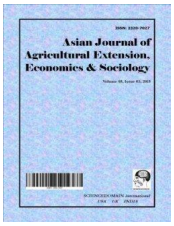

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Impact of Farm Mechanization on Cropping Pattern and Cropping Intensity - A Case Study from Assam, India

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Authors' contributions

This work was carried out in collaboration between all authors. Author SB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ND and PD managed the analyses of the study. Author PD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Farm mechanization is considered as important pathways of agricultural development. A farming system cannot sustain with the traditional system. The mechanization of farm is also inductive to the diversification of the cropping pattern as it enables farmer to raise a second crop or multi crop ultimately raising cropping intensity. The study was conducted in Central Brahmaputra Valley and Upper Brahmaputra Valley Zone of Assam, India. The objective of the study is to examine the effect of mechanization on cropping pattern and cropping intensity .Primary data were collected with the help of specially design pretested schedule by interview method. Thus, a sample of 240 farmers had been taken for the study. Cropping intensity was higher in case of all mechanize farm than bullock operated farm not only individual size groups but all farm size taken together. Tractor Hired Farm had the highest cropping intensity (162.21 per cent) followed by Power Tiller Hired Farm (161.49 per cent) and Tractor Operated Farm (152.00) per cent) and Power Tiller Operated Farm (154.62 per

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cent), respectively. In case Bullock Operated Farm cropping intensity showed positive relationship with farm size but reverse was the in case of each mechanized farm. Mechanized farm had higher cropping intensity which was confirmed by regression analysis that in all the categories of farm had positive significant relationship with cropping intensity but farm size and cropping intensity had highly significant inverse relationship. Cropping pattern of different categories of mechanized farms slightly shifted to high valued crops while in case of Bullock Operated Farm it was remain sali rice biased as usual. Mechanization showed an impact on increasing cropping intensities in the study area where Tractor Ownership Farm by hiring appeared to be the most important form of mechanization as it depicted a very high significant relationship with the cropping intensity in the study area. Cooperative management of farm machinery, financing of second-hand tractors for small farmers should be given for strengthening mechanization amongst the small farmers in the study area.

Keywords: Cropping intensity; cropping pattern; bullock operated farm; cooperative management; farm machinery,

1. INTRODUCTION

Agriculture has changed significantly with advances in science and technology. Traditional agriculture was mostly dependent on human labor and draught animals with less fertilizer application, plant protection measures etc. where modern agricultural practices are mainly based on machines especially high-speed, powerful tractors and its implements with higher rate of input application. Farm mechanization is considered to one of the several pathways of agricultural development. Human population grow exponentially while food production grows at an arithmetic mean (Malthus, 1978 in his book "Essay on The Principle of Population"). In Asia and Latin America Economic growth and the commercialization of agricultural systems is leading to further mechanization of agricultural systems. Low levels of mechanization of Sub-Saharan Africa and available data indicate declining rather than increasing levels of adoption among the countries like Kenya and Zimbabwe [1]. Verma (1997) in his paper entitled "Impact of Agricultural Mechanization on Production, Productivity, Cropping Intensity, Income Generation and Employment of Labour", reported that the agricultural mechanization on human labour employment had shown that agricultural mechanization helped in overall increase in the employment of human labour whereas1.3 to 12 per cent reduction in aggregate labour used on tractor operated farms was quite nominal as compared to bullock operated farms and found 38.55 per cent increase in employment of casual male labour [2]. To meet the expected demand for food we have to increase food production with fixed limited resources. A farming system cannot sustain with the traditional system. The mechanization of farm is also inductive to the diversification of the cropping pattern as it enables farmer to raise a second crop or multi crop ultimately raising cropping intensity. Assam has the largest cultivable plain land in North-East India with power consumption for mechanization is 0.75 kW/ha but it is still below the national average which is 1.5 kW/ha., mechanization of agriculture is mandatory to an optimum level of mechanization is necessary for sustainable food grain production and drudgery reduction [3]. Farm mechanization leads o proper utilization of moisture content of soil for further multiple cropping which ultimately increase agricultural production from same piece of land [4]. In order to observe this therefore the present study was done to see the impact of farm mechanization in cropping pattern and cropping intensity in Assam.

