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TRENDS IN FARM MECHANIZATION DURING THE POST-GREEN REVOLUTION PERIOD AND ASSOCIATED VARIABLES— AN INTER-STATE ANALYSIS*

The main objectives of this paper are to analyse (*i*) the trends in farm mechanization in India, (*ii*) to study the inter-State variations in and (*iii*) the variables associated with farm mechanization.

Trends in Farm Mechanization

Before the 'fifties there was no significant use of machines in Indian agriculture. Using the Quinquennial Livestock Census of India, the trends of the most important farm machines—tractors, oil engines and electric pumps—from 1951 to 1972 are given in Tables I and II. Information relating to wooden as well as iron ploughs is also shown. The percentage growth rate of machines and implements between the quinquennia is shown in Table I and their intensity is shown in Table II. Tractors, electric pumps and oil engines reach new heights in 1972. The rate of growth is the highest and more dramatic during the period 1966-1972. Throughout the period iron ploughs substituted wooden ploughs. Wooden ploughs even showed decreasing trend between 1966 and 1972. One would naturally attribute the dramatic rise in machines to the 'Green Revolution' which has started in the middle 'sixties and spread during this period.

* The author is grateful to Prof. G. Parthasarathy, his research director for valuable comments on earlier drafts of this paper.

TABLE I—PERCENTAGE RATE OF GROWTH OF SELECTED MECHANICAL EQUIPMENTS FOR THE QUINQUENNIA BETWEEN 1951-72: ALL-INDIA

Year	Wooden ploughs	Iron ploughs	Tractors	Electric pumps	Oil engines
1951					
1956*	16.0	46.9	145.9	118.0	48.7
1961*	7.0	68.1	28.8	192.2	88.1
1966*	4.0	53.3	99.8	143.8	95.3
1972	—1.5	52.1	244.1	314.3	262.5

* Tara Shukla, *op. cit.*

TABLE II—TRENDS IN SELECTED MECHANICAL EQUIPMENTS PER 100 OR 1,00,000 ACRES OF NET SOWN AREA: ALL-INDIA

Year	Wooden ploughs (per 100 acres)	Iron ploughs (per 100 acres)	Tractors (per 1,00,000 acres)	Electric pumps (per 1,00,000 acres)	Oil engines (per 1,00,000 acres)
1951	11.00	0.31	2.9	8.4	27.6
1956	11.89	0.43	6.6	17.2	38.3
1961	12.19	0.69	8.1	48.0	68.9
1966	11.79	1.04	15.0	115.4	132.7
1972	11.41	1.56	53.4	469.8	472.7

Inter-State Variations in Farm Mechanization

As there is a spectacular rise in farm mechanization during the period 1966 to 1972, the study of inter-State variations is restricted to the quinquennium 1966 and 1972.[1] The number of tractors, oil engines and electric pumps per 1,00,000 acres of net sown area and their rates of growth (State-wise) are shown in Tables III, IV and V respectively. In tractorisation, Punjab,[2] Kerala, Uttar Pradesh and Gujarat occupy the top positions whereas West Bengal, Assam, Karnataka, Orissa and Madhya Pradesh occupy the lowest ranks in 1972. Kerala, which occupied the tenth position in 1966 has improved its level and claims the second rank in 1972 whereas the position of Assam has gone down to fourteenth from fourth during the same period. In the case of oil engines, Gujarat, Punjab, Tamil Nadu, and Uttar Pradesh occupy the top positions while West Bengal, Orissa, Rajasthan and Madhya Pradesh occupy the bottom ranks in 1972. Punjab, Uttar Pradesh and Bihar occupy the sixth, eighth and twelfth ranks in 1966. By 1972 they

1. The trend and patterns of farm mechanization in India were studied by Tara Shukla and K. N. Raj upto 1966. See Tara Shukla, "Farm Mechanization—An Analytical Study of the Trend," Problems of Farm Mechanization, Seminar Series-IX, The Indian Society of Agricultural Economics, Bombay, 1972. K. N. Raj, "Mechanization of Agriculture in India and Sri Lanka (Ceylon)," *International Labour Review*, Vol. 106, No. 4, October, 1972.

