping intensity, cropping pattern and yield of important crops on all tractor and bullock farms

Sr. No.	Index	Mean for all size on		Mean for medium size on	
		All bullock farms	All tractor farms	All bullock farms	All tractor farms
1.	Cropping intensity with fodder	180.0	175.2	174.5	180.0
2.	Cropping intensity without fodder	153.1	153.9	149.6	153.9
3.	Per cent area under Paddy	20.5	25.0	20.7	27.8
4.	Per cent area under maize	26.7	17.8	18.5	18.0
5.	Per cent area under groundnut	7.7	11.0	6.9	9.4
6.	Per cent area under wheat after paddy	18.1	21.0	18.8	23.6
7.	Yield (Qt/ha) of Paddy	59.1	62.2	60.0	60.9
8.	Yield (Qt/ha) of maize	13.2	15.7	14.0	14.6
9.	Yield (Qt/ha) of wheat after paddy	27.0	30.5	28.1	29.4
10.	Yield (Qt/ha) of wheat after maize	31.4	34.5	28.7	35.1

Source: Pathak, B.S. et al.; 1978

intensity was found to be generally higher on small farms. Among the States surveyed, cropping intensity of tractorised farms was the highest in the Punjab, followed by Uttar Pradesh, Tamil Nadu and the lowest in Rajasthan and Maharashtra.

In a study by Pathak et al. (1978), on a sample of 115 farms in Ludhiana district, the average cropping intensity with fodder crop was reported to be higher on bullock farms than on tractor farms. However the cropping intensity without fodder crop was comparatively higher for tractor farms. On medium size farms of 6 to 12 hectares, the cropping intensity with fodder crop on tractor farms was 180 per cent as compared to 174.5 per cent for the bullock farms. The cropping intensity without fodder crop on tractor farms was 153.9 percent as compared to 149.6 percent on bullock farms (Table 4).

The cropping intensity with fodder was higher on bullock farms than on tractor farms whereas the cropping intensity without fodder was lower. But when comparing the cropping intensities in the two categories having medium size of holdings (6 to 12 hectares), the tractor farms were in a better position since the cropping intensity with and without fodder on these farms was 3.2 and 2.8% higher (Table 4) respectively than on bullock farms. The higher intensity was attributed to the availability of more mobile power on tractor farms than on bullock farms. The differences were lower and statistically not significant. But it was observed that bullocks became the major constraint and thus the bullock farms began to depend on the use of tractors through custom-hiring. The group of the bullock farms feared that if tractors were not made available to them, the output and cropping intensity would decline.

NCAER (1980) conducted a comprehensive study to ascertain the factors motivating a farmer to own or use/ hire a tractor and also the impact of tractorization on rural income and agricultural employment. A sample of 815 farming households from 85 villages of 7 States belonging to three major agro-climatic zones was selected. To study the impact of tractor use on cropping intensity, the land use of tractorised farms was compared with that of the bullock farms. The cropping intensity of tractor-owning and tractor-using households in all the States was higher than that of bullock farms (Table 5). An average tractor owner had a cropping intensity of 12 per cent higher than that of the bullock

Table 5. Cropping Intensity in Different Categories of Farming Households (Percent) during 1977-78

State	Tractor-owner	Tractor-user	Bullock-farm
Punjab	193(105)	193(105)	184(100)
Haryana	165(101)	164(100)	164(100)
Uttar Pradesh	193(105)	189(103)	184(100)
Tamil Nadu	157(117)	135(101)	134(100)
Andhra Pradesh	134(110)	126(102)	122(100)
Gujarat	119(114)	111(107)	104(100)
Maharashtra	175(122)	167(117)	143(100)
All States	165(111)	156(105)	149(100)

Note : Figures in brackets are indices. Bullock farm – 100
Source : NCAER (1980), Implications of Tractorisation for Farm Employment, Productivity and Income. National Council of Applied Ecomomic Research, New Delhi

Table 6. Cropping Intensity of seven selected states by Farm Size (Percent)

Farm size (ha)	Tractor-owner	Tractor-user	Bullock-farm
Below 2	180	172	161
2-4	176	170	151
4-10	163	154	148
Above 10	168	140	148
All Farms	165	156	149

Source : NCAER (1980), Implications of Tractorization for Farm Employment, Productivity and Income. National Council of Applied Ecomomic Research, New Delhi

farms. Similarly, the cropping intensity of tractor using households exceeded that of bullock farms by 8 per cent. Cropping intensity of small farms was found to be uniformly higher than that of larger farms and those with the facility of a tractor had raised their cropping intensities further (Table 6).

Aggarwal (1983) reported that the use of tractors and tubewells, in comparison with the use of bullocks and canals had a significant bearing on the cropping intensity. However, the advantage of tubewells over canals was found much greater than that of tractors over bullocks. Among the tractor-using farms, it was essentially those owning tractors which accounted for higher average cropping intensity. However, those depending solely on hired tractors were not found to differ much from the bullock farms in regard to cropping intensity. As the farm size increased, the cropping intensity declined. The percent gross cropped area irrigated was positively related to the cropping intensity.

Nandal and Rai (1986) conducted a study in Haryana State on a sample of 54 farmers from each of the three zones making a total sample of 162 farming households. The study concluded that the cropping intensity showed consistently positive relationship with tractorization. Within the given size groups, tractor-owning farms had higher cropping intensity as compared to tractor-using or animal operated farms.

Patil and Sirohi (1987) conducted a study to measure the impact of tractorization on the irrigated farms of Ahmednagar District of Maharashtra State. The study analysed the differences in cropping intensities of different farm size groups of four categories as given in Table 7. In Maharashtra, the duration of sugarcane crop varied from one to one and half years depending on the planting season. Thus, cropping intensity (I) and cropping intensity (II) was calculated considering sugarcane as a single crop and as equivalent to two crops, respectively. The cropping intensity on small sized TOF and TOF + BOF was significantly higher in comparison with the small sizes BOF and BOF+THF, when the cropping intensity pattern (I) was considered. But the differences in cropping intensity on medium and large-sized farms were not significant among different categories of farms. The cropping intensity on all size groups of farms of TOF and TOF+BOF was also significantly higher in comparison with the BOF and BOF+THF when the cropping pattern (II) was considered. This was attributed to allocation of higher proportion of area for cultivation of longer duration sugarcane crop on tractor-owning farms.

