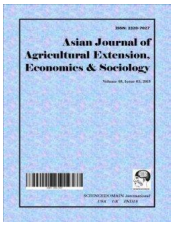

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Impact of Farm Mechanization on Income of Farmers in Assam, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The study was conducted in Central Brahmaputra Valley and Upper Brahmaputra Valley Zone of Assam in India. The present study is an attempt to study the effect of mechanization on income and limiting factors of farm mechanization of the sample farms. Primary data of 240 sample farms by personal interview schedule method was used for examining the effect of farm mechanization on income along with limiting factors for mechanization adoption . All data collected from sample farms pertains to the year 2014-15. Tabular, per cent analysis were done and results obtained from these analysis were summarized to examine the impact of farm mechanization on income . In case of Tractor Ownership Farm, Tractor Hired Farm, Power Tiller Ownership Farm, Power Tiller Hired Farm and Bullock Operated Farm gross return per cropped hectare were Rs.62916.24, Rs. 61370.31, Rs.62408.87, Rs. 56783.89 and Rs.34425.58, respectively. Family labour income and net income also had inverse relationship with farm size in each categories of mechanized and Bullock Operated Farm and exception in case of under Group III under Tractor Hired Farm. Family labour income and net income relative proportion of each mechanized farm was higher over Bullock Operated Farm. Net return were observed to be Rs. 33898.17, Rs.377.76, Rs. 33606.45,

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Rs.27831.05 and Rs. (-)12075.51 in Tractor Ownership Farm, Tractor Hired Farm, Power Tiller Ownership Farm, Power Tiller Hired Farm and Bullock Operated Farms, respectively. Family labour income and net income also had inverse relationship with farm size in each categories of mechanized and Bullock Operated Farm and exception in case of under Group III under Tractor Hired Farm. Family labour income and net income relative proportion of each mechanized farm was higher over Bullock Operated Farm. Hence it was observed that there was positive impact of farm mechanization on income. In case of Tractor Hired Farm net income was higher than Tractor Ownership Farm. Small and scattered land holding and inadequate sufficient funds to meet the initial cost of purchasing were the most serious problem faced by the farmers in the study area as out of total household 170 and 169 numbers of farmers found it most serious in case of small and scattered land holding and high initial cost to purchase the machineries respectively So, hence effort should be given to make available of the tractors amongst the farmers in the study area through establishment of Farm Machinery Banks for custom hiring along with development financing of second hand tractors for small farmers having operational holding less than 2 hectares should been given to make economical use machineries amongst the small farmers in the study area.

Keywords: Mechanized; non mechanized; family labour income; net income.

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. whereas 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. In modern agricultural practices, mechanization of farm is needed from the view point of the profitability of agriculture by reducing the cost of cultivation. Agricultural mechanization has not only changed the characteristics of labor in agriculture but also influenced the workload involve in it. 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 recognized in India. Human population grows exponentially while food production grows at an arithmetic mean (Malthus, 1978 in his book “Essay on The Principle of Population”). 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. With the implementation of the modern farming machinery, the cost of cultivation may be reduced to a substantial level and hence mechanization of farm is expected to generate enormous development opportunities for the agricultural sector.

Assam like other state of India, is predominantly an agricultural state. However, development of agricultural sector is still less as compared to other states of the country. Predominance of marginal farmers, limited irrigation facilities, lack of credit facilities and unfavorable weather condition are the main reasons for this less development. Mwangi and Kariuki (2015) studied the factors affecting adoption of new agricultural technology by smallholder farmers in developing countries and concluded that perception of farmers towards a new technology was a key precondition for adoption to occur [1]. Other factors included were human specific factors, economic factors, technological and institutional factors. They reported that the determinant of agricultural technology adoption did not always have the same effect on adoption rather the effect varies depending on the type of technology being introduced It has been felt that agricultural growth rate is increasing gradually in the state due to the high yielding varieties programs along with gradual shift in the modern technology but it is still less as compared to the other state. The low availability of farm power is the most serious problem which is main constraints for double or multiple cropping in the state. Special thrust has been given by the State Agriculture Department in order to boost up the mechanization level in the state. Directorate of Agriculture, Assam, India revealed that farm power availability in Assam is 1.78 HP per hectare whereas it is 2.05 HP per hectare at national level during 2014-15.

