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RESEARCH PAPER

Farm mechanization and agricultural growth in Eastern India

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Abstract : The agriculture sector plays a vital role in the Indian economy. It contributes about 17 per cent of the country's total GDP. According to Indian Economic Survey 2018, it is estimated that percentage of agricultural workers of total workforce would drop to 25.7 per cent by 2050 from 58.2 per cent in 2001. Mechanization in the form of tractors, seed drills or tube wells (pump sets) enable a farmer to grow more crop and earn more by increasing the input use efficiencies. Further, adoption of mechanization ensures double benefit of reduction of cost and increase the productivity and production. Though there has been a substantial progress of mechanization in agriculture through various programmes, the level of mechanization in the Eastern region was lesser (8.18 hrs/ha) than the country's average (11.56 hrs/ha) resulting lesser crop productivity and net returns. This study intends to assess the effect of increased use of mechanization on farm income and profitability in Eastern region with the comparison of India as whole. The study used the plot level cost of cultivation data (DES-Directorate of Economics and Statistics) to compare the level of inputs (labour, animal and machine) use for two period *viz.*, 2000-01 and 2013-14 and estimated translog cost functions to calculate labour demand elasticities and Allen Elasticities of Substitution between labour and other factors like animal and machine power under two different period at constant price (1993-94). This study found that in Eastern region the use of man labour and animal labour in cultivation practices has declined over the years. However, it was noticed that the employment of animal labour in this region was significantly higher while it was lower in case machine labour for almost all the crops cultivated in comparison with the country. Further, the study found that the share of payment on machine labour has increased over years across crops for Eastern region as well as India as whole, however, the increment was comparatively higher in India. The lesser level of cross price elasticities clearly states that machine labour is a weak substitute to man and animal labour. This implies that mechanization had not been strong alternate to animal and man labour for crop production activities in Eastern region.

Key Words : Farm mechanization, Labour demand, Input substitution, Input demand elasticity, Agricultural growth

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INTRODUCTION

The agriculture sector plays a vital role in the Indian economy. It contributes about 17 per cent of the country's total GDP. India exports a large quantity of agricultural commodities like fruits, vegetables, pulses, tea, spices, etc. and the government is acquiring good revenue from it. Most of the people of India have adopted agriculture for their occupation. Over 70 per cent of the rural household in India depends on agriculture.

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Agriculture in India has witnessed tremendous progress through the green revolution. It resulted 252 million tones (mt) of food grains in 2015-16 from 108 mt in 1970-71, which turned the country to self-sufficiency in food grains production. It covered the whole country, particularly doubled the rice and wheat productivity in the irrigated region *viz.*, Punjab, Haryana and UP where about 85 per cent of the cropped area with irrigation compared to one fifth of cropped area in Eastern and North Eastern region (E and NE). Green revolution made significant contribution in reducing the incidence of rural poverty from 42 per cent in 2004-05 to 25.7 per cent in 2011-12 in India. In case of Eastern India, more than half of rural population at below poverty line which reduced upto 35.3 per cent in the same period. This warrants special emphasis on green revolution technologies in the Eastern region which helps in reducing the rural poverty further.

Mechanization in the form of tractors, seed drills or tube wells (pump sets) enable a farmer to grow more crop and earn more by increasing the input use efficiencies. Further, adoption of mechanization ensures double benefit of reduction of cost and increase the productivity and production. The percentage of mechanization in India was 40 per cent while the percentage of population engaged in agriculture was 55 per cent, leading to a mechanization intensity of 0.73 as compared to 40 in US and 24 in Western European countries. This gives an indication of the low level of mechanization in India. However, the farm power availability on Indian farms has grown from 1.47 kW/ha in 2005-06 to 2.02 kW/ha in 2013-14 which is again highly varied among region. Though there has been a substantial progress of mechanization in agriculture through various programmes like strengthening of agricultural machineries and Macro Management of Agriculture (MMA), Rashtriya Krishi Vikas Yojana (RKVY), National Horticulture Mission (NHM) and National Food Security Mission (NFSM), etc., in recent time, the level of mechanization (*i.e.* usage of machine hours in various crop operation) in the Eastern region was lesser (8.18 hrs/ha) than the country's average (11.56 hrs/ha) resulting low productivity and low net return. In this context, the study intends to assess the effect of increased use of mechanization on farm income and profitability.

According to Indian Economic Survey 2018, it is estimated that percentage of agricultural workers of total workforce would drop to 25.7 per cent by 2050 from 58.2 per cent in 2001. Thus, there is a need to enhance the level of farm mechanization in the country. Due to intensive involvement of labour in different farm operations, the cost of production of many crops is quite high. Mechanization is a cost cutting technology besides to overcome the increasing labour scarcity particularly for agriculture. For sustained agricultural production adapting farm mechanization is need of the hour.

There are, however, studies of somewhat disaggregated labourelasticities. Moolman (2003) attempts industry-level demand estimations for skilled and unskilled labour, but the equations are rudimentary and the wage variables are aggregated across skill/ occupation types. Toit and Koekemoer (2003) estimate macro-economic models for skilled and unskilled labour demand and supply based on a Cobb Douglas technology. Edwards (2003) uses firm-level manufacturing data from Gauteng to estimate relative demand functions for two occupations using Constant Elasticity of Substitution (CES) production technologies. In this study Cobb Douglas technologies are inappropriate because they assume the AES is unity, while CES functions are not easily conducive to multiple factors and also impose various technological restrictions on the technology and elasticities (Heathfield and Wibe, 1987). Translog functions can overcome these disadvantages. This paper, therefore, estimates a translog cost function to derive the AES and factor demand elasticities. This paper motivates why estimating translog cost functions is the most appropriate for deriving substitution elasticities in section 2. Section 3 discusses the estimation process and inference options. Section 4 discusses the data, in particular the process by which wages are constructed using household data.