Balishter et al. (1991) based on their study in Mathura district of Uttar Pradesh, concluded that the average

Table 7. Average Farm size and Intensity of Cropping on Different Categories on Farms

Farm Category	Net cultivated area per farm (ha)	Cropped area per farm (ha)		Cropping intensity (%)		Irrigated Area (%)
		I	II	I	II	
Small Farms						
BOF	4.62	6.00	7.08	129.87	153.11	92.86
BOF+THF	4.57	5.99	7.44	131.07	162.74	95.44
TOF	5.05	7.59	9.59	150.40	190.04	92.93
TOF + BOF	5.49	8.14	10.40	148.44	189.56	92.19
Medium Farms						
BOF	7.51	9.97	11.29	127.46	150.44	89.40
BOF+THF	7.24	9.27	10.95	128.09	151.25	88.42
TOF	8.52	11.24	14.12	131.90	165.71	90.90
TOF + BOF	8.79	11.41	14.25	129.89	162.21	89.53
Large Farms						
BOF	11.89	14.16	16.77	119.07	141.12	82.35
BOF+THF	11.65	13.48	16.45	115.67	141.20	81.82
TOF	13.30	16.16	20.08	121.54	150.97	89.98
TOF + BOF	13.94	16.89	20.99	121.11	150.55	92.17
Overall						
BOF	7.09	8.90	10.50	125.53	148.03	88.27
BOF+THF	6.97	8.68	10.45	124.63	150.04	87.38
TOF	9.74	12.48	15.66	128.15	160.35	90.83
TOF + BOF	10.91	13.69	17.13	125.55	127.11	92.04

Note : BOF: Bullock Operated Farm; THF: Tractor Hired Farm; TOF: Tractor Operated Farm
I Cropping intensity calculated assuming sugarcane as one crop
II Cropping intensity calculated assuming sugarcane as two crops
Source : Patil et al., 1987

Table 8. Major Inputs and Annual Grain Equivalent Yield, 1995-1996

State	Annual Rainfall (mm)	% Irrigated area	Power (kW/ha)	Fertilizer (kg/ha)	Cropping intensity	Grain equivalent yield (ton/ha)
Jammu & Kashmir	617	40.0	0.71	69.8	1.48	2.01
Himachal Pradesh	494	13.1	0.61	50.9	1.71	2.40
Punjab	555	93.7	2.96	299.5	1.80	5.26
Uttar Pradesh	837	64.7	1.48	150.6	1.49	3.58
Haryana	494	78.6	2.33	202.5	1.68	3.63
Rajasthan	421	29.63	0.53	39.2	1.20	0.93
Assam	1449	27.9	0.56	18.2	1.42	1.61
Bihar	1024	44.3	0.82	93.5	1.38	1.91
West Bengal	1355	24.7	1.21	158.9	1.65	3.11
Madhya Pradesh	1021	25.2	0.71	42.2	1.24	1.38
Gujarat	609	31.1	0.90	81.1	1.13	1.08
Orissa	1123	28.6	0.48	37.7	1.38	1.23
Maharashtra	920	13.4	0.78	76.6	1.24	1.28
Andhra Pradesh	594	40.8	1.18	158.9	1.21	1.83
Karnataka	802	24.9	0.80	90.2	1.15	1.58
Tamil Nadu	950	53.6	2.00	135.4	1.21	2.81
Kerala	1927	19.3	0.86	90.5	1.36	1.45
Total	880	38.3	1.02	97.6	1.32	1.96

Source: Singh, Gajendra, 2001. Relationship between mechanization and agricultural productivity in various parts of India, AMA 32 (2): 68-76

cropping intensity was the highest in mechanised farms having tubewell and tractor (206.4%) followed by partially mechanised farms having only tubewell (176.6%) and non-mechanised farms (143.8%). Thus, facilities of assured tubewell irrigation and mechanical power helped the farmers in raising the cropping intensity on their farms significantly.

Singh (2001) summarized the availability of major inputs of crop production viz. percent irrigation, farm power, fertilizer and cropping intensity and grain equivalent yield for different States of India (Table 8) Singh argued that, cropping intensity was mainly dependent on annual water availability. Rainfall distribution in a year as well as the percent area irrigated in different seasons reflected the water availability. The State of Punjab had low annual rainfall of 555 mm concentrated mainly during three months (July, August, and September) but with 94 per cent area irrigated had a cropping intensity of 1.80. On the other hand, Assam with very high annual rainfall (1449 mm) but with limited area under irrigation (27.90%) had low cropping intensity of 1.42. Due to assured water supply throughout the year, the farmers in Punjab could use high yielding varieties and high doses of fertilizer. Assisted by high amounts of available power they were able to get high yields of the order 5.36 ton/ha, which were 2.1 times that of the national average.

The average annual yield of rice in India was about 2 t/ha. However, Punjab had already achieved an annual yield of 5.3 t/ha. If the whole of India could achieve this level of annual yield, a grain production, of over 500 million tons, enough to feed a population of 1.7 billion could be achieved. However, the yields obtained in many countries for a single crop were as high as 7 t/ha for rice in Korea, 7.6 t/ha for wheat in France and U.K. and 9.3 t/ha for maize in Italy. Thus, even Punjab had a potential for further enhancement of the crop productivity.

4. IMPACT OF MECHANIZATION ON EMPLOYMENT OF HUMAN LABOUR

The impact of farm mechanization on labour employment, particularly in a labour surplus country like India, has been a matter of concern and debate. The available evidences suggest that mechanization had helped in overall increase in employment of human labour.

A study by Rao and Singh (1964) on "Tractorization in Kanjhawala Block in Delhi Territory" had showed that both tractor as well as non-tractor farms had on an average 8.2 persons per farm and the labour force at their disposal was neither surplus nor inadequate.

GIPE, Poona (1967) concluded that tractorization generated greater demand for labour by facilitating more intensive cultivation. Thus, there was no significant displacement of human labour after tractorization. UPAU (1969) reported that mechanization accompanied by use of new seed technology and adoption of modern cultivation methods had a beneficial effect on employment. Kahlon (1969-70), reported that reduction in aggregate labour use on tractor-operated farms owning tubewells was only 1.3% as compared to bullock

Table 9. Utilization of Human Labour per Hectare in Western UP

Size-group (hectares)	Mechanized				Non-mechanized			
	Permanent		Casual	Total	Permanent		Casual	Total
	Family	Hired			Family	Hired		
I. Below 6	65	20	53	138	86	35	69	190
II. 6-10	63	27	78	168	78	30	69	177
III. 10-15	53	28	108	189	67	24	85	176
IV. 15-20	46	37	91	174	60	51	71	182
V. Above 20	34	36	91	161	63	56	62	181
Average	45	33	91	169	68	43	69	180

Source: Singh, Roshan and B.B. Singh, (1972) "Farm Mechanization in Western UP – Problems of Farm Mechanization", Seminar Series – IX, Indian Society of Agricultural Economics, Feb. (Page 147).

operated farms. Billing and Singh (1970) studied the changes in the demand for labour. The aggregate impact of adopting the improved technologies in Punjab resulted in reduction of human labour employment to the tune of 11.5% compared to conventional level. In Maharashtra, the reduction was negligible at 0.2%. The study, however, failed to estimate the possible increase in human labour employment arising out of the increase in cropping intensity followed by mechanized cultivation.