2. In this paper Punjab refers to undivided Punjab which includes Haryana.

TABLE III—NUMBER OF TRACTORS PER 1,00,000 ACRES OF NET SOWN AREA AND RATE OF GROWTH : STATEWISE

State	1966	Rank	1972	Rank	Percentage rate of growth from 1966 to 1972	Rank
1. Andhra Pradesh . ..	10.5	8	25.1	9	140.5	10
2. Assam	14.0	4	10.9	14	—22.1	15
3. Bihar	10.6	7	35.7	6	242.4	5
4. Jammu & Kashmir ..	6.2	12	28.7	8	362.9	2
5. Kerala	8.1	10	142.4	2	593.8	1
6. Karnataka	10.3	9	11.4	13	196.7	7
7. Madhya Pradesh ..	6.0	13	12.7	11	174.5	9
8. Gujarat	13.6	5	46.5	4	229.0	6
9. Maharashtra	7.3	11	14.7	10	104.6	13
10. Orissa	4.5	14	11.9	12	134.9	11
11. Punjab	99.4	1	356.8	1	290.9	4
12. Rajasthan	11.8	6	32.1	7	188.4	8
13. Tamil Nadu	22.0	3	44.6	5	113.5	12
14. Uttar Pradesh	23.2	2	102.1	3	331.0	3
15. West Bengal	4.1	15	6.4	15	41.9	14

TABLE IV—NUMBER OF OIL ENGINES PER 1,00,000 ACRES OF NET SOWN AREA AND RATE OF GROWTH: STATEWISE

State	1966	Rank	1972	Rank	Percentage rate of growth from 1966 to 1972	Rank
1. Andhra Pradesh	170.0	4	420.0	5	150.0	10
2. Assam	6.3	13	—	—	—	—
3. Bihar	18.5	12	239.6	8	312.0	6
4. Gujarat	470.0	1	16,100.0	1	229.9	8
5. Jammu & Kashmir ..	1.1	15	—	—	—	—
6. Karnataka	98.0	7	168.0	9	75.0	11
7. Kerala	131.0	5	352.0	7	178.0	9
8. Madhya Pradesh ..	40.0	9	150.0	10	288.0	7
9. Maharashtra	328.0	2	383·0	6	18.5	13
10. Orissa	4.8	14	39.7	12	745.0	2
11. Punjab	99.4	6	1,599.1	2	3,602.0	1
12. Rajasthan	20.4	11	98.1	11	410.0	5
13. Tamil Nadu	288.0	3	1,492.0	3	446.0	4
14. Uttar Pradesh	64.5	8	481.4	4	632.0	3
15. West Bengal	30.9	10	35.4	13	20.0	12

have improved their positions spectacularly with second, fourth and eighth rank respectively. With regard to electric pumps Tamil Nadu, Punjab, Karnataka and Andhra Pradesh occupy the top most ranks whereas West Bengal, Rajasthan, and Madhya Pradesh occupy the lowest ranks in 1972.

TABLE V—NUMBER OF ELECTRIC PUMPS PER 1,00,000 ACRES OF NET SOWN AREA AND RATE OF GROWTH: STATEWISE

	State	1966	Rank	1972	Rank	Percentage rate of growth from 1966 to 1972	Rank
1.	Andhra Pradesh ..	206.0	2	520	4	153	11
2.	Assam	4.0	14	—	—	—	—
3.	Bihar	34.0	8	259	6	673	4
4.	Gujarat	61.5	6	208	8	225.9	9
5.	Jammu & Kashmir ..	7.0	12	—	—	—	—
6.	Karnataka	108.0	3	623	3	488.0	6
7.	Kerala	95.0	4	185	9	105.0	12
8.	Madhya Pradesh ..	15.0	10	132	10	881.0	3
9.	Maharashtra	84.8	5	374	5	347.6	7
10.	Orissa	1.0	15	—	—	—	—
11.	Punjab	56.0	7	763	2	1,541.0	1
12.	Rajasthan	14.0	11	96	11	627.0	5
13.	Uttar Pradesh	23.0	9	248	7	940.0	2
14.	Tamil Nadu	1,402.0	1	4,341	1	227.0	8
15.	West Bengal	5.0	13	14	12	218.0	10