Binswanger (1973) lists why cost functions are more popular than production functions for estimation purposes. First, as a consequence of optimising behaviour, cost functions exhibit homogeneity of degree one in prices, which can be imposed to improve estimation efficiency without recourse to technological assumptions. Also, cost functions are more consistent with the view that wages are exogenous. The main reason, however, for using a cost function in this study is that, as shown in section 2, the AES and elasticity of factor demand can be far more tractably arrived at than by using production functions. Constant Elasticity of Substitution functions allow the Elasticity of Substitution to differ from one,

but the Elasticity of Substitution is the same between all input pairs. This is still a major restriction, but the resulting factor demand equations yield easily estimable elasticities between two factors. For example, Edwards (2003) estimates an equation for the demand for skilled relative to unskilled labour (S/U) as a function of relative wages (Ws/Wu), import penetration variables (M), export orientation (X), and technology variables. Edwards estimates to be –0.47 between skilled and unskilled labour and –0.41 between less-skilled and unskilled labour. Fallon and Lucas (1998) include capital in their CES function to estimate, with non-linear 3 stage least squares and calibration techniques, demand for black and white labour as proxies for unskilled and skilled labour. They produce industry-level long run elasticities of demand for unskilled labour of about –0.7 in manufacturing. This study uses a translog cost function, which can be interpreted as second order Taylor Approximations to an unknown underlying technology.

Wang *et al*. (2016) observed that there is a large substitution between labour and machines in Japonica rice production, followed by cotton in China. This could be explained as rice and cotton are more labour-intensive than the other crops. The MES ranges around 0.33–0.35 for soybean, corn and rapeseeds. The labour-machine substitution is relatively small in wheat.When the wage has risen, the farmers are more likely to use machines to substitute for labour in the production largely through machine services and/or rental.

MATERIAL AND METHODS

The study used the plot level cost of cultivation data of Eastern region of India (DES-Directorate of Economics and Statistics) to compare the level of inputs (labour, animal and machine) use for two period *viz.*, 2000-01 and 2013-14.

Estimating elasticities using trans-log cost functions:

This paper attempted to estimate the own price and cross price elasticites for labour, animal and machine power used in production of different crops under different regions of India and India. This study uses a translog cost function, which can be interpreted as second order taylor approximations to an unknown underlying technology.

$$\ln C = \ln a_0 + \sum_i a_i \ln w_i + a_y \ln y + \sum_i \sum_j b_{ij} \ln w_i \ln w_j + b_y (\ln y)^2 + \sum_i b_y \ln w_i \ln y;\ (i,j = 1,2..4)$$

where, C is total A_1 cost, for each plot of each crop

Y= value of the output-

W_i are the wage or price for labour, animal, machine and capital.y is output or value added. The cost share equation for factor i is derived by differentiating the cost function with respect to ln w_i. Following Chung and Pruitt (1994): the cost equation are:

$$\frac{\partial \ln C}{\partial \ln w_i} = \frac{w_i \partial C}{C} = \frac{w_i x_i}{C} = S_i$$

$$S_i = a_i + \sum_j b_{ij} w_j + b_{ij} \ln y$$

where,

$$C = \sum_{i=1}^{4} w_i x_i;\ S_i = \frac{w_i x_i}{C};$$

Slutsky symmetry $bij = b_{ji}$

$\frac{\partial \ln C}{\partial \ln w_i} = 1$ price homogenity if $\sum_j b_{ij} = \sum_j b_{ij} = 0; \sum_i b_{iy} = 0;$

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Importance of Eastern region in context food security of the country:

In support of the focus on Eastern region the area, production and yield of the crops cultivated in this region was estimated and it is compared with the other regions of the country. Here we have given importance in context of food security and the estimates are presented in Table 1.

The food security status of India revealed (Table 1) that the Northern region of India accounted 35.29 per cent of the country's food grain production followed by Western (27.45%) and Eastern (22.63%) regions. These three regions alone accounted the 85 per cent of country's

food grain production. The cropping intensity pertaining to these respective regions clearly indicates, why for the food grain production was higher in these regions. As expected, the cropping intensity of northern region was the highest (166.62%) among the regions, followed by Eastern (141.94%) and Western (139.28%). However, cropping intensity alone doesn't determine the level production, productivity has considered one of the important factor. As for as productivity is concerned, Northern region had the higher level of food grain productivity (2545 kg/ha) followed by southern region (2230 kg/ha). While taking into account of area cultivated, food grains were cultivated in 1210.34 lakh ha in India, of that, 35.75 per cent were cultivated in Western region while Northern and Eastern region accounted 27.86 per cent and 23.21 per cent, respectively. In sum, India's food grain production during 2014-15 was 243 million tonnes and about 85 per cent of these production was sourced from north, west and Eastern regions of India. Though Eastern region accounted nearly about 23 per cent of the country's food grain production as well as area cultivated, the comparatively lesser level of productivity of this region need to be addressed in ordered to attain the food security needs of the country.

The cropping pattern of the Eastern region is presented in Table 2. The estimated results revealed that rice is predominantly cultivated in Eastern region which accounted 67.89 per cent of cropped area. The other major crops pertains to this region are wheat (8.88 %), pulses (7.99%), maize (4.02%), mustered (3.40%), potato (2.49%) and jute (2.43%). In comparison with entire country, this region alone accounts about 49 per cent of the rice cultivated area of the country while it was 43.66 per cent in case of potato followed by mustard (18.16 %), sesame (16.92%) and maize (15.27%). In account of jute cultivation of the country it has been observed that almost entire jute cultivation (99.46%) has pertains to this region. These results clearly indicates how important this region in Indian agriculture, hence that accelerating the adoption of mechanization in this region would results improvement in efficiency so that of productivity and farm profitability.

Input use pattern in different crops:

The regional diversity in performance of agricultural

Table 1 : Agricultural scenario of India in the context of food security

Sr. No.	Region	Area (lakh ha)	% share	Production (m tons)	% share	Yield (kg/ha)	Cropping intensity
1.	Eastern*	280.87	23.21	55.03	22.63	1959	141.94
2.	Northern	337.19	27.86	85.81	35.29	2545	166.62
3.	Southern	159.56	13.18	35.58	14.63	2230	123.42
4.	Western	432.72	35.75	66.73	27.45	1542	139.28
	India	1210.34	100.00	243.14	100.00	2009	142.36

*Includes North-Eastern Region

Table 2 : Cropping pattern of Eastern region

Sr. No.	Crops	Area (lakh ha)	% share to crops	% share in India
1.	Rice	204.80	67.89	49.05
2.	Maize	12.13	4.02	15.27
3.	Wheat	26.80	8.88	8.36
4.	Gram	4.09	1.36	5.39
5.	Other pulses	20.00	6.63	9.44
6.	Potato	7.50	2.49	43.66
7.	Cotton	0.02	0.01	0.02
8.	Jute	7.33	2.43	99.46
9.	Groundnut	1.77	0.59	3.84
10.	Sesame	2.90	0.96	16.92
11.	Mustered	10.26	3.40	18.16
	All	301.68	100.00	22.20

reduction is mainly attributed to input use level particularly labour, animal power and machine power, apart from level of application of fertilizers and plant protection measures. This sections trace out the difference in input use pattern among different crops between the periods of 2001 and 2014 in comparison with Eastern region.