1.1 Statement of the Problem

In the context of growing demand of selective forms of farm machinery in Assam, the pertinent question to ask is whether the farm mechanization contributes to income or not and unlike the other states, there has hardly been any study so far in the state of Assam to answer this question. Impact of farm mechanization is a controversial issue and therefore the present study was therefore an attempt to answer the aspects of farm mechanization in Assam with the following specific objectives.

1.2 Objectives

1. Socio economic characteristics of the respondents.
2. Effect of the farmers' socioeconomic characteristics of the respondents.
3. Examine the effect of mechanization on Gross Income, Family Labour Income and Net Income in the study area.
4. Identify the limiting factors to farm mechanization in the study area.

2. MATERIALS AND METHODS

The present study is an attempt to study the effect of mechanization on income of the sample farms. The study was conducted in Upper Brahmaputra and Central Brahmaputra Valley Zone of Assam. The sampling design followed for the study was four stage random sampling design. Districts from the first stage unit, blocks were the second stage unit, villages were the third and the sample farmers were the fourth ultimate stage of units of sampling. For Central Brahmaputra Valley Zone, Nagoan district had been selected as Nagaon district is ahead of mechanization compared to other districts. Dibrugarh and Jorhat district represented the Upper Brahmaputra Valley Zone. In consultation with Agricultural Development Officer (ADO) and Agricultural Engineering Department, Government of Assam in the selected districts, the blocks having higher concentration of farm implements were selected.The sample household were classified into 5 sub groups *viz.,*Tractor Ownership Farm (TOF), Tractor Hired Farm (THF), Power Tiller Ownership Farm (PTOF), Power Tiller Hired Farm(PTHF), Bullock Operated Farm(BOF). Most of the farmers in the sample were having less operational holding as most of the farmers of Assam is small and marginal. Only very few farmers were found to have land holding more than 3 hectares hence the stratification of groupings were made as follows:

i) Group I (less than 1.00 ha)
ii) Group II (1.00-2.00 ha) and
iii) Group III (more than 2.00 ha)

Thus, a sample of 240 farmers comprising of 120 from Upper Brahmaputra Valley Zone and 120 from Central Brahmaputra Valley Zone had been taken for the study. The sampling design was as follows:

Primary data of 240 sample farms by personal interview schedule method was used for examining the effect of farm mechanization in income and limiting factors of farm mechanization. All data collected from sample farms pertains to the year 2014-15. Tabular with averages, percentage, were carried out to find out socioeconomic characteristics, of farms effect of farm mechanization on income and limiting factors of farm mechanization in the study area

3. RESULTS AND DISCUSSION

3.1 A Socio-economic Characteristics and Effect of the Farmers' Socio Economic Characteristics of the Respondents

3.1.1 Distribution of population according to age and sex

Data on population by age groups and sex in the sample are given in the Table 1. The age group between 15 to 60 years, which can be considered as the potential labour force accounted for 68.42 per cent of the total population. In the age group below 15 years and above 60 years, the proportions of population were 19.25and 12.33 percent of the total. The proportion of population for males and females in the sample were 56.25 and 12.33 per cent, respectively. It was observed that highest proportion of male working population was concentrated in the large size-groups i.e. group III under THF and lowest proportion in case of BOF under Group II showing a relationship between mechanization adoption and male workers. However, no distinct relationship was observed between farm size and female working population.

3.1.2 Distribution of population according to educational standard

Farm family education for different size group under various categories of mechanized and

BOF are shown in Table 2 .About 38.22 per cent of the total population was found to be literate. Highest illiterate rate was found in Group I under BOF i.e. 93.75 which might be the constrains of advance technology adoption. It was observed that illiteracy rate was lowest in case of TOF. Rate of literacy, thus,seemed to have a positive relationship with the level of mechanization in the study area. These findings are in conformity with the findings reported by Kazemi (2015) in North of Iran where education was the facilitating factors affected on acceptance of mechanization technologies to reduce losses in rice [2].

3.1.3 Working force and occupational pattern

Data on distribution of population of different farm sizes under various categories of mechanized and BOF are given in Table 3. Workers constituted to 80.60 per cent of the total population, with the rest 39.40 per cent being non-worker. Tractor Hired Farm had the highest working force than other categories of mechanized and non mechanized farm. Further proportion of female worker is higher in case of BOF in Group I.