Bhagwati Committee on Unemployment (1970) concluded that mechanization of agricultural operations, by and large, displaced bullock labour and not human labour. In another study, Johl (1970) reported that increased use of tractors was associated with marked rise in employment due to their effect on cropping intensity.

AERC, Delhi (1970-71) conducted a study on a sample of 96 farms in Haryana. It was concluded that the use of tractors had, in most cases, displaced only one pair of bullocks. The overall human labour input for crop production per cultivated hectare was practically the same for both types of farms. USAID, New Delhi (1970-71) conducted a study to assess the impact of tractorization. It was concluded that the large scale adoption of high yielding varieties accompanied by higher use of chemical fertilisers and enhanced cropping intensity led to higher demand for farm labour. Permanent labour on tractor holdings showed a decline to the tune of 2.2% compared to the conventional level. The employment of casual male labour showed an increase of 38.5%. In respect of labour employment, the increase was even higher at 80%. A tractor on an average displaced four bullocks.

Babu (1971) conducted a study in West Godavari district of Andhra Pradesh and reported that tractor use induced changes in cropping pattern which promoted the demand for human labour. Grewal (1972) reported that the employment of bullock labour on mechanized farms was 85 per cent less than those, which used only bullock labour for farm operations. The average reduction in labour input on mechanized farms was 11.9 per cent in comparison to non-mechanized farms. The average output per man-days on tractor-operated farms was about 42 per cent higher than on bullock operated farms. According to Harrington (1972) restraint on the rate of agricultural mechanization was necessary to solve the problem of under-employment in India. In his opinion, more labour would be employed for land preparation, water management, weed control, insect and disease control, harvesting and threshing when higher yields were obtained by adopting HYV technology.

Singh and Singh (1972) conducted a study in Muzaffarnagar district of Western U.P. and observed that mechanization did not displace labour significantly. The average human labour employment per hectare on mechanized farms was 169 man-days as compared to 180 man-days on non-mechanized farms, which was only 6.1 per cent less. It was concluded that displacement of human labour was significant only on mechanized farms in the size group of 15-20 ha and above (Table 9).

NCAER (1973) studied the impact of mechanization on employment in Muzaffarnagar district of Uttar Pradesh (Table 10). It was concluded that the labour input per hectare increased as one switched over from non-mechanized farms to farms using tubewells in both small and medium size groups. In small tubewell farms, the increase was much larger over non-mechanized farms. When a thresher in addition to a tractor and tubewell was acquired, there was additional labour input per hectare for crop cultivation in both small and medium sized farms as compared to tractor plus tubewell farms. The mechanized small farms used 5.7 per cent more labour. Labour displacement was observed on medium size farms during initial stages of mechanization. As the level of mechanization increased, there was a

Table 10. Labour Input per Cultivated Hectare by Farm Size and Level of Mechanization

Activity	Small Farms	Medium Farms	Large Farms
TTT			
Crop culture	188.7	118.9	118.9
Sundry farm activities	95.2	46.2	47.0
ALL FARM ACTIVITIES	283.9	165.1	165.9
NON-FARM ACTIVITIES	6.0	2.9	1.7
DISPLACED MALE FAMILY LABOUR*	–	25.6	–
TOTAL	289.9	193.6	167.6
TT			
Crop culture	181.5	108.1	–
Sundry farm activities	69.4	58.2	–
ALL FARM ACTIVITIES	250.9	166.3	–
NON-FARM ACTIVITIES	5.7	3.1	–
DISPLACED MALE FAMILY LABOUR**	47.2	33.1	–
TOTAL	303.8	202.5	–
T			
Crop culture	269.3	161.1	113.0
Sundry farm activities	94.4	43.0	19.8
ALL FARM ACTIVITIES	363.7	204.1	132.8
NON-FARM ACTIVITIES	–	–	–
DISPLACED MALE FAMILY LABOUR***	–	–	–
TOTAL	363.7	204.1	132.8
NM			
Crop culture	178.5	128.4	–
Sundry farm activities	80.5	44.9	–
ALL FARM ACTIVITIES	259.0	173.3	–

Note : *Displacement in TTT level over TT level; **Displacement in TT level over T level; ***Displacement in T level over NM level; TTT = Tubewell + Tractor + Thresher; TT = Tubewell + Tractor; T = Tubewell; NM = Non-Mechanised.

Source: NCAER, 1973, "Impact of Mechanization in Agriculture on Employment," New Delhi, National Council of Applied Economic Research, P. 54.

significant gain in labour employment. It was not possible to assess the labour input for several non-farm activities directly related to the use of tractors and farm equipment. If this was also taken into account, the labour input for each level of mechanization might go up further correspondingly.

AERC, Viswa Bharati (1973-74) conducted a study on a sample of 60 farms in Shahabad District of Bihar. It revealed that the displacement of human labour in terms of value of all the inputs was 11.6% in case of farms owning tractors and 5.1% in case of farms using tractors. The maintenance of tractors by the first category of farms led to additional employment of labour, which more or less compensated for displacement of labour in farming operations. Animal power was completely replaced by tractor power by the farms in the first category, while the farms in the second category continued to make partial use of animal power combining it with tractor-hire services.

NCAER (1974) conducted a survey of tractorised and non-tractorised farms in 9 States to study the impact of tractorization on employment, economics of tractorization, horsepower preferences and subsidiary uses of tractors. According to this study, the use of human labour on the tractorized farms was lower by less than 7 per cent in the case of paddy HYV and less than 8 per cent in the case of wheat HYV compared to the use of human labour on non-tractorised farms growing these crops. In the case of paddy, tractor using farms showed a 3 percent higher use of human labour compared to farms using animal labour. A tractor replaced the bovine stock to the extent of 50 per cent.