Human labour use pattern in Eastern region:

The labour use pattern among different corps is presented in Fig.1. It could be seen from the figure that labour usage was highest in potato (435 hrs/ha) among crops cultivated in Eastern region followed by jute (301 hrs/ha) and groundnut (268 hrs/ha). In account of country it was jute (1426 hrs/ha) which account the highest level of labour usage followed by potato (1127 hrs/ha) and cotton (963 hrs/ha). Further, it was observed that there is a remarkable difference in human labour use among different crop in Eastern region in comparison with the

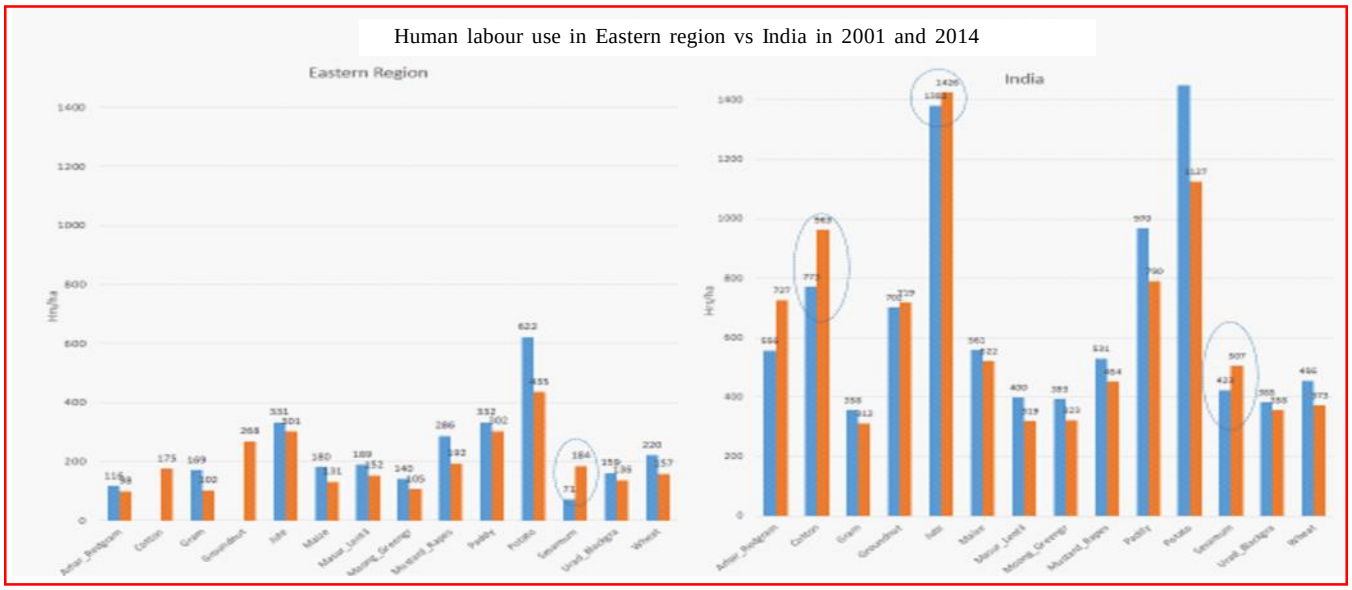
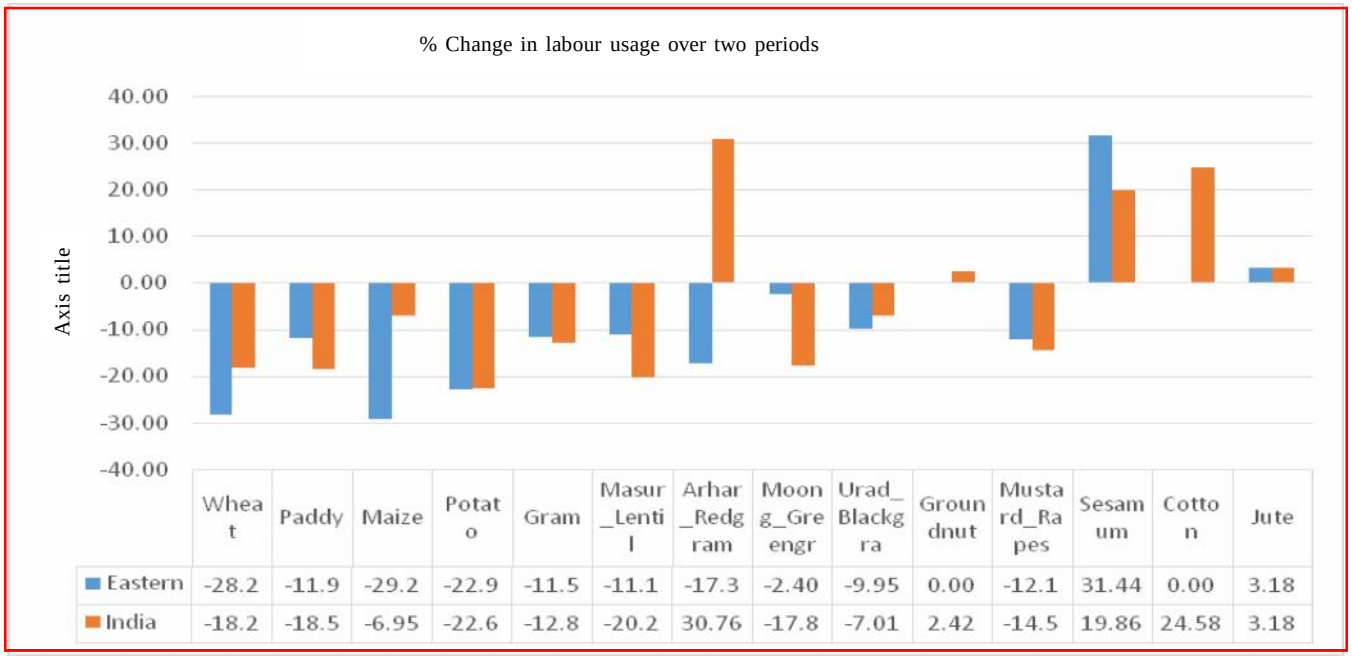