With regards to the occupational pattern of the working force as shown in the Table 4 it was observed that cultivation, salaried job, business and others were the major occupation in the sample farms. 81.87 percent of the population engaged in agriculture followed by 4.19 per cent in salaried jobs and rest 13.94 percent of the household engaged in business and others. While the data showed that agriculture was still the major source of income to the sample households in the both mechanized and non mechanized farms, with business and allied activities coming a distant second followed by salaried jobs. Lack of industrial development in the area may be one of reason behind it

3.1.4 Type of family

Farm families may be either nucleus families (only one family) or joint families (comprising of more than one family living jointly together). Table 5 showed the type of family for different farm size group under various categories of mechanized and non mechanized farm. It was observed that proportion of nucleus to joint family was 87.50:12.50 in the sample household with little exception in case BOF where only nucleus family exist and in TOF proportion of joint family to nucleus family is 57.89:42.11.The greater proportion of joint family in TOF might be due joint families usually had bigger size of holding and financially sound to bear machineries like tractors.

The average size of holding in TOF, THF, PTOF, PTHF and BOF were found to be 3.07, 0.95, 1.86, 0.79 hectares respectively, as shown in the Table 6. There was considerable difference in the average size of holding between TOF and BOF. However, average size of holding did not show much variation in case of PTHF and BOF. In case of TOF and PTOF size of holding were higher than other categories. Thus, positive relationship with mechanization level with the farm size in the sample farm was demonstrated. These findings were in conformity with the findings reported by Singh et al. (2013) in Punjab state in India where tractor owners typically own 4 times as much land as tractor hirers [3] and contradicted the findings with Berg et al. (2007) the impact of increasing farm size and mechanization on rural income and rice production in China [4]. They reported that larger farm sizes labour constraints inhibit farmers from specialization in non-rice crops leads to rising per capita income.

3.1.5 Effect of mechanization on Income

Mechanization, along with other new technology has a tendency to shift upward in production by increasing output and decreasing costs which ultimately increase the income of the household. In this section therefore examine the impact of mechanization on income generation in the study area.

Aurangzeb et al. (2007) argued that the application of mechanization will boost up the overall productivity and production with the lowest cost of production [5]. Cost and return analysis was done for different categories of mechanized and BOF and presented in Table 7. Where family labour income and net income could be analyzed. Gross return per cropped hectare in TOF, THF, PTOF, PTHF were found to be higher by 70.84, 66.65, 69.47 and 54.19 per cent than BOF. Contrary to the gross return, total cost per cropped was higher in case of BOF than other categories of mechanized farm. It was lowered by 40.64, 51.74, 41.10, 40.79 per cent in case of TOF, THF, PTOF, PTHF, respectively over BOF including family labour. Mahrouf and Rafeek (2002) reported that mechanization of paddy harvesting in Srilanka reduced the harvesting cost by Rs. 3800 per hectare, increased the net returns by Rs. 7850 per ha and

that the cost of production of paddy was reduced by 10-15 per cent and ultimately solved the problem of scarcity of labour during peak harvesting season [6]. In the study area, total cost was declining with increase in the level of mechanization. This was mainly due to the reason of labour displacement where family and labour cost declined with increase in the level of mechanization. But on the other hand cost of manure and fertilizers and seeds were higher in various categories of mechanized farm over BOF. This indicated that mechanized farm adopted improved verities and other plant protection measures. Similarly, Takeshima et al. (2016) observed the impact of mechanization on smallholders in Nepal smallholder landholding size 0.45 ha of land and were benefited more from the adoption of tractors through custom hiring service [7]. They also found that various imperfections in custom-hired tractor markets, land markets, and so forth, which could be alleviated by appropriate government interventions were the main barriers faced by smallholders for mechanization adoption.

Gross return along with gross cost and farm income of different size group under various categories of mechanized and BOF are presented in Table 8. From the table, within each category of mechanized and BOF cost of different size group of different form of inputs such as material costs, human labour cost, all were found to be increase with decrease in farm size .Similarly in case of gross return also seen inverse relationship with farm size while a little exception incase of THF where gross return per cropped hectare was decreasing with increase in farm size and in case of THF under Group III (Rs. 60560.83) which was lowest within the groups.