IIM, Ahmedabad (1975) concluded that tractorization did not lead to decrease in human labour employment. On the contrary, it helped in relaxing the constraints of the operational area which increased employment on farms significantly. In fact, tractor farms employed more casual and permanent labour. Another study by IIM (1975) covered a sample of 161 farms drawn from three major crop zones of Gujarat State. The study revealed that tractor farms utilized less human labour as compared to custom farms and bullock farms. As the level of mechanization increased, use of bullocks steadily decreased. However, upto a certain intermediate level of tractor use, only bullock power was displaced. Beyond this stage, a marginal reduction in manual labour was also observed.

IEG, Delhi (1975) analysed the economics of technological changes such as the use of high yielding varieties of seeds, tractorization etc. in Indian agriculture. The study covered the country as a whole with main focus on Punjab and deltaic Andhra Pradesh. The study reported that the technological displacement of labour associated with tractor use was compensated by the employment of labour owing to increased yield as a result of tractor use among farms characterized by partial tractorization. The net employment effect of tractor use turned out to be positive when its complementarity with other techniques was taken into account.

Rao (1975) considered the effect of tractor use on employment by comparing farms, which owned tractors with those that did not. He concluded that the tractors had neutral effect on farm employment. Based on a study conducted in Tiruchirapalli district of Tamil Nadu, AERC, Madras (1975-76) reported that the human labour input accounted for 32 per cent for bullock farms while it accounted for 22 to 23 per cent for the tractor-owing and tractor hiring farms.

ITES, Madras (1975) studied the displacement of labour due to mechanization of agriculture on a total

sample of 510 farmers under three levels of mechanization in seven districts of Tamil Nadu. The study covered the principal crops of the State and revealed that the displacement of labour due to mechanization was more than offset by the employment created through increased production, additional area brought under cultivation and higher intensity of cropping. An additional area of about 425 ha was brought under cultivation in 170 farms selected for the study with an average value of 2.5 ha per farm. Additional human labour employment varied from 96.22 to 559.52 man-days giving an average value of 330.57 man-days per farm.

Singh and Singh (1975) in their study on "Impact of Farm Mechanization on Human and Bullock Labour use" in two regions of U.P. reported that for seed bed preparation, one hour use of tractor replaced 5.12 labour-days whereas the corresponding figures for medium and large farms were 1.61 and 1.29 labour days respectively. Likewise, the magnitude of decrease in labour employment due to an additional one hour use of tractor in land preparation decreased with an increase in farm size in Meerut District. An additional hour of tractor would replace 1.04, 0.76 and 0.13 human and bullock labour days on small, medium and large farms respectively. Thus, the rate of labour displacement through tractorisation was higher on relatively small farms of Jaunpur District than large farms of Meerut District of U.P. This was obvious because the negative relation between cropping intensity and farm size was steeper for bullock farms than for tractor farms.

In a comparative study of tractorised and bullock operated farms in Purnea district of Bihar, Singh and Goswami (1977) reported that the human labour days employed on an average cropped hectare on tractorised farm worked out to 87.6 man-days with 113.9 man-days on custom-hiring farms and 120.6 man-days on bullock operated farms which were reduced to 3.10 per cent on tractorised farms (Tables 11 & 12). The percentage share of labour requirement for interculture, irrigation, harvesting and threshing operation was higher in case of tractorised farms as compared to bullock operated farms.

NCAER (1980) studied the implications of tractorization on employment adopting a cross-section comparison of tractorised households with bullock-operated farms. In conventional practice, the bullocks provided the motive power and implements were guided by human labour. Certain amount of human labour displacement was inevitable in the operations where a tractor was employed. However, tractorized farms produced more output on a hectare of land by following

Table 11. Human Labour Employment Days for Different Operations on an Average Farm per Cropped Acre for Different Types of Farms

Type of Farm	Unit	Preparatory Tillage	Sowing and Transplanting	Inter-culture	Manu-ring	Irrigation	Harvesting & threshing	Total
Tractorized	Per farm	90.2	554.9	1049.6	7.8	59.4	1064.4	2826.3
	Per acre	1.1	7.0	13.2	0.1	0.7	13.4	35.5
	%age to total	3.10	19.73	37.18	2.28	1.97	37.75	100.00
Custom- Hiring	Per farm	251.1	271.0	341.5	7.4	19.7	376.8	1267.5
	Per acre	9.1	9.9	12.4	0.3	0.7	13.7	46.1
	%age to total	19.14	21.48	26.90	0.65	1.51	29.72	100.0
Bullock- Operated	Per farm	226.8	182.4	181.4	10.3	14.4	277.9	893.2
	Per acre	12.4	10.0	9.8	0.6	0.8	15.2	48.8
	%age to total	25.42	20.49	20.08	1.23	1.64	31.14	100.0

Source: Singh, RP. & H.G. Goswami, (1977) "A Comparative Study of Tractorised and Bullock Farms in Purnea District (including Katihar), Bihar", Agro-Economic Research Centre, University of Allahabad, Allahabad.

Table 12. Extent of Human Labour Days Classified by Category of Labour and the Farm

Type of Farm	Unit	Causal labour	Permanent labour	Family labour	Total
Tractorized	Per farm Per acre	2568.4	179.7	78.2	2826.3
	%age to total	20.88	6.36	2.76	100.00
Custom- Hiring	Per farm Per acre	953.4	263.3	50.8	1267.5
	%age to total	75.22	20.67	4.01	100.00
Bullock- Operated	Per farm Per acre	577.0	219.8	96.4	893.2
	%age to total	64.60	24.61	10.79	100.00

Source: Singh, RP. & H.G. Goswami, (1977) "A Comparative Study of Tractorised and Bullock Farm in Purnea District (including Katihar), Bihar", Agro-Economic Research Centre, university of Allahabad, Allahabad.

Table 13. Human Labour Input per Hectare in Different States (Unit in man-days)

State	Tractor-owner	Tractor-user	Bullock-farm
Punjab	75.5	78.9	89.3
Haryana	56.4	54.5	66.8
Uttar Pradesh	96.1	449.6	131.3
Tamil Nadu	195.0	177.8	173.7
Andhra Pradesh	82.6	68.3	85.1
Gujarat	61.6	55.8	52.6
Maharashtra	206.6	184.3	134.6
All States	110.5	105.6	104.8

Source: NCAER (1980). Implications of Tractorisation for Farm Employment, Productivity and Income-Summary and Highlights, New Delhi.

more scientific agronomic practices and applying optimal doses of material inputs and thereby provided employment to more labour. Tractorised farms also raised commercial crops on a relatively larger area. Such changes in the cropping pattern had a favourable impact on the total employment. Table 13 provides the details on per hectare employment of human labour on tractorized and non-tractorized farms based on the NCAER study. An average tractor owner employed 110.5 man-days per cropped hectare as compared to 104.8 man-days by bullock farms. Thus, the aggregate employment of tractor owners was 5.4 per cent higher than that provided by bullock farms. Tractor-using farms as a group employed 0.8 per cent additional man-days on a cropped hectare as compared to bullock farms. The survey revealed that tractorized farms employed less number of persons in operations where a tractor was used, but more in other operations. This helped in increasing the aggregate employment.