Fig. 1 : Human labour use in Eastern region vs India in 2001 and 2014



	Wheat	Paddy	Maize	Potato	Gram	Masur_Lentil	Arhar_Redgram	Moong_Gregengr	Urad_Blackgra	Groundnut	Mustard_Rapes	Sesamum	Cotton	Jute
Eastern	-28.2	-11.9	-29.2	-22.9	-11.5	-11.1	-17.3	-2.40	-9.95	0.00	-12.1	31.44	0.00	3.18
India	-18.2	-18.5	-6.95	-22.6	-12.8	-20.2	30.76	-17.8	-7.01	2.42	-14.5	19.86	24.58	3.18

Fig. 2 : Percentage changes in labour usage over the years

country; the level of labour usage in the Eastern region was almost half the level in almost all the crops in comparison with the country's labour usage.

Another interesting information is derived from the labour use pattern (Fig. 2) is, there is a significant difference between two periods considered; particularly declining trend was noticed in labour use in all the crop in Eastern zone except in sesamum, in which the labour use was 71 hours in 2001 has been increased now to 184 hours. This observed trend may be due to the adaptation of improved practices in accompanied with machine powers; by substituting machine powers in place of human labour in different operations of crop production *i.e*. weeding, harvesting, threshing, etc, further, the reduction was high in maize, paddy, potato and wheat comparatively. In account of India, the declining trend was largely observed in potato from 1450 to 1127, rapeseed mustard from 531 to 454, wheat from 456 to 373, paddy from 970 to 790 and so on. Though the level of labour usage declined in most of the crops over years, it was observed that the labour usage was witnessed increasing trend in cotton, jute, sesamum, ground nut and red gram. This observed increasing trend of labour usage over those crops may be due to the adoption of irrigation practice of those rainfed crops and increased population of weed and pest diseases as a result of climate change.

Animal power usage in Eastern region and India:

As a populated nation; engaged most of its population in agriculture, land fragmentation is inevitable results that most of farmers in country are small and marginal holders. This could be the prime constraint in adoption mechanization in this country. The level of animal usage across crops in crop production in Eastern region as well as the country is presented in Fig. 3. It could be seen from the figure that in Eastern region the employment of animal labour in crop production during 2014 was the highest in paddy (102 hrs/ha) and it was followed by black gram (88 hrs/ha) and potato (87 hrs/ha) while the lowest was witnessed in maize (14 hrs/ha). Considering this in country level the animal labour usage was highest in jute (67 hrs/ha) and it was followed by red gram (58 hsr/ha) and ground nut (45 hrs/ha) while lowest level of usage was observed in wheat (12 hrs/ha) during 2014.

Further it was noticed that animal labour use in crop production was significantly higher in Eastern region for almost all the crops cultivated in comparison with the country. This higher animal labour usage in crop production in Eastern region may due to the lack of technical skills in operating machine power in accompanied with larger amount man labour. Added, the level of animal usage was significantly declined across crops over the years in both Eastern region and the country. In case of Eastern region the decline in labour usage was highest in maize (97.33%) followed by wheat (80.00%) and jute (59.64%) while in mustard and sesamum it was about 50 per cent. Considering the