It was observed that in case of TOF, THF, PTOF, PTHF and BOF gross return per cropped hectare was Rs. 62916.24, Rs. 61370.31, Rs. 62408.87, Rs. 56783.89 and Rs. 34425.58, respectively. Brief analysis of income of different categories of mechanized farm along with BOF is apparent from Table 8. Family labour income was found tobe Rs. 34492.26 Rs. 49737.51, Rs. 37414.46, Rs. 43812.74 and Rs. 25353.29 inTOF, THF, PTOF, PTHF and BOF, respectively and net return was observed to be Rs.33898.17, Rs.377.76, Rs.33606.45, Rs.27831.05 and Rs. (-) 12075.51 in TOF, THF, PTOF, PTHF and BOF, respectively .Zhizhang and Hanlin (2014) reported existence of co-integration relationship between farmers' income and total power of agricultural machinery from 1981-2011 in China [8].

Family labour income and net income also showed inverse relationship with farm size in each categories of mechanized and BOF and exception in the case of Group III under THF. Family labour income and net income relative proportion of each mechanized farm was higher over BOF. Similarly, Rai and Bezbaruah (2002) had reported that, mechanization comparative cost advantage increased the marginal productivity of labour substantially [9]. Again negative value of net return was due to imputed vale of family labour as involvement of family labour higher in case of BOF. Mohamed (2012) had also reported high wages and scarcity of manual labour in ploughing, transplanting, spraying, harvesting and threshing increased the cost of production in paddy cultivation in Kerala [10].

Further, comparative analysis of mechanized and BOF were worked out and showed in Table 9.. Family labour income and net income relative proportion of each mechanized farm was higher over BOF. This results indicated that mechanized farm had considerably higher return than BOF. Gross income was also higher in case of mechanized farm than BOF. Net income was found negative in case BOF due to the inclusion of imputed value of family labour. In case of mechanized farm net income was 393 per cent higher than BOF. These findings are in conformity with the findings with Rahman*et al.* (2011) examined the effect of mechanization on labour use and profitability in wheat cultivation in Northern Bangladesh and revealed that Gross margin was found to be higher for mechanized farm compared to traditional farm [11]. Similarly Mamman (2015) also found the effect agricultural mechanization on crop production in Bauchi and Yobe states [12]. Descriptive research survey design was used to examine the effects and found that farmers crop yields increased with full adoption of agricultural mechanization resulted in increase in income of the farmers.

Thus, from the above discussion it was observed that there was positive impact of farm mechanization on productivity and income. Tekwa et al. (2007) also observed the impacts of agricultural mechanization on floodplain sugar-cane growers farmers' income in Nigeria and found that 95 per cent of farmers experienced positive impact of mechanization in farm output and income [13].

Table 1. Distribution of population under various categories of Mechanized and BOF across different farm sizes

Zone	Districts	Population (nos.)	Soil and climatic condition	GPS coordinates	Blocks	Villages
Central Brahmaputra Valley Zone	Nagaon	1894788	i)Tropical climatic condition ii)sandy loam soil	26.35˚ N,92.68˚E, Elevation :73-62 m	Juria	1. Thiotanguni 2. JuriaDagaon
					Botodrawa	1. Batomari 2. Bhomoraguri
Upper Brahmaputra Valley Zone	Jorhat	1091295	i)Warm and temperate climatic condition ii)Fertile alluvial soil	26.75˚N,94.22˚E Elevation :116 m	Kaliapani	1. Bamunpukhuri 2. Balijaan
					Titabor	1. Bekajan 2. Ekorani
	Dibrugarh	136335	i)Humid subtropical climate with extremely wet summer ii)fertile alluvial soil	27.45˚N, 95.91˚E Elevation :123-108 m	Lahoal	1. Natun Bosapathar Gaon 2. Basmotia
					Khowang	1. KutuhaBaligaon 2. Ouphulia

Table 2. Extent of literacy under various categories of Mechanized and BOF across different farm sizes