The fluctuations in the ranks between 1966 and 1972 in the case of electric pumps are less when compared to the other two types of machinery. To see the inter-State variations in farm mechanization from another angle, the percentage share of selected Indian States in sown area and in agricultural machinery for 1972 and 1966 is given in Table VI. The most striking fact is that around 60 per cent of the total tractors in India are in the two States—Punjab and Uttar Pradesh in 1972. These two States accounted for around 50 per cent of tractors in 1966. Electric pumps are concentrated in Tamil Nadu both in 1966 and in 1972. Oil engines are less unevenly distributed among the States as compared to electric pumps and tractors. Even in respect of these, about 50 per cent of the oil engines are in three States—Gujarat, Punjab and Tamil Nadu in 1972. Maharashtra and Gujarat accounted for more than 50 per cent of the oil engines in 1966.

The share of oil engines in 1972 of Gujarat, Punjab, Tamil Nadu and Uttar Pradesh is greater than their share of net sown area. The share of electric pumps of Andhra Pradesh, Karnataka, Punjab and Tamil Nadu in 1972 is greater than their corresponding share of net sown area. Both in 1972 and in 1966 the share of tractors of Punjab and Uttar Pradesh only is greater than their corresponding share of net sown area.

TABLE VI—PERCENTAGE SHARE OF SELECTED INDIAN STATES IN SOWN AREA AND IN AGRICULTURAL MACHINERY

State	Net sown area (1969-70)	Share in agricultural machinery (1972)		
		Oil engine	Electric pumps	Tractors
1. Andhra Pradesh	8.2	7.1 (10.4)	8.9 (9.5)	3.8 (5.4)
2. Bihar	6.0	3.0	3.2	3.9
3. Gujarat	6.8	22.7 (25.0)	2.6 (3.8)	5.8 (6.0)
4. Karnataka	7.5	0.3	9.8	4.1
5. Madhya Pradesh	13.5	0.4	3.7	3.1
6. Maharashtra	13.2	10.6 (32.5)	10.5 (9.7)	3.6 (6.0)
7. Punjab	5.3	15.6 (1.8)	8.8 (2.3)	36.6 (28.7)
8. Rajasthan	9.3	0.2	2.2	6.5
9. Tamil Nadu	4.3	14.3 (9.5)	40.1 (53.4)	3.8 (6.1)
10. Uttar Pradesh	12.5	12.6 (6.3)	6.5 (2.6)	23.7 (18.8)
11. Other States and centrally administered territories	13.6	13.2	3.7	5.1
	100.0	100.0	100.0	100.0

Figures in brackets are for 1966. See K. N. Raj, *op. cit.*

The share of all the three types of machinery in Andhra Pradesh and Gujarat decreased between 1966 and 1972, whereas the share of Uttar Pradesh and Punjab increased during this period. In this period the share of oil engines in Maharashtra decreased whereas it increased in Tamil Nadu. Regarding the position of electric pumps in these two States the share of Tamil Nadu decreased and the share of Maharashtra increased during this period. The share of tractors of both these States decreased from 1966 to 1972. The distribution of oil engines and electric pumps in 1972 is more even among the States than in 1966. But the concentration of tractors in Punjab and Uttar Pradesh increased from 1966 to 1972.

Variables Associated with Farm Mechanization

The inter-relationship between some of the important variables and intensity of mechanization is also studied. The variables selected are

(1) working animals per 100 acres of net sown area, (2) agricultural workers per 100 acres of net sown area (3) wage rates of labourers, (4) percentage of area irrigated to the net sown area, (5) percentage of double cropped area to the net sown area, (6) annual growth rate of agricultural output, (7) percentage area of holdings with more than 20 hectares to the net sown area and (8) percentage of area under the high-yielding varieties (HYVs) of seeds to the net sown area. All these variables and their ranks for 1972 (Statewise) are given in Table VII. Rank correlations separately for tractors and pumpsets (both oil engines and electric pumps clubbed together) with all these variables are presented in Table VIII.

One would expect a negative association between tractor use and pumpsets, on the one hand and working animals, on the other. As expected, there is a negative relationship between tractor use and working animals and the correlation coefficient is also significant at 10 per cent level. The correlation coefficient of pumpsets is found to be negative but it is not significant even at 10 per cent level. There is a negative correlation between tractors and agricultural workers and also a negative correlation between pumpsets and agricultural workers. But these two correlation coefficients are not significant even at 10 per cent level.