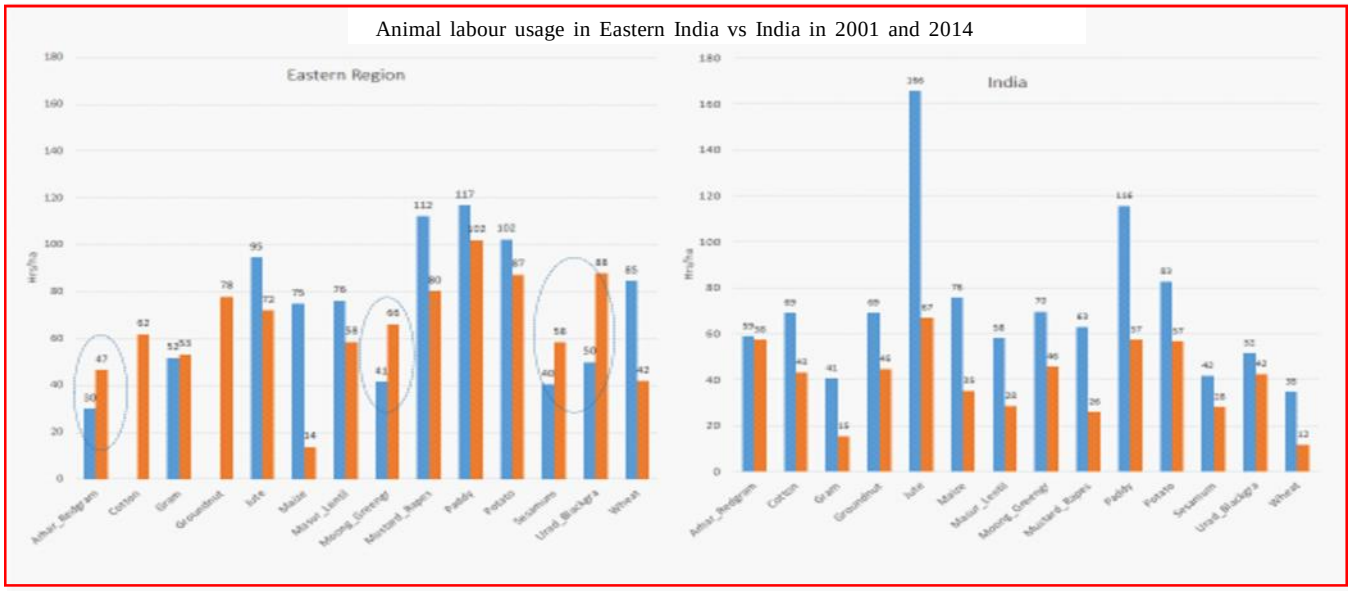


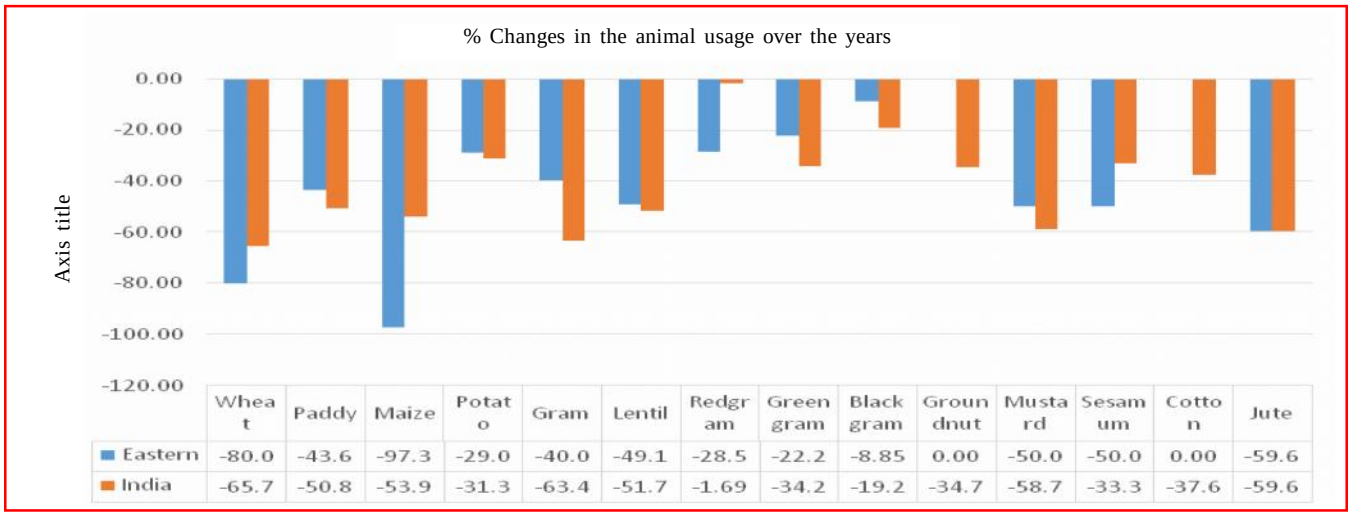
Fig. 3 : Animal labour usage in Eastern India vs India in 2001 and 2014

country the decline was highest in wheat (65.71%) followed by gram (63.41%) and mustard (58.73%).

Further, it was noticed that the employment of animal labour in crop production was significantly higher in Eastern region for almost all the crops cultivated in comparison with the country. This higher animal labour usage in crop production in Eastern region may due to the lack of technical skills in operating machine power in accompanied with larger amount man labour. Added, the level of animal usage was significantly declined across crops over the years in both Eastern region and the country (Fig. 4). In case of Eastern region the decline in labour usage was highest in maize (97.33%) followed by wheat (80.00%) and jute (59.64%) while in mustard and sesamum it was about 50 per cent. Considering the country the decline was the highest in wheat (65.71%) followed by gram (63.41%) and mustard (58.73%).

Machine power usage in Eastern region and India:

The level of machine power usage in crop production across crops in Eastern region and India is graphically presented in Fig. 5. It was observed that in Eastern regionthe use of machine power in crop production during 2014 was the highest in paddy (11.5 hrs/ha) followed by potato (10.9 hrs/ha) and jute (9.5 hrs/ha) while the lowest level of machine usage was found in red gram (1.3 hrs/ha). In account of country as whole the usage of machine labour was the highest in red gram (17.6 hrs/ha) followed by cotton (16.9 hrs/ha), wheat (13 hrs/ah) and grams (12.2 hrs/ha) while the



	Wheat	Paddy	Maize	Potato	Gram	Lentil	Redgram	Green gram	Black gram	Groundnut	Mustard	Sesamum	Cotton	Jute
Eastern	-80.0	-43.6	-97.3	-29.0	-40.0	-49.1	-28.5	-22.2	-8.85	0.00	-50.0	-50.0	0.00	-59.6
India	-65.7	-50.8	-53.9	-31.3	-63.4	-51.7	-1.69	-34.2	-19.2	-34.7	-58.7	-33.3	-37.6	-59.6