2. METHODOLOGY

The study was conducted in Upper Brahmaputra and Central Brahmaputra Valley Zone of Assam. The study included four categories of mechanized farms *viz.*, Tractor Ownership Farm (TOF), Tractor Hired Farm (THF), Power Tiller Ownership Farm (PTOF), Power Tiller Hired Farm (PTHF), and a non mechanized category of Bullock Operated Farm. Total two hundred forty sample of one hundred twenty sample from each Zone of Assam were selected for the study. These sample were categories as Tractor Ownership Farm (TOF), Tractor Hired Farm (THF), Power Tiller Ownership Farm (PTOF), Power Tiller Hired Farm (PTHF), and Bullock Operated Farm (BOF) and further classified into three groups *viz.,* Group I (less than 1 ha) Group II(1.00-2.00 ha)and Group III(more than 2 ha) for the purpose of easy analysis. Primary data pertaining to the year 2014-15 and secondary data were collected from different published

source along with government institution. Primary data were collected with the help of specially design pretested schedule by interview method. Tabular, percent, log linear regression were used for the study .Primary data of 240 sample farms by personal interview method and with the help of specially designed pretested schedule used for examining the effect of farm mechanization on cropping intensity. All data collected from sample farms pertains to the year 2014-15.

2.1 Cropping Intensity

Cropping intensity is computed by the formula:

$$\text{Cropping intensity} = \frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100$$

2.2 Regression

In addition, log linear regression analyses was carried out to isolate the effects of mechanization on cropping intensity. In total four dummy variables were used in the regression analyses to present the four forms of mechanization *viz*., Tractor Ownership Dummy(D_1), Tractor Hired Dummy(D_2), Power Tiller Ownership Dummy (D_3), Power Tiller Hired Dummy(D_4). The forms of equations used to isolate the effect of mechanization on cropping intensity

Linear Equations:

$$\text{Cropping Intensity } (Y_1) = a + b_1 x_1 + c_1 D_1 + c_2 D_2 + c_3 D_3 + c_4 D_4 + e$$

3. RESULTS AND DISCUSSION

Farm mechanization led to increase which increase in average cropping intensity and larger area and increase farm productivity. This section is thus, examines in detail the impact of farm mechanization in cropping pattern and cropping intensity.

3.1 Cropping Pattern

The cropping pattern followed by the sample farmers as showed in the Table 1 weresali rice, ahu rice, boro rice, mustard, pulse, potato, jute and other horticultural crops and vegetables. Sali rice was the main dominant crops in all categories of mechanized and Bullock Operated Farm in the study area. But relative share of sali rice area to gross cropped was highest in case of Bullock Operated Farm was 9.17 per cent and 52.06 per cent in case of Tractor Ownership Farm which was lowest amongst different categories of mechanized farms. On the other hand, relative share of potato, pulse and jute in case of all categories mechanized farm was higher with exception in case of Bullock Operated Farm where it was cereal(sali paddy) biased which was indicative of the fact that cropping pattern in mechanized farm slightly shifted in favour of high valued crops. About 8.44 cent 13.21 per cent of grossed cropped area were under mustard and others vegetables in case Bullock Operated Farm for home consumptions only. This result was in consistent with [5] Berg et al. (2005) that household who adopted modern advance technology practiced double rice rotation whereas others stick to single rice only .Again in case of mechanized farm the household shifted to ahu and boro paddy while in case of Bullock Operated Farm they stuck to only Sali paddy. This may be due to the reason that for cultivation of boro rice irrigation and mechanization is necessary and in case of Bullock Operated Farm, their land area were un irrigated.

The cropping pattern of different farm sizes in both mechanized and Bullock Operated Farm is presented in Table 2. Relative share of Sali rice to gross cropped area was much higher than that of all other crops in all farm size group under various categories of mechanized and Bullock Operated Farm. It, was thus clear that cropping pattern of different categories of mechanized farms slightly shifted to high valued crops while in case of Bullock Operated Farm it is remain sali rice biased as usual.