Tractor use and wage rates are found to be positively correlated and the correlation coefficient is significant at 0.5 per cent level. But use of pumpsets and wage rates are negatively correlated but it is not significant even at 10 per cent level. The percentage of area irrigated to the net sown area is positively correlated to tractors and pumpsets. But the correlation coefficient of pumpsets is not significant even at 10 per cent level.

There is a positive correlation between tractors and the percentage of double cropped area to the net sown area. The correlation coefficient is significant at 10 per cent level. But there is a negative correlation between pumpsets and the percentage of double cropped area to the net sown area and it is not significant even at 10 per cent level. Tractors and the annual growth rate of agricultural output are found to be positively correlated and it is significant at 5 per cent level. There is also a positive correlation between pumpsets and the annual growth rate of agricultural output, but it is not significant even at 10 per cent level.

There is a positive correlation between tractors and the percentage of area of holdings with more than 20 hectares to the net sown area. Pumpsets and the percentage of area of holdings with more than 20 hectares to the net sown area are found to be negatively correlated. But these two correlation coefficients are not significant even at 10 per cent level. Tractors, on the one hand and pumpsets, on the other, are positively correlated to the percentage of area under HYVs to the net sown area and these two correlations are significant at 10 per cent level.

TABLE VII—INTENSITY OF MECHANIZATION AND SELECTED VARIABLES ASSOCIATED WITH MECHANIZATION AND THEIR RANKS: 1972

State	Tractors per 1,00,000 acres of NSA	Rank	Pumpsets per 1,00,000 acres of NSA	Rank	Working animals per 100 acres of NSA	Rank	Agricultural workers per 100 acres of NSA	Rank	Wage rates of male agricultural labourers	Rank
(1)	(2)		(3)		(4)		(5)		(6)	(7)
1. Andhra Pradesh	25.1	9	470	4	24.3	8	54.0	7	222	10
2. Assam	10.9	14	—	—	45.4	1	72.1	2	378	3
3. Bihar	35.7	6	250	9	40.2	3	92.5	1	229	8
4. Gujarat	46.5	4	909	3	13.4	13	20.4	15	245	6
5. Jammu & Kashmir	28.7	8	—	—	41.9	2	71.9	3	—	—
6. Karnataka	11.4	13	395	5	16.0	11	34.0	11	191	11
7. Kerala	142.4	2	269	8	11.4	14	50.7	8	425	2
8. Madhya Pradesh	12.7	11	136	10	23.6	9	35.2	10	168	13
9. Maharashtra	14.7	10	379	6	14.2	12	33.4	12	228	9
10. Orissa	11.9	12	—	—	35.5	6	44.7	9	190	12
11. Punjab	356.8	1	1,181	2	20.2	10	27.4	13	471	1
12. Rajasthan	32.1	7	97	11	11.1	15	21.5	14	303	4
13. Tamil Nadu	44.6	5	2,917	1	34.3	7	71.4	4	242	7
14. Uttar Pradesh	102.1	3	364	7	35.6	5	58.1	5	247	5
15. West Bengal	6.4	15	24	12	36.3	4	55.4	6	—	—

NSA = Net sown area.

(Contd.)

TABLE VII—(*Concld.*)

State	Percentage of area irrigated	Rank	Percentage of double cropped area to the NSA	Rank	Annual growth rate of agricultural output (from 1961-1971)	Rank	Percentage of area of holdings with more than 20 hectares to NSA	Rank	Percentage of area under HYVs of seeds to NSA	Rank
(1)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1. Andhra Pradesh	30	6	12	11	1.32	13	3.05	13	13.3	9
2. Assam	28	8	27	6	1.35	11	1.24	14	15.8	7
3. Bihar	32	5	29	5	0.31	14	8.4	9	27.8	4
4. Gujarat	13	13	6	14	5.43	2	9.3	7	13.4	8
5. Jammu & Kashmir	42	4	20	7	3.72	4	0.95	15	36.3	3
6. Karnataka	15	12	7	13	3.29	6	11.0	5	6.7	12
7. Kerala	22	10	35	2	3.32	5	10.18	6	8.7	10
8. Madhya Pradesh	10	14	13	10	1.41	10	16.9	3	6.0	13
9. Maharashtra	7	15	5	15	—1.15	15	13.4	4	4.6	15
10. Orissa	26	9	15	9	3.26	7	4.24	11	7.3	11
11. Punjab	66	1	41	1	7.35	1	8.83	8	47.3	1
12. Rajasthan	16	11	10	12	5.11	3	35.6	1	5.9	14
13. Tamil Nadu	47	2	20	8	2.13	8	4.6	10	45.0	2
14. Uttar Pradesh	45	3	33	3	2.10	9	31.0	2	24.1	5
15. West Bengal	29	7	30	4	1.34	12	3.9	12	18.1	6