Fig. 4 : Percentage changes in the animal usage over the years

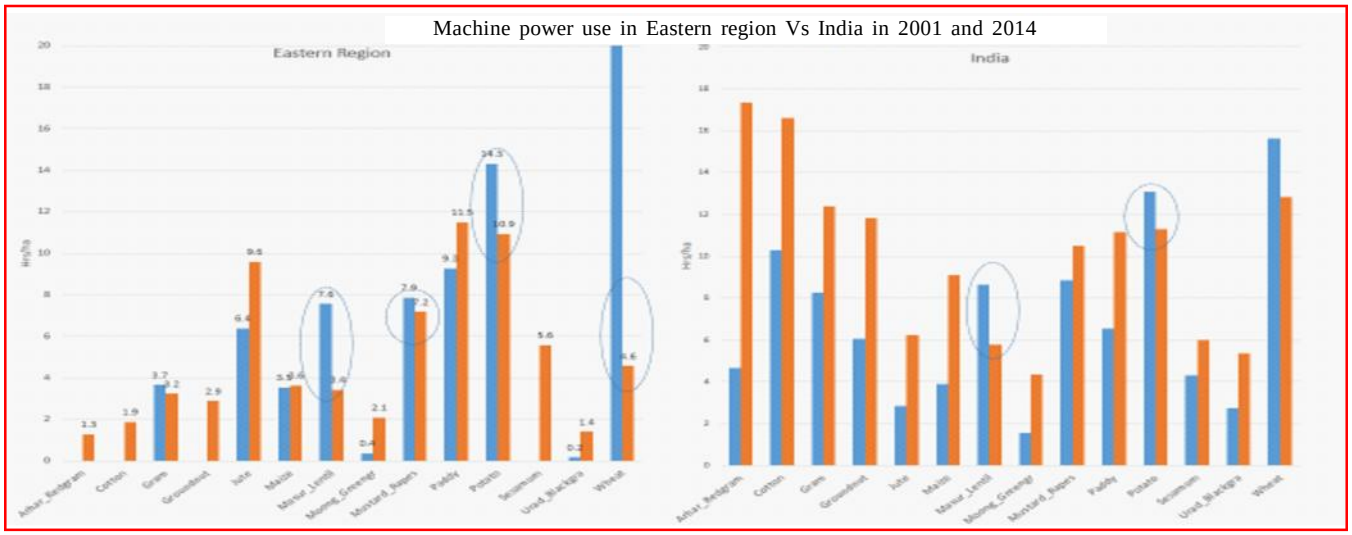


Fig. 5 : Machine power use in Eastern region Vs India in 2001 and 2014

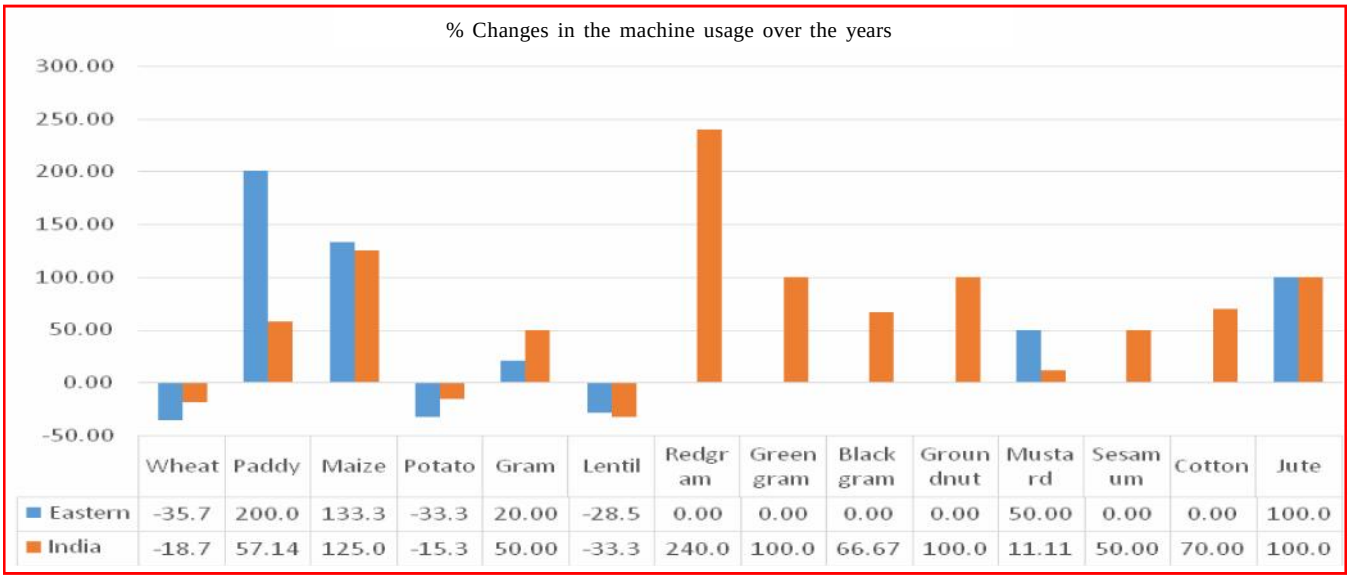
lowest was observed in green gram (4.2 hrs/ah). Further, it was observed that the level of mechanization in Eastern region was comparatively lesser.

Changes in machine power usage in Eastern region and India:

Machine power use over two periods has significantly increased in Eastern region and the country indicating the progress in mechanization in all the crops which was noticed in Fig. 6. In account time, it was observed that in Eastern region paddy, maize, mustard and jute were the crops attained increasing growth during the period accounted, while paddy claimed 200 per cent growth over the years and registered maximum growth among crops cultivated in Eastern region. The crops which registered decline in growth were wheat, potato and lentil. Considering country as whole, red gram registered the maximum growth (240%) among all followed by maize (125%). The crops which registered negative growth were lentil (33.33 %), wheat (18.75%) and potato (15.38%).

Input payments:

The share of input payments in terms of gross revenue across crops were estimated for the both periods of 2001 and 2014 for both of Eastern India as well as India. The results are graphically presented in Fig. 7. The results revealed that the share of input payments has increased over years across crops for both of the regions considered for this study. The share of payment



	Wheat	Paddy	Maize	Potato	Gram	Lentil	Redgram	Green gram	Black gram	Groundnut	Mustard	Sesamum	Cotton	Jute
Eastern	-35.7	200.0	133.3	-33.3	20.00	-28.5	0.00	0.00	0.00	0.00	50.00	0.00	0.00	100.0
India	-18.7	57.14	125.0	-15.3	50.00	-33.3	240.0	100.0	66.67	100.0	11.11	50.00	70.00	100.0

Fig. 6 : Percentage changes in the machine usage over the years

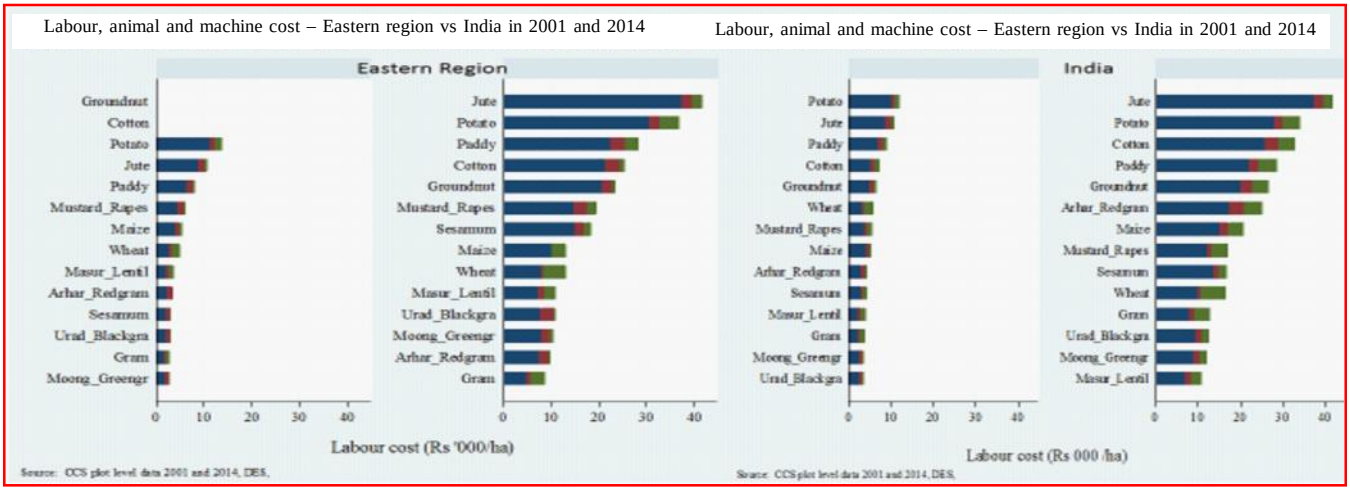


Fig. 7 : Labour, animal and machine cost – Eastern region vs India in 2001 and 2014