Categories of farm		No. of households	Below 15 yrs			Between 15 to 60 yrs			60 yrs and above			Total population		
			M	F	Total	M	F	Total	M	F	Total	M	F	Total
TOF	Group III	19	20 (13.98)	13 (9.09)	33 (23.08)	71 (49.15)	31 (21.68)	102 (71.32)	5 (3.49)	3 (2.09)	8 (5.59)	84 (58.74)	59 (41.25)	143 (100)
THF	Group I	88	19 (15.13)	22 (24.79)	41 (39.92)	143 (50.84)	131 (37.82)	274 (88.66)	11 (2.94)	7 (2.52)	18 (5.46)	173 (51.95)	160 (48.05)	333 (100)
	Group II	46	21 (9.63)	17 (7.80)	38 (17.43)	79 (36.24)	66 (30.38)	145 (66.51)	17 (7.80)	18 (8.26)	35 (16.06)	117 (53.67)	101 (46.33)	218 (100)
	Group III	7	11 (15.94)	2 (2.90)	13 (18.84)	22 (31.88)	14 20.29)	36 (52.17)	15 (21.74)	5 (7.25)	20 (28.99)	48 (69.57)	21 (30.43)	69 (100)
PTOF	Group II	16	14 (11.48)	10 (8.20)	24 (19.67)	41 (33.61)	32 (26.23)	73 (59.84)	16 (13.11)	9 (7.38)	25 (20.49)	71 (58.20)	51 (41.80)	122 (100)
	Group III	21	19 (11.73)	12 (7.41)	31 (19.14)	54 (33.33)	49 (30.25)	103 (63.58)	20 (12.35)	8 (4.94)	28 (17.28)	93 (57.41)	69 (42.59)	`162 (100)
PTHF	Group I	19	18 (17.14)	6 (5.71)	24 (22.86)	38 (36.19)	31 (29.52)	69 (65.71)	8 (7.62)	4 (3.81)	12 (11.43)	64 (60.95)	41 (39.05)	105 (100)
	Group II	13	10 (13.70)	15 (20.55)	25 (34.25)	27 (36.99)	13 (17.81)	40 (54.79)	6 (8.22)	2 (2.74)	8 (10.96)	43 (58.90)	30 (41.10)	73 (100)
BOF	Group I	8	5 (16.13)	4 (12.90)	9 (29.03)	9 (29.03)	11 (35.48)	20 (64.52)	1 (3.23)	1 (3.23)	2 (6.45)	15 (48.39)	16 (51.61)	31 (100)
	Group II	3	2 (11.76)	5 (29.41)	7 (41.18)	5 (29.41)	4 (23.53)	9 (52.94)	1 (5.88)	-	1 (5.88)	8 (47.06)	9 (52.94)	17 (100)
Total		240	130 (10.21)	106 (8.33)	245 (19.25)	489 (38.41)	382 (30.01)	871 (68.42)	100 (7.86)	57 (4.48)	157 (12.33)	716 (56.25)	557 (43.75)	1273(100)

M= Male; F= Female

Figures within parentheses indicate percentage of the total

Table 3. Working force for under various categories of Mechanized and BOF across different farm sizes

Categories of farm		No. of households	Total illiterate population			Primary level			H.S pass and under graduate			Graduate and above			Total literate		
			M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
TOF	Group III	19	8 (6.72)	16 (13.45)	24 (20.17)	46 (38.66)	29 (24.37)	75 (63.03)	20 (16.81)	11 (9.24)	31 (26.05)	10 (8.40)	3 (2.52)	13 (10.92)	76 (63.87	43 (36.13)	119 (100)
THF	Group I	88	36 (15.13)	59 (24.79)	95 (39.92)	121 (50.84)	90 (37.82)	211 (88.66)	7 (2.94)	6 (2.52)	13 (5.46)	9 (3.78)	5 (2.10)	14 (5.88)	137 (57.56)	101 (42.44)	238 (100)
	Group II	46	21 (13.55)	42 (27.10)	63 (40.65)	76 (49.03)	49 (31.61)	125 (80.65)	12 (7.74)	3 (1.94)	15 (9.68)	8 (5.16)	7 (4.52)	15 (9.68)	96 (61.94)	59 (38.06)	155 (100)
	Group III	7	8 (16.00)	11 (22.00)	19 (38.00)	9 (18.00)	7 (14.00)	16 (32.00)	5 (10.00)	2 (4.00)	7 (14.00)	7 (14.00)	1 (2.00)	8 (16.00)	40 (80.00)	10 (20.00)	50 (100)
PTOF	Group II	16	9 (9.47)	18 (18.95)	27 (28.42)	31 (32.63)	20 (21.05)	51 (53.68)	4 (4.21)	9 (9.47)	13 (13.68)	-	4 (4.21)	4 (4.21)	62 (65.26)	33 (34.74)	95 (100)
	Group III	21	11 (8.66)	24 (18.90)	35 (27.56)	28 (22.05)	21 (16.54)	49 (38.58)	10 (7.87)	15 (11.81)	25 (19.69)	9 (7.09)	9 (7.09)	18 (14.17)	82 (64.57)	45 (35.43)	127 (100)
PTHF	Group I	19	19 (29.23)	21 (32.31)	40 (61.54)	31 (47.69)	9 (13.85)	40 (61.54)	9 (13.85)	8 (12.31)	17 (26.15)	5 (7.69)	3 (4.62)	8 (12.31)	45 (69.23)	20 (30.77)	65 (100)
	Group II	13	12 (26.09)	15 (32.61)	27 (58.70)	25 (54.35)	6 (13.04)	31 (67.39)	3 (6.52)	7 (15.22)	10 (21.74)	3 (6.52)	2 (4.35)	5 (10.87)	31 (67.39)	15 (32.61)	46 (100)
BOF	Group I	8	8 (50.00)	7 (43.75)	15 (93.75)	4 (25.00)	5 (31.25)	9 (56.25)	3 (18.75)	2 (12.50)	5 (31.25)	-	-	-	7 (43.75)	9 (56.25)	16 (100)
	Group II	3	3 (30.00)	4 (40.00)	7 (70.00)	4 (40.00)	4 (40.00)	8 (80.00)	1 (10.00)	1 (10.00)	2 (20.00)	-	-	-	5 (50.00)	5 (50.00)	10 (100)
Total		240	135 (14.66)	217 (23.56)	352 (38.22)	338 (36.70)	240 (26.06)	578 (62.76)	74 (8.03)	64 (6.95)	138 (14.98)	51 (5.54)	34 (3.69)	85 (9.23)	581 (63.08)	340 (36.92)	921 (100)