3.2 Cropping Intensity

Agricultural mechanization has made significant contribution in enhancing cropping intensity. [6] Singh concluded that cropping intensity was mainly dependent on annual water availability and the farm power available. Hence, cropping intensity is another common issue in connection with mechanization as it leads to higher productivity. [7] Ramya also reported that cropping intensity was higher after the introduction of tractor than without tractor in Indian farms. Table 3 showed the average cropping intensity farm size under different categories of mechanized and Bullock Operated Farm. It was seen from the Table 3 that cropping intensity was higher in case of all mechanized farms than Bullock Operated Farm not only individual size groups but all farm size taken

Table 1. Cropping pattern under various categories of mechanized and bullock operated farm (ha)

Crops	TOF	THF	PTOF	PTHF	BOF	Pooled
Sali rice	46.21	124.87	62.85	24.54	8.63	267.10
	(52.06)	(57.62)	(59.10)	(60.29)	(79.17)	(57.70)
Ahu rice	8.66	32.40	19.19	4.13	-	64.38
	(9.76)	(14.95)	(18.04)	(10.15)		(13.91)
Boro rice	4.90	6.01	4.80	1.20	-	16.91
	(5.52)	(2.77)	(4.51)	(2.95)		(3.65)
Mustard	6.63	10.71	1.60	2.08	0.92	21.94
	(7.47)	(4.94)	(1.50)	(5.11)	(8.44)	(4.74)
Pulse	9.06	11.65	3.60	2.76	-	27.07
	(10.21)	(5.38)	(3.39)	(6.78)		(5.85)
Potato	5.15	15.59	3.86	3.43	-	28.03
	(5.80)	(7.19)	(3.63)	(8.43)		(6.05)
Jute	6.098	3.06	1.53	-	-	10.69
	(6.87)	(1.41)	(1.44)			(2.31)
Others	2.06	11.72	9.06	2.53	1.44	26.81
	(2.32)	(5.41)	(8.52)	(6.22)	(13.21)	(5.79)
Gross Cropped Area	88.768	216.71	106.35	40.70	10.90	462.93
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Net Cropped Area	58.4	133.6	68.78	25.20	8.63	294.61
CI	**152.00**	**162.21**	**154.62**	**161.49**	**126.36**	**157.13**

Figures within parentheses indicate percentage to total cropped area

Table 2. Cropping pattern under various categories of mechanized and bullock operated farm across different farm sizes (ha)

Crops	TOF		THF		PTOF		PTHF		BOF		Pooled
	Group III	Group I	Group II	Group III	Group II	Group III	Group I	Group II	Group I	Group II	
Sali rice	46.21 (52.06)	56.94 (58.19)	53.53 (60.64)	14.4 (48.19)	18.02 (58.61)	44.83 (59.18)	11.07 (61.79)	13.47 (59.21)	5.33 (79.55)	3.3 (76.92)	267.10 (57.70)
Ahu rice	8.66 (9.76)	12.99 (13.27)	13.66 (15.47)	5.76 (19.28)	5.2 (16.92)	13.99 (18.47)	2.00 (11.17)	2.13 (9.36)	-	-	64.38 (13.91)
Boro rice	4.9 (5.52)	3.26 (3.33)	0.87 (0.99)	1.88 (6.31)	1.07 (3.47)	3.73 (4.93)	1.20 (6.70)	-	-	-	16.91 (3.65)
Mustard	6.63 (7.47)	5.73 (5.86)	3.97 (4.49)	1.013 (3.39)	0.40 (1.30)	1.20 (1.58)	0.66 (3.69)	1.42 (6.24)	0.41 (6.12)	0.51 (11.89)	21.94 (4.74)
Pulse	9.06 (10.21)	6.13 (6.26)	4.06 (4.60)	1.47 (4.91)	2.39 (7.78)	1.21 (1.59)	0.80 (4.47)	1.96 (8.62)	-	-	27.07 (5.85)
Potato	5.15 (5.80)	7.09 (7.24)	5.74 (6.50)	2.77 (9.25)	1.53 (4.99)	2.33 (3.07)	1.33 (7.43)	2.10 (9.23)	-	-	28.03 (6.05)
Jute	6.09 (6.87)	-	2.06 (2.34)	1.00 (3.35)	-	1.53 (2.02)	-		-	-	10.69 (2.31)
Others	2.06 (2.32)	5.73 (5.85)	4.40 (4.98)	1.59 (5.32)	2.13 (6.94)	6.93 (9.14)	0.86 (4.79)	1.67 (7.33)	0.96 (14.33)	0.48 (11.19)	26.81 (5.79)
Gross Cropped Area	88.77 (100.00)	97.86 (100.00)	88.27 (100.00)	29.88 (100.00)	30.74 (100.00)	75.75 (100.00)	17.91 (100.00)	22.75 (100.00)	6.70 (100.00)	4.29 (100.00)	462.93 (100.00)
Net Cropped Area	58.40	60.00	54.80	18.80	19.46	49.32	11.07	14.13	5.33	3.30	294.61