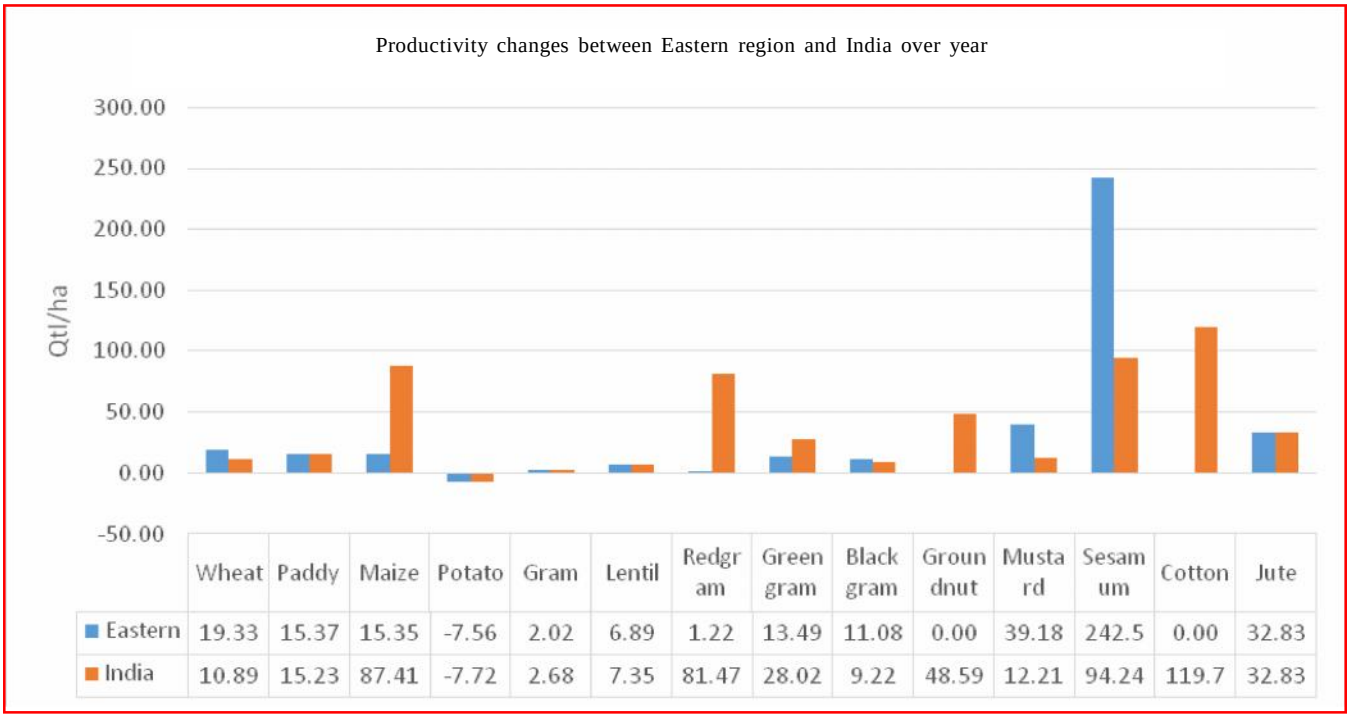
on machine labour has increased over years across crops for Eastern region as well as India as whole, however, the increment was comparatively higher in India. These increment on machine labour was at the cost of animal labour and these could be due to the technical advancement in crop production activities over years. Further the share of payment of machine labour was the highest in wheat followed by potato, gram and maize in Eastern region during 2014, while it was higher in wheat followed by arhar, redgram, paddy, potato and gram in India as whole. These results clearly states that the mechanization was increased over years across crops in Easternregion, however, it was significantly lower comparatively.

Crop productivity:

The improvement in crop yield over years for Eastern region and India is presented graphically. It could be seen from the figure that the crop productivity has increased over the years for almost all the crops except potato across regions considered for this study. In Eastern region, the increment was highest in sesamum (242.58 qtl/ha) followed by mustard (39.18 qtl/ha), jute (32.83 qtl/ha), wheat (19.33 qtl/ha) and paddy (15.37 qtl/ha). Potato is the only crop in this region claimed negative growth on yield (-7.56 qtl/ha) while, there is no change in yield of cotton and groundnut during the period considered. In account of India, it was found that the increment son crop yield was highest in cotton (119.74 qtl/ha) followed by sesamum (94.24 qtl/ha), maize (87.41 qtl/ha), redgram (81.47 qtl/ha) and groundnut (48.59 qtl/ha). In comparing with India, the growth on crop yield was considerably lower in Eastern region for the crops of maize, redgram, green gram and, while it was higher in wheat, black gram, mustard and sesamum.

Crop profitability:

The profitability over cost A1 at 1993-94 prices was estimated and presented in Fig. 9. It could be seen that potato was the most revenue generated crops in both of the regions considered for this study and obviously it was the most expensive crop to produce too for the both periods (*i.e.* 2001 and 2014). Jute was the next best revenue crop in Eastern region followed by wheat, cotton, paddy, lentil and mustard. Further, it was observed that black gram was the least expensive crop to be cultivate in Eastern region followed by red gram and green gram. In case of India as a whole, it was found that next to potato cotton was the most revenue generated crop and it was followed by jute, red gram, wheat and ground nut. The lesser income of India were most of the gram crops (pulses) followed by lentil, maize



	Wheat	Paddy	Maize	Potato	Gram	Lentil	Redgram	Green gram	Black gram	Groundnut	Mustard	Sesamum	Cotton	Jute
Eastern	19.33	15.37	15.35	-7.56	2.02	6.89	1.22	13.49	11.08	0.00	39.18	242.5	0.00	32.83
India	10.89	15.23	87.41	-7.72	2.68	7.35	81.47	28.02	9.22	48.59	12.21	94.24	119.7	32.83

Fig. 8 : Productivity changes between Eastern region and India over year

and sesamum.