M= Male; F= Female

Figures within parentheses indicate percentage of the total

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Table 4. Primary occupation under various categories of Mechanizedand BOF across different farm sizes

Categories of farm		Number of households	Worker			Non worker			Total		
			Male	Female	Total	Male	Female	Total	Male	Female	Total
TOF	Group III	19	69 (48.25)	51 (35.66)	120 (83.92)	15 (10.49)	8 (5.59)	84 (16.08)	84 (58.74)	59 (41.26)	143 (100)
THF	Group I	88	149 (44.74)	133 (39.94)	282 (84.68)	24 (7.21)	27 (8.11)	173 (15.32)	173 (51.95)	160 (48.05)	333 (100)
	Group II	46	101 (46.33)	79 (36.24)	180 (82.57)	16 (7.34)	22 (10.09)	117 (17.43)	117 (53.67)	101 (46.33)	218 (100)
	Group III	7	42 (60.87)	14 (20.29)	56 (81.16)	6 (8.70)	7 (10.14)	48 (18.84)	48 (69.57)	21 (30.43)	69 (100)
PTOF	Group II	16	59 (48.36)	33 (27.05)	92 (75.41)	13 (20.66)	17 (13.93)	72 (24.59)	72 (59.02)	50 (40.98)	122 (100)
	Group III	21	69 (42.59)	52 (32.10)	`121 (74.69)	24 (14.81)	17 (10.49)	93 (25.31)	93 (57.41)	69 (42.59)	162 (100)
PTHF	Group I	19	41 (39.05)	40 (38.10)	81 (77.14)	13 (12.38)	11 (10.48)	54 (22.86)	54 (51.43)	51 (48.57)	105 (100)
	Group II	13	38 (52.05)	20 (27.40)	58 (79.45)	6 (8.22)	9 (12.33)	44 (20.55)	44 (60.27)	29 (39.73)	73 (100)
BOF	Group I	8	11 (35.48)	15 (48.39)	26 (83.87)	4 (12.90)	1 (3.23)	15 (16.13)	15 (48.39)	16 (51.61)	31 (100)
	Group II	3	6 (35.29)	4 (23.53)	10 (58.82)	2 (11.76)	5 (29.41)	8 (41.18)	8 (47.06)	9 (52.94)	17 (100)
Total		240	585 (45.95)	441 (34.64)	1026 (80.60)	123 (9.66)	124 (9.74)	708 (19.40)	708 (55.62)	565 (44.38)	1273 (100)

Figures within parentheses indicate percentage of the total

Table 5. Type of family under various categories of Mechanized and Bullock Operated Farm across different farm sizes