Aggarwal (1983) concluded that the tractors replaced mainly family labour time on small farms and permanent labour time on large ones. Use of threshers displaced mainly family and casual labour time on small farms and family and permanent labour time on large ones. The combined effect of family labour time was increased in the use of permanent and casual labour time on farms of most size groups. With the addition of power threshers, these effects were lessened.

Patil and Sirohi (1987) studied the employment per hectare of cropped area. The total labour employment was the highest on small farms and decreased as the farm size increased in respect of all categories of farms. The overall human labour employment was the highest for tractor operated farms followed by tractor plus bullock operated farms. The ratio of family labour to total labour employed per hectare decreased with an increase in farm size. On an average, the per hectare employment of hired labour and total labour was higher by 39 per cent and 24 per cent on tractor operated farms and by 43 per cent and 22 per cent on tractor plus bullock operated farms respectively than that of bullock operated farms. The higher percentage of hired labour employment with the increase in farm size, in general, and of tractor-owning farms in particular disproved the general opinion held regarding displacement of human labour by mechanized farming.

Sidhu and Grewal (1991) analysed human labour employment in Punjab based on the data collected for the agricultural year 1981-82 under tractor operated farms and tractor operated plus combine harvester using farms. The study showed that tractorisation did not replace human labour. There was no significant difference in human labour use on tractor operated farms and bullock operated farms. The introduction of harvester combines, however, significantly reduced the use of human labour on the farms.

Balishter, Gupta and Singh (1991) reported human labour utilisation based on their study conducted in Mathura district of Uttar Pradesh for the crop year 1984-85. Table 14 presents human labour utilization per hectare at different levels of mechanization. It was reported that in absolute terms, there was no decrease in human labour employment due to mechanization. In fact, there was an increase which could be attributed to increase in the cropping intensity and shift in cropping pattern from less labour intensive to more labour-intensive crops. It was also reported that with mechanization, the demand for hired labour increased while participation of family labour in crop production declined. Thus, mechanization reduced the use of family labour while it increased the use of hired labour.

Almost all the studies which reported reduction in human labour employment resulting from mechanization attributed it largely to loss of human

Table 14. Human Labour Utilization per hectare at Different Level of Mechanisaton

S. No.	Category of Farms	Man-days per cultivated hectare		
		Family labour	Hired labour	Total
1	Non-mechanized having neither tubewell nor tractor	132.44	64.22	196.66
2	Partially mechanised having only tubewell	111.97 (-10.9)	89.60 (+39.5)	201.57 (+5.5)
3	Mechanised having both tubewell and tractor	110.00 (-16.9)	102.04 (+58.9)	212.04 (+7.8)

Note : Figures in parentheses indicate percentage increase (+) or decrease (-) over non-mechanised farms.

Source: Balishter, Gupta, V.K. and Singh, R. (1991) Impact of Mechanization on Employment and Farm productivity, Productivity, 32(3); 484-489.

Table 15. Comparative Position of Labour Use (Man-days) Matching Size Bullock and Tractor Farms

Crop Regions	Size Group Compared (Range in Acres)	Labour Use Bullock Operated	Labour Use Tractor Operated	Percent over Reduction Bullock Operated Farm
Rice	20-30	41.03	39.77	3.07
Groundnut	25-35	33.12	35.84	-8.21
	50-60	26.95	29.67	-10.09
Potato	10-20	87.59	122.59	-39.96
Sugarcane	20-30	49.12	45.35	7.68
Overall average		45.52	46.61	-2.39
Average Excluding Potato Regions		37.23	35.97	3.98

Source : Grewal, S.S. and Kahlon, A.S. (1972) "Farm Mechanization and Labour Employment". Agricultural Situation, August.

labour associated with maintenance of bullock labour hours, which got reduced as a result of mechanization. But the more important reason seemed to be wrong inferences drawn from unadjusted farm size, and a comparison of labour use made on all sizes of bullock operated farms with that of large tractor operated farms. Thus, in the presence of mixed effects of farm size and all other variables on employment, it was difficult to lean heavily on the findings of these studies. Grewal and Kahlon (1972) attempted to control such variables as irrigation and farm size at the sampling stage. Their study showed that in the situation of matching size farms, the labour use on tractor farms was higher than that of bullock farms in case of groundnut, cotton and potato regions. On the other hand, there was a decline of 3.38 per cent in labour use in general crop farming area. In making this comparison, it was hypothesized that when bullock operated farms falling in the upper size brackets switched over to the use of tractors, with farm size undergoing no change, there was no reduction in human labour employment. Table 15 supported this contention. There was no decline in labour use in these situations because cropping intensity and crop yields that were low on large sized bullock operated farms recorded an increase with the introduction of tractors which resulted in increased labour use.

Desai and Gopinath (1975) in their study on "Impact of Farm Tractorization on Productivity and Employment (Gujarat State)" reported that the effect of tractor use was positive on employment. According to this study, with an increase of every hectare in area, the

Table 16. Employment of Human Labour Hours per cropped Hectare, 1973-74

		Pure Bullock Farms				Bullock with Custom Farms				Pure Tractor Farms			
Zone	Strata	F.L.	P.L.	C.L.	T.L.	F.L.	P.L.	C.L.	T.L.	F.L.	P.L.	C.L.	T.L.
I	1	347.56	69.03	111.71	528.30	271.98	94.20	130.10	496.28	137.32	132.22	139.39	408.93
	2	161.02	70.21	241.25	472.48	160.96	44.09	330.50	535.55	68.80	102.38	416.54	587.72
	3	132.60	142.33	181.52	456.45	136.54	126.70	220.57	483.81	32.95	121.03	203.19	357.17
II	4	269.02	42.74	167.71	479.47	180.98	87.27	250.78	519.03	99.06	120.00	272.86	491.92
III	5	231.72	115.65	108.71	456.08	124.09	204.40	122.56	451.05	-	-	-	-
Overall													
1973-74		231.24	94.08	149.04	474.36	172.38	116.32	205.90	494.60	93.57	119.34	256.30	469.21
1972-73		219.74	124.02	188.25	532.01								

Contd.....