Input elasticity of substitution:

In order to estimate the cross elasticity of substitution between man labour, animal labour and machine labour of the major crops (*i.e*. paddy, wheat and potato) in Eastern region, translog production function was employed separately for two periods and the results are presented in Table 3. Almost all the estimated parameters in the regressions for the considered crops are significant at 1 per cent level. When the wage has risen, the farmers are more likely to use machines to

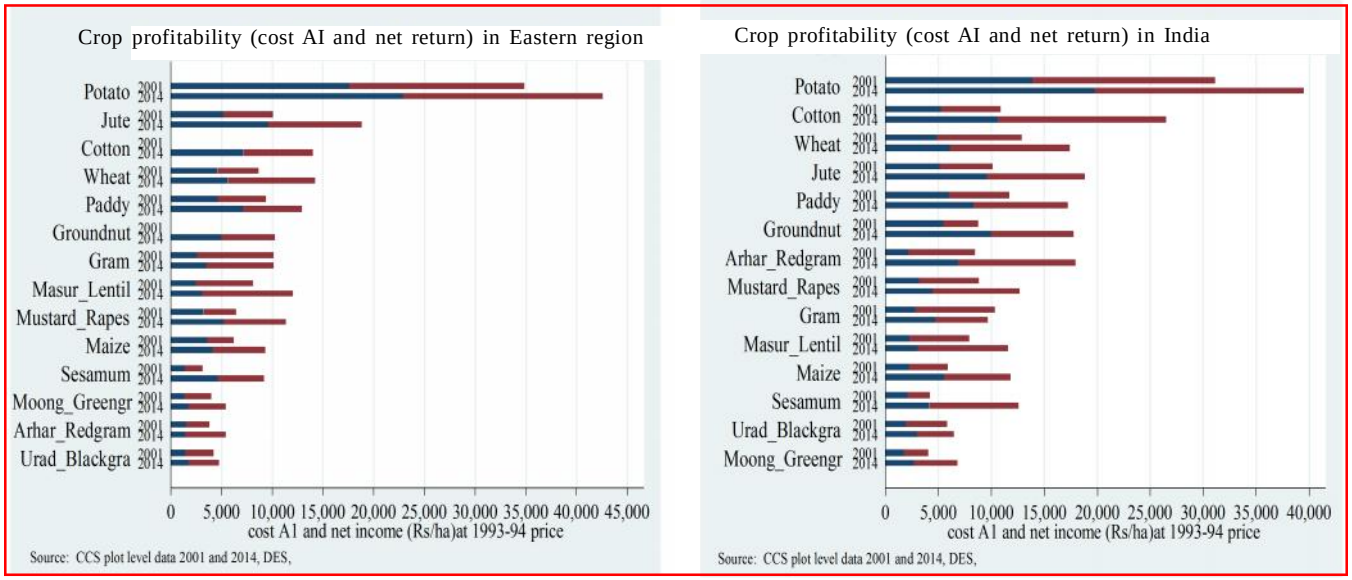


Fig. 9 : Crop profitability Eastern region vs India

Table 3 : Elasticity of substitution

Particulars	Paddy		Wheat		Potato	
	Co-efficient	p-value	Co-efficient	p-value	Co-efficient	p-value
			Period I (2001)			
lcLh	0.706	0.00	0.183	0.00	0.254	0.00
lcAh	-0.359	0.00	-0.008	0.76	0.154	0.02
lcMh	-0.201	0.00	-0.064	0.30	0.107	0.14
lcLA	0.103	0.00	0.000	1.00	-0.031	0.10
lcLM	0.060	0.00	0.022	0.27	-0.017	0.39
lcAM	0.001	0.24	-0.002	0.38	0.004	0.13
_cons	-1.559	0.00	1.940	0.00	3.396	0.00
$AdjR^2$	0.2962		0.0544		0.6088	
n=	7390		1032		244	
			Period II (2014)			
lcLh	0.444	0.00	0.252	0.00	-0.066	0.24
lcAh	-0.017	0.24	0.121	0.00	-0.075	0.21
lcMh	0.165	0.00	0.131	0.15	-0.384	0.00
lcLA	0.011	0.01	-0.038	0.00	0.036	0.05
lcLM	-0.035	0.00	-0.021	0.46	0.134	0.00
lcAM	-0.009	0.00	-0.011	0.00	-0.035	0.00
_cons	0.359	0.00	1.677	0.00	5.536	0.00
$AdjR^2$	0.2114		0.258		0.3877	
n=	6955		1178		202	

substitute for labour in the production largely through machine services and/or rental.

These results shows that during 2001 the own price elasticities of animal labour and machine labour were negative in case of paddy and wheat, while for potato it is positive for all the three labour categories. The greater own price elasticities suggest that demand for man labour is more elastic than demand for animal and machine labour across crops. The cross price elasticity estimates of paddy suggest that one per cent increase in man labour price leads to less than one per cent increase in animal labour and in machine labour demand. Similar trend was observed both in wheat. However, the comparatively negative price elasticity in both labour with animal and labour with machine indicated, still labour use is more response in potato. Further the positive sign of the cross price elasticities revealed that the inputs were substitutes while the negative sign implies the complementarity between the inputs. During 2014 almost all the own price elasticities were positive in case of both paddy and wheat while it was negative for potato. Considering the cross price elasticity for this period, all the inputs were compliment to each other in case of wheat, whereas for paddy there were complementarity exist in man-machine combinations and machine-animal combinations. In case of potato substitution exists in man-animal and man-machine combinations while complementarity exist between machine and animal labour. The lesser cross price elasticities means that machine labour is weak substitute to man and animal labour. This implies that mechanization had not been strong alternate to animal and man labour for crop production activities in this region. This may be due to practical constraints like farm size, availability of cheap labour and operational suitability in many crops.

Summary and conclusion:

Adoption of mechanization ensures double benefit of reduction of cost and increase the productivity and production. This study intends to assess the effect of increased use of mechanization on farm income and profitability in Eastern region with the comparison of India as whole. The study results revealed that rice is predominantly cultivated in Eastern region which accounted 67.89 per cent of cropped area. Further it was found that in Eastern region the engagement of man labour and animal labour in cultivation practices has declined over the years. However, it was noticed that the employment of animal labour in this region was significantly higher while it was lower in case machine labour for almost all the crops cultivated in comparison with the country. The share of payment on machine labour has increased over years across crops for Eastern region as well as India as whole, however, the increment was comparatively higher in India. The lesser level of cross price elasticities clearly states that machine labour is a weak substitute to man and animal labour particularly in rice, wheat and potato. This implies that mechanization had not been strong alternate to animal and man labour for crop production activities in Eastern region.

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