Categories of farm		Number of households	Type of family	
			Nucleus	Joint
TOF	Group III	19 (100)	8 (42.11)	11 (57.89)
THF	Group I	88 (100)	83 (94.32)	5 (5.68)
	Group II	46 (100)	41 (89.13)	4 (8.70)
	Group III	7 (100)	4 (57.14)	3 (42.86)
PTOF	Group II	16 (100)	15 (93.75)	1 (6.25)
	Group III	21 (100)	16 (76.19)	5 (23.81)
PTHF	Group I	19 (100)	19 (100.00)	-
	Group II	13 (100)	12 (92.31)	1 (7.69)
BOF	Group I	8 (100)	8 (100.00)	-
	Group II	3 (100)	3 (100.00)	-
Total		240 (100)	210 (87.50)	30 (12.50)

Figures within parentheses indicate percentage of the total

Table 6. Average operational holdings under various categories Mechanized and BOF**across different farm sizes (ha)**

Farm Size	TOF	THF	PTOF	PTHF	BOF	All Farm
Group I	-	0.68		0.58	0.67	0.66
Group II	-	1.19	1.22	1.09	1.10	1.10
Group III	3.07	2.69	2.35	-	-	2.66
Total	3.07	0.95	1.86	0.79	0.78	1.23

Table 7. Farm Income (Rs. /ha) per hectare under various categories of Mechanized and BOF

Sl. No.	Particulars	TOF	THF	PTOF	PTHF	BOF
1	Particulars					
2	a) Main product	57595.17 (167.30)	55813.81 (162.13)	56365.04 (163.73)	51787.75 (150.43)	34425.58 (100.00)
	b) By product	5321.07 (221.62)	5556.50 (231.43)	6043.83 (251.73)	4996.14 (208.09)	2400.94 (100.00)
	Total Gross Returns per cropped hectare	62916.24 (170.84)	61370.31 (166.65)	62408.87 (169.47)	56783.89 (154.19)	36826.52 (100.00)
	Cost A					
	a) Seeds	610.15 (141.99)	572.06 (133.13)	620.51 (144.40)	532.05 (123.82)	429.71 (100.00)
	b) Fertilizers, manures value of plant protection	411.22 (176.32)	356.84 (153.00)	515.69 (221.11)	301.22 (129.15)	233.23 (100.00)
	c) Depreciation on implements and machineries	6598.43 (343.10)	195.87 (10.18)	3654.48 (190.02)	112.59 (5.85)	1923.18 (100.00)
	d) Labour cost	15474.21 (428.54)	8345.99 (231.13)	16074.17 (445.16)	9378.84 (259.74)	3610.91 (100.00)
	e) Other cost (including oil & msc)	2500.70 (326.13)	-	1400.21 (182.61)	-	766.79 (100.00)
	f) Interest on working capital	1959.04 (46.13)	2124.06 (50.01)	2241.86 (52.79)	2619.38 (61.68)	4246.94 (100.00)
	g) Interest on fixed capital	859.23 (341.71)	26.89(10.69)	476.50 (189.50)	16.06 (6.39)	251.45 (100.00)
	h) Value of land revenue.	11 (100.00)	11 (100.00)	11 (100.00)	11 (100.00)	11 (100.00)

Sl. No.	Particulars	TOF	THF	PTOF	PTHF	BOF
3	Cost C	29018.07 (59.34)	23598.55 (48.26)	28802.42 (58.90)	28952.84 (59.21)	48902.03 (100.00)
4	Gross Income	62916.24 (170.84)	61370.31 (166.65)	62408.87 (169.47)	56783.89 (154.19)	36826.52 (100.00)
5	Family Labour Income	34492.26 (136.05)	49737.51 (196.18)	37414.46 (147.57)	43812.74 (172.81)	25353.29 (100.00)
6	Net Income	33898.17 (4597268.00)	37771.76 (4984627.00)	33606.45 (4568096.00)	27831.05 (3990556.00)	-12075.51 (100.00)