TABLE VIII—RANK CORRELATION MATRIX

Tractors per 1,00,000 acres of NSA	Pumpsets per 1,00,000 acres of NSA	Working animals per 100 acres of NSA	Agricultural workers per 100 acres of NSA	Wage rates of male agricultural labourers	Percentage of area irrigated to NSA	Percentage of double cropped area to NSA	Annual growth rate of agricultural output (1961-1971)	Percentage of area of holdings with more than 20 hectares	Percentage of area under HYVs to NSA
Tractors	0.27	—0.36*	—0.17	0.75***	0.40*	0.36*	0.49**	0.29	0.41*
Pumpsets		—0.07	—0.12	—0.04	0.33	—0.09	0.32	—0.32	0.42*
Working animals			0.86***	—0.16	0.54**	0.42*	—0.42*	—0.68†	0.57**
Agricultural workers				—0.03	0.56**	0.49**	—0.49**	—0.57**	0.54**
Wage rates					0.43*	0.49**	0.46*	0.02	0.47*
Irrigated area						0.71***	0.11	0.36*	0.90***
Double cropped area							0.03	—0.23	0.79***
Growth rate								0.16	0.18
Holdings with more than 20 hectares									—0.44*

* Significant at 10 per cent level.
** Significant at 5 per cent level.
*** Significant at 0.5 per cent level.
† Significant at 1 per cent level.

Implications of Statistical Analysis of Farm Mechanization in relation to (a) Growth of Agricultural Output, (b) Wage Rates, (c) Displacement of Human Labour and Bullock Labour and (d) Adoption of HYVs of Seeds

The annual growth rate of agricultural output and intensity of tractor use have a significant positive correlation. But what needs to be noted is that HYVs and tractor use are positively and significantly correlated. The suggestion is that tractor use which is high in the irrigated areas is associated with high rates of growth via HYV and should not be taken as the cause of high rate of growth. Pumpsets and rate of growth are also positively correlated though not significant. Significant correlation is seen between pumpsets and HYV use. HYV area and irrigated area are highly correlated. The correlation coefficient is as high as 0.90. Thus higher levels of irrigation lead to higher levels of HYV area; and higher levels of HYV area lead to higher levels of mechanization. The spectacular rise in the number of machines after the middle 'sixties is due to the adoption of new technology.

Wage rates and tractor use are positively associated. This should not be taken to mean that tractors are the cause of high wages. There is a positive and significant association between the percentage of area irrigated to the net sown area and intensity of tractors. Generally, wage rates are higher in the irrigated areas. In the irrigated areas, tractors are used more intensively and the wages are also higher. Therefore, the association of tractors with high wage rates is because of the association of tractors with irrigation. The association between use of pumpsets and wages is found to be negative though not significant.

Between the intensity of agricultural workers and tractor use though the correlation sign is negative, it is not significant. Pumpsets suggest similar result. The association between lower density and higher tractor use is significant in the case of bullocks, but not so between pumpsets and bullocks.

Conclusions

The study reveals that mechanisation does not lead to the displacement of human labour but bullock labour is displaced by tractors. Increased rates of agricultural output are seen at higher levels of tractorisation. But tractorisation is associated with higher levels of HYVs and HYV area is positively correlated with irrigation. Thus the positive interaction between tractors, HYVs and irrigation has led to the observed association between tractors and rate of growth. The effects of tractors in relation to growth can only be seen by isolating the effects of HYV and irrigation, and this could be studied only at the micro level.

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