		Tractor with bullock Farms				Large Tractor Farms				Difference			
Zone	Strata	F.L.	P.L.	C.L.	T.L.	F.L.	P.L.	C.L.	T.L.	1973-74 1972-73	1973-74 1972-73	1973-74 1972-73	1973-74 1972-73
I	1	188.97	134.31	142.01	465.29	135.69	199.45	124.66	379.80	* **	NS -	NS -	NS **
	2	150.13	68.58	251.36	470.07	31.72	92.92	525.78	650.42	* **	NS -	* -	NS -
	3	104.33	117.15	181.18	402.66	54.24	104.90	144.33	303.47	* -	NS -	NS -	NS -
II	4	139.67	73.84	252.64	466.15	82.13	87.45	343.25	422.83	* **	NS -	* -	NS -
III	5	157.64	176.46	112.76	446.86	44.25	158.26	18.08	347.19	* -	* -	NS -	NS -
Overall													
1973-74		147.20	125.01	75.35	447.56	69.54	117.23	210.64	397.41				
1972-73		136.82	124.66	209.56	471.04								

Note : The analysis for 1972-73 was based on two categories of bullock and tractor operated farms.
*Significant at 5% level; **Significant at 1% level; F.L. = Family Labour; P.L. = Permanent Labour; C.L. = Casual Labour; T.L. = Total Labour.

Source : Kahlon, 1978

Table 17. Percentage Change in Employment of Human Labour per cropped Hectare due to Tractorization

Zone	Strata	From pure bullock to bullock with custom service				From pure bullock to pure tractor				From pure bullock to tractor with bullock			
		F.L.	P.L.	C.L.	T.L.	F.L.	P.L.	C.L.	T.L.	F.L.	P.L.	C.L.	T.L.
I	1	-21.74	+36.46	+16.46	-60.06	-60.49	+91.54	+24.78	-22.59	-45.63	+94.56	+27.12	-11.92
	2	-0.03	-37.20	+36.99	+13.35	-57.27	+45.82	+72.66	+24.39	-6.76	-2.12	+4.19	-0.51
	3	+29.70	-10.98	+21.51	+5.99	-75.15	-14.96	+11.94	-21.75	-21.32	-17.69	-0.19	-11.78
II	4	-32.72	+104.19	+49.53	+8.5	-63.18	+80.77	+62.69	+2.59	-48.08	+72.76	+50.64	-2.77
III	5	-46.45	+76.74	+12.74	+1.10	-	-	-	-	-31.97	+52.58	+3.72	-2.02
Overall													
1973-74		-25.45	23.64	+10.15	+4.26	-59.53	+26.85	+71.96	-1.08	-36.34	+32.87	+17.65	-5.64
1972-73		-37.74	-0.52	-11.32	-1.46		-		-	-	-	-	-

Zone	Strata	From bullock with custom service to pure tractor				From bullock with custom service to tractor with bullock				From pure tractor to tractor with bullock			
		F.L.	P.L.	C.L.	T.L.	F.L.	P.L.	C.L.	T.L.	1973-74 1972-73	1973-74 1972-73	1973-74 1972-73	1973-74 1972-73
I	1	-49.51	+40.49	+7.14	-17.60	-30.52	+42.58	+9.15	-9.24	+37.1	+1.58	+1.88	+13.78
	2	-75.89	+132.20	+26.03	+9.74	-6.73	+5.54	-23.94	-12.22	+118.21	-33.01	-39.64	-19.95
	3	-75.56	+4.47	-7.88	-26.17	-23.59	-7.53	-17.86	-16.77	+216.63	-3.20	-10.83	+12.73
II	4	-45.26	+34.50	+8.80	-5.22	-22.82	-15.39	-0.74	-10.19	+40.99	-38.46	-7.41	-5.23
III	5	-	-	-	-	+27.03	-33.66	-7.99	-0.94	-	-	-	-
Overall													
1973-74		-45.72	+2.59	+24.47	-5.13	-14.60	+7.47	-14.83	-9.91	+57.31	+4.75	-14.83	-4.61

Source: Kahlon, 1978

employment went up by 29.43 and 38.74 man-days on tractor and custom hiring farms. The study showed that for every hundred rupees increase in output, employment increased by 3 days on tractor and 2 days on custom and bullock farms, thereby showing a close relationship between output and employment. Thus, the positive impact of rapid growth in output on employment could offset the effect of displacement of human labour by tractor power. These results rejected the findings of Binswanger (1978) who observed that tractor farms had much less labour input per unit of output and measured in this way, labour displacement could be very large. No doubt, a technical change could reduce demand for factors including labour per unit of output, but the expansion in production would be more than enough to offset this reduction, which means the rapid growth in output would bring about not only increase in productivity but also increase in employment, as had happened in the Punjab situation. Rao (1972) argued that 'tractors would not lead to unemployment in regions of expanding agricultural output because they were in response to genuine shortage and high cost of draft power. In so far as tractors saved the resources allocated for maintaining draft animals and enabled an increase in output by raising cropping intensity and yield per hectare, their use proved socially beneficial in the context of the shortage and high prices of agricultural commodities.

Kahlon (1978) studied the "Impact of Mechanization on Punjab Agriculture with special reference to Tractorization" under a Bank study. The pattern of employment of human labour per holding showed that family labour was employed more on the pure bullock farms, causal labour was hired more on the pure tractor farms and permanent labour was employed more on the tractor with bullock farms. It was found that family labour increased by 17.65 per cent with shift from pure bullock to tractor plus bullock technology and total labour employment per cropped hectare declined by just 5.64 per cent (Tables 16 & 17). Assuming simultaneous nature of relations in the employment of family labour, hired labour and permanent labour, the demand function was fitted for various categories of labour, using two stage least squares technique. The study showed that as for the geometric means for other factors affecting labour demand, the total labour input increased very slightly on pure tractor farms, 512.12 man hours per hectare, in comparison with 504.97 man hours on pure bullock farms, with very little change in the composition on the labour force.