Figures within parentheses indicate percentage to total cropped area

Table 3. Cropping intensity under various categories mechanized and bullock operated farm across different farm sizes (%)

Farm size	TOF	THF	PTOF	PTHF	BOF	Total
Group I	-	163.10	-	161.79	125.70	160.30
Group II	-	161.09	157.97	161.00	130.00	160.8
Group III	152	158.94	153.59	-	-	153.74
Pooled	**152.00**	**162.21**	**154.62**	**161.49**	**126.36**	**157.13**

together also. Tractor Hired Farm had the highest cropping intensity (162.21 per cent) followed by Power Tiller Hired Farm (161.49 per cent) and Tractor Ownership Farm (152.00 per cent) and Power Tiller Ownership Farm (154.62 per cent), respectively. In case of Tractor Ownership Farm had lower level of cropping intensity (152.00 per cent) than other categories of mechanized farm in the study area. This might be due to the fact that Tractor Ownership Farm were normally sound farm and had other source of primary occupation like service and business than agriculture and gave less importance in the farming. Again, cropping intensity showed a inverse relationship in case of mechanized farm i.e. higher the farm size lower was the cropping intensity and vice versa with a little exception in case of Bullock Operated Farm. However, cropping intensity of Assam was 142.00 per cent (Department of Agriculture, GoA) during 2014-15 which was lower than the sample farm in the study area. Further, in case Bullock Operated Farm cropping intensity showed positive relationship with farm size.This results is in conformity with the findings of Muhammad [8,9] Houssou and Chapoto who reported that causes and effects of agricultural mechanization and found that cropping intensity was higher in case of mechanized farms.

3.3 Regression Analysis

Regression analysis was carried out to examine the impact of farm mechanization on cropping intensity and results are presented in Table 4. From the table it was observed that farm size and cropping intensity had highly significant inverse relationship (-1.98) at 5 per cent probability level. Moreover, in all the categories of farm had positive significant relationship with cropping intensity. Amongst all the categories of mechanized dummies, Tractor Hired Farm (2.68) had the highest significant relationship with cropping intensity followed by Power Tiller Hired Farm (2.13) at 1 per cent and 5 per cent probability level, respectively. Thus, it is clear that mechanization showed an impact on increasing cropping intensity in the study area where tractor operated farm by hiring appeared to be the most important form of mechanization as it depicted a very high significant relationship with the cropping intensity in the study area. Thus from the above discussion it was observed that there was positive impact of farm mechanization on cropping pattern and cropping intensity. This findings is in conformity with [10] Bordaloi on farm mechanization in Titabar sub-division of Jorhat district of Assam.

Table 4. Effect of mechanization on cropping intensity

Particulars of variable	Regression coefficients
No. of Observations	240
R^2	0.38
Constant	1.35
Farm Size	-1.98**
Tractor Ownership Dummy	2.01**
Tractor Hired Dummy	2.68***
Power Tiller Ownership Dummy	2.13**
Power Tiller Hired Dummy	1.69*

** Significant at 10% probability level; ** Significant at 5% probability level; *** Significant at 1% probability level*

4. CONCLUSION

A farming system cannot sustain with the traditional system. The mechanization of farm is also inductive to the diversification of the cropping pattern as it enables farmer to raise a second crop or multi crop ultimately raising cropping intensity. In the study area sali paddy, ahu paddy, boro paddy, mustard, pulse ,potato, jute were included in the cropping pattern of the sample farmers. Sali paddy was the dominant crops in categories of mechanized and non mechanized farm where relative share of sali rice to the total copped was maximum in case of bullock operated farm. In case of mechanized farm shifted to ahu and boro paddy while in case of bullock operated farm stick to only sali paddy and relative share of sali ice to gross crop area was much higher than that of all farm size group

under various categories of mechanized and bullock operated farm. Cropping pattern in medium and large sized mechanized farms were shifted in favour of high valued crops and cropping intensity was higher in case of mechanized farms and it was seen that cropping intensity showed a negative significant relationship with farm size i.e. -1.98.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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