Kahlon's study showed that total labour employment per cropped hectare did not fall by any significant

amount on tractorised farms except on very large tractor farms of an average size of 23.28 hectares which had further declined in number owing to laws of inheritance and ceilings on holdings. There was enough evidence to show that the large bullock operated farms, when mechanised, were able to obtain a cropping intensity and employment that matched well with small and medium bullock operated farms and this gain from the introduction of the tractors could not be minimized. Studies made by Kahlon, Grewal, Verma and Sharma supported these results. Verma (1972) reported that on small and medium size farms, the increase in the requirement of labour due to increased cropping intensity was not enough to compensate for the decrease in the requirement of labour due to mechanization. However, on large farms, higher cropping intensity increased the requirement of labour more than the labour displaced due to mechanization. Again Sharma (1976) observed that if resources were optimally used and multiple cropping (three crops a year) was adopted and working capital was liberally available, farm mechanization did not create unemployment. Mechanization created unemployment if capital was not freely available on mechanized farms. The study indicated that although farm mechanization decreased labour employment per hectare, the use of multiple cropping and credit on these farms could offset this effect (Tables 18 and 19). Binswanger interprets this to say 'that in all cases where

Table 18. Human Labour Employment of Different Levels of Mechanization in Gheora Soil Zone, Delhi (1971-72)

(Man-Hours)

Category	Size of Holding (Acres)	Optimal Plans							
		Without Multiple cropping				With Multiple Cropping			
		Restricted Capital and Existing Fertilizers		Unrestricted Capital and Existing Fertilizers		Restricted Capital and Existing Fertilizers		Unrestricted Capital and Existing Fertilizers	
		Total	Per Acre	Total	Per Acre	Total	Per Acre	Total	Per Acre
Non-Mechanised Farms	6.00	3729	621 (291.55)*	3589	598 (194.79)	4206	701 (229.08)	4066	678 (170.35)
Partly Mechanised Farms	9.25	4854	525 (246.48)	5325	576 (187.62)	5627	608 (198.69)	6188	669 (168.09)
Mechanized farms	23.50	5015	213 (100.00)	7208	307 (100.00)	7187	306 (100.00)	9353	398 (100.00)
Custom Hiring Farms	4.00	1877	469 (220.12)	1881	470 (153.00)	1912	478 (156.21)	1912	478 (120.10)

Note :*Figures in parentheses give the percentage to the mechanised farms.
Source: Sharma, Brij Mohan, (1975) Farm Labour Employment and Income Implications of Multiple Cropping, Fertilizer, Credit Use and Farm Mechanization- A Normative Analysis for farms in Alipur block (Delhi), p 99, Unpublished Ph.D. Thesis, I.A.R.I.

Table 19. Human Labour Employment of Different Levels for Mechanization in Alipur Soil Zone, Delhi (1971-72)

(Man-Hours)

Category	Size of Holding (Acres)	Optimal Plans							
		Without Multiple cropping				With Multiple Cropping			
		Restricted Capital and Existing Fertilizers		Unrestricted Capital and Existing Fertilizers		Restricted Capital and Existing Fertilizers		Unrestricted Capital and Existing Fertilizers	
		Total	Per Acre	Total	Per Acre	Total	Per Acre	Total	Per Acre
Non-Mechanised Farms	6.50	3501	539 (139.64)*	3501	539 (124.19)	3837	590 (121.15)	3979	612 (91.34)
Partly Mechanised Farms	11.00	5035	458 (118.65)	5479	576 (114.75)	5300	482 (98.97)	7351	668 (99.70)
Custom Hiring Farms	3.00	2067	689 (178.50)	1712	470 (131.34)	1883	627 (128.75)	2044	631 (101.64)
Mechanized farms	16.0	6368	386 (100.00)	7164	434 (100.00)	8036	437 (100.00)	11056	670 (100.00)

Note :*Figures in parentheses give the percentage to the mechanised farms.
Source: Sharma, Brij Mohan, (1975) Farm Labour Employment and Income Implications of Multiple Cropping, Fertilizer, Credit Use and Farm Mechanization- A Normative Analysis for farms in Alipur block (Delhi), p 99, Unpublished Ph.D. Thesis, I.A.R.I.

there was substantial increase in labour use by tractor farms, it was associated with shifts in cropping pattern or irrigation which were an outgrowth of the better overall capital availability rather than that of the tractors per hectare'. One wonders if all this development would come about in the absence of mechanization. If not, why separate out these effects through mechanistic statistical tests.

It would not be out of place to mention that most of the mechanization studies were conducted during the early years of the introduction of the tractors i.e. during 60's and 70's. The opposition to this technology and particularly to the introduction of tractors was based on the findings of some of these studies, which showed that the differences in timeliness of operations and productivity per hectare did not come out to be statistically significant on tractor farms as compared with bullock farms. While quoting such findings, the limitations of inadequate infrastructure for machinery maintenance and repair and the time it took to master the mechanical skills, which largely contributed to these results, were conveniently forgotten. Against this background, it would be wrong to conclude that tractorization did not improve the timeliness and output of farm operations or increased secondary and tertiary employment only marginally.

5. IMPACT OF MECHANIZATION ON SUBSIDIARY AND NON-FARM EMPLOYMENT

Different studies conducted on farm mechanization indicated that net human labour displacement in agricultural operations was not significant and it was more than compensated by increased demand for human labour due to multiple cropping, greater intensity of cultivation and higher yields. On the other hand, the demand for non-farm labour for manufacture, services, distribution, repair and maintenance as well as other complementary functions increased substantially and helped in relieving rural unemployment to some extent. Mechanization in agriculture provided indirect employment to skilled and unskilled persons engaged in operation, repair and maintenance of prime movers and farm equipment.

ITES, Madras (1977) quantified the number of persons employed in maintaining the tractors and operating them in the field. Table 20 gives the extent of indirect employment generated in the government and private organizations at the district level including private workshops.

As evident from Table 18, mechanization in agriculture in seven selected districts had provided employment to 3651 persons per year. Agricultural

Table 20. Indirect Employment generated by Farm Mechanization in Selected Districts

Sr. No.	District	No. of Persons employed
1	Chingelpet	403
2	South Arcot	473
3	North Arcot	439
4	Tiruchirapalli	467
5	Thanjavur	695
6	Coimbatore	528
7	Madurai	646
	Total	**3651**

Source: ITES (1977). Mechanization in Agriculture and Labour Substitution in Tamil Nadu. Report of Institute for Techno-economic Studies, Madras.

households undertook subsidiary farm activities including dairying, poultry-keeping etc. The survey conducted by NCAER (1980) provided details of employment created through such activities and taken up by different households as shown in Table 21.

Table 21. Subsidiary Employment per Hectare (Man-days)

	Tractor-owner	Tractor-user	Bullock-farm
Family labour	17.6	33.7	48.6
Hired labour	11.6	10.1	7.0
Total labour	29.2	43.8	55.6

Source: NCAER (1980). Implications of Tractorization for Farm Employment, Productivity and Income. Summary and Highlights.

Though, the total subsidiary employment of tractor owners and users was less than that of bullock farms, they employed more hired labour. Thus, demand for hired labour in case of tractorised farms had increased both in case of crop production and subsidiary activities. The non-farm employment generated by mechanization provided employment through manufacture of farm machinery, distribution of the spare parts, fuel and lubricants and repair and maintenance of tractors, engines, and other machines. Thus, the marginal loss in direct farm employment resulting from farm mechanization was more than offset by non-farm employment in agro-industrial activities and secondary and tertiary sectors of the economy.

NCAER (1980) assessed the employment in the manufacture, distribution, repair and servicing of tractors based on sample survey of private repair workshops and manufacturer's authorised service establishments. It was concluded that a private repair shop, in general, generated employment of 22.2 man-days per tractor per year.

According to Baig (1978), there was labour displacement in the area of ploughing and transport

which was, however, more than compensated by higher employment in other agricultural operations notably, fertilizing, weeding, interculture, pest control, irrigation, harvesting, threshing etc. Tractors also generated indirect employment in providing skilled and semi-skilled work in distribution, maintenance, service etc. The estimated employment pattern is summarized as below:

Indirect Employment due to use of Tractors

I. Employment in the organised sector	
(a) Employment in 12 operating tractor plants	15,000
(b) Employment in the auto-ancillary industries 28% of their total employment of 1,60,000 workers.	45,000
Total	60,000
II. Employment in rural based small industries	
(a) Manufactures of Implements, Trailers and accessories:	
(i) 20% value of 40,00 new tractors 36 crores of which 40% labour-14.4 crores @ 200 p.m.	60,000
(ii) Purchase by 3,50,000 old tractors @ 2000/- p.a.- 70 crores of which 40% labour –28 crores support workers @ 200 p.m.	1,17,000
(b) Sales, service & repairs	
(i) 1,200 authorised dealer points	12,000
(ii) Repairs of 3,50,000 tractors @ 2,500 p.a.–87.5 crores of which 40% labour –35.5 crores support @ 200/- per worker	97,000
(c) Sales of diesel & lubricants (10% of total of POL outlets)	14,000
Total	3,00,000

6. IMPACT OF MECHANIZATION ON NON-FARM INCOME

Mechanization has generated many non-farming and subsidiary activities among the farming households. On one hand additional employment was created in the manufacture of farm machinery, distribution of the equipment and spare parts, fuel and lubricants, repair and servicing etc., on the other hand many subsidiary activities like dairying and poultry keeping got generated. NCAER (1980) showed that tractorised farms reduced their draught animal stock and increased their milch stock. Tractor-owners and tractor-users had 82% and 25% more milch cattles, respectively as compared to bullock farms.

A tractor owner was able to increase his household income by undertaking supplementary activities such as dairying and provisions of custom-hiring. A tractor-owner with a land holdings of 6.28 ha, had an average gross income of Rs. 47,534 which exceeded that of a bullock farm and tractor-user household by 285% and 132%, respectively (NCAER, 1980).

7. IMPACT OF MECHANIZATION ON GROSS FARM INCOME AND NET RETURN

Farm mechanization has greatly helped the farming community in the overall economic upliftment. The studies conducted on impact of mechanization on farm income clearly support this view –point. AERC (1970 & 1971) conducted a series of studies related to economics of mechanization. These studies revealed that the gross income was higher on mechanized farms than non-mechanized farms. The gross crop output per cultivated hectare was reported to be Rs.3144 for tractor operated farms as compared to value Rs.2677 for bullock operated farms

NCAER (1974) reported that the tractor farms secured 21% more income per hectare of gross cultivated area compared to bullock farms. The net return per hectare of gross cropped area or net cultivated area was higher for tractorised farms than the non- tractorised farms as a result of better utilization of resources. Another study by NCAER (1980) revealed that the tractor owners and users derived higher per hectare gross income compared to bullock farms. The gross income per hectare of an average tractor-owned house hold was 63% higher than that of a household using only bullock labour. The gross income per hectare of tractor-using households as a group exceeded that of the bullock farms by 31%. The average net return from a tractor-owning farm on a cropped hectare exceeded that of a bullock farm by 152%. A tractor using farm also derived a net additional income of 84% over a bullock farm. A tractor-owning farm spent 57% more than bullock on material inputs and 62% more on human labour. An average tractor owner and user, inspite of spending more on cultivation expenses, derived higher net income on a cropped hectare compared to bullock farm. However, this should not be attributed entirely to tractor usage as other factors such as hybrid seeds, fertilizer and irrigation also contributed to it.

In the study in an irrigated area of Ahmednagar district of Maharashtra, Patil and Sirohi (1987) reported that, on an average, the gross return were higher by about 33 to 34% on tractor-owning farms than those on bullock operated farm.

Balishter and others (1991) reported that net return

per hectare from mechanized farms having tubewells and tractors and partially mechanized farms having only tubewell were 49% and 29% higher respectively than that from non-mechanized farms.

8. CONCLUSIONS

A common finding that emerged from various studies was that tractorisation displaced mainly bullock labour up to about 60% in some situations, but its impact on man-power was much less, the displacement being less than 15%. Various studies concluded that owing to this relatively low displacement of man power that was unavoidable, mechanization should not be viewed in isolation. Indeed, mechanization opened up new avenues for human employment such as managerial and supervisory jobs on the one hand and driving, servicing, maintenance and repair of the machines on the other. Therefore, recommended selective mechanization in an increasing manner for farms between 5-20 ha groups, which constituted 40% of the area under cultivation, and near total mechanization in operational holdings greater than 20 ha., which accounted for 13% of the cultivated area. NCA supported the view that animal, mechanical and electric power work complemented each other. NCA advocated tractorization for time bound operations like sowing, planting especially in rainfed areas where the operations were required to be completed in a short span of time while the rain occurred and for harvesting and threshing, as well as for non repetitive works such as land reclamation, levelling, terracing, eradication of wild-shrubs & perennial weeds like kans, (Saccharum spontaneum), as well as for command area development works.

Studies were also conducted by several other organisations & individuals on the impact of farm mechanization on agricultural inputs & outputs. Almost all such studies led to the following broad conclusions.

(i) That farm mechanization led to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labour.

(ii) That farm mechanization increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs.

(iii) That farm mechanization increases on- farm human labour marginally, whereas the increase in off- farm labour such as industrial production of tractors and ancillaries was much more.

(iv) That farm mechanization displaced animal power to the extent of 50 to 100% but resulted in lesser time for farm work.

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