Figures within parentheses indicate percentages expressed in terms of BOF

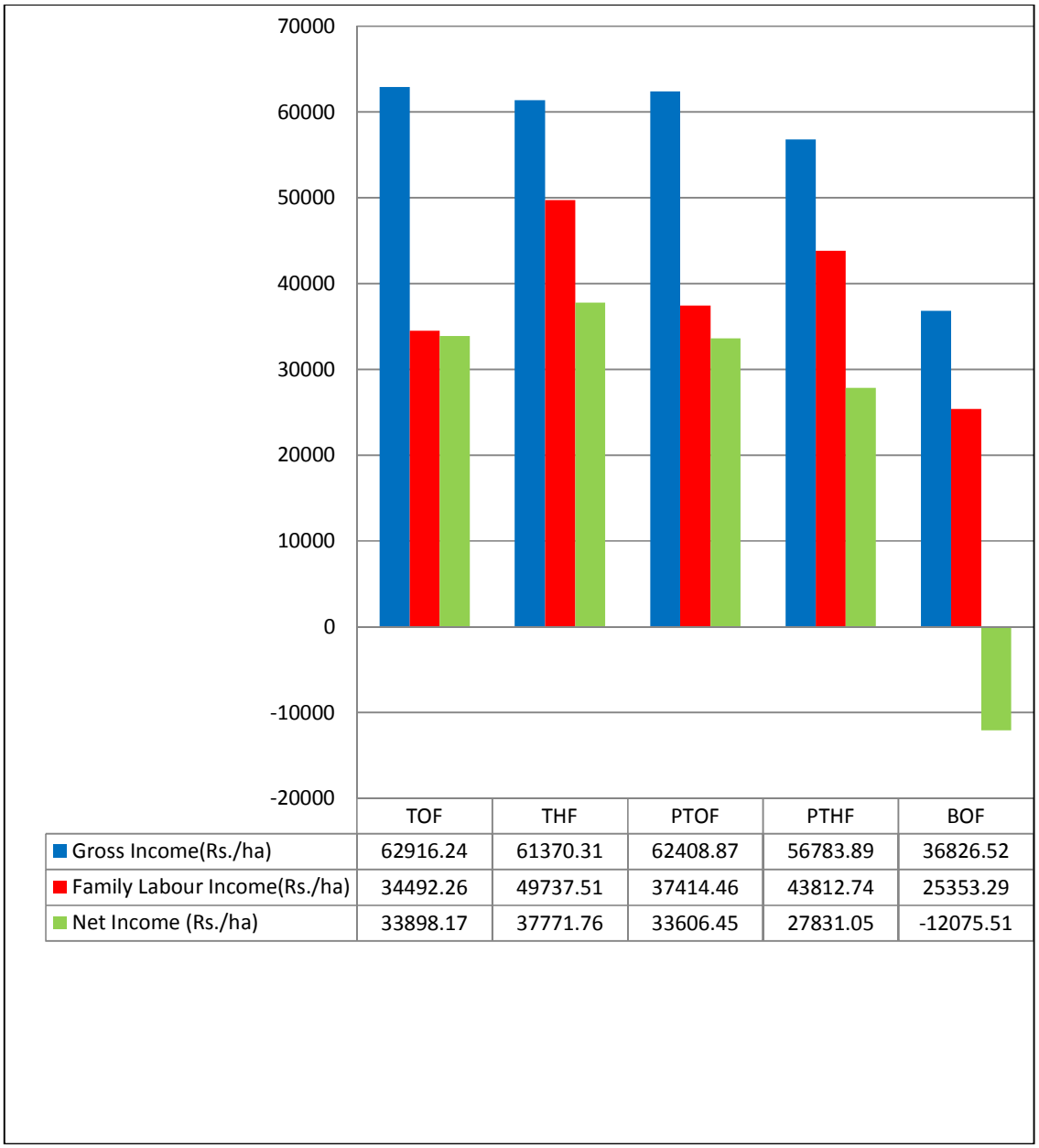

Fig. 1. Comparative analysis of mechanized and BOF

Table 8. Farm Income (Rs./ha) under various categories of mechanized and BOF across different farm sizes

Sl. No.	Particulars	TOF		THF		PTOF		PTHF		BOF	
		Group III	Group I	Group II	Group III	Group II	Group III	Group I	Group II	Group I	Group II
1	Gross Returns per cropped hectare										
	a) Main product	57595.17	55857.22	55958.01	54320.49	56780.77	56048.30	51600.46	52061.48	33839.04	35989.67
	b) By product	5321.07	5201.39	6131.77	6240.34	6109.65	5993.69	4910.67	5121.05	2134.17	3112.31
2	Total Gross Returns per cropped hectare	62916.24	61058.61	62089.78	60560.83	62890.42	62041.99	56511.13	57182.53	35973.21	39101.98
	Cost A1										
	a) Seeds	610.15	545.75	615.17	619.53	623.21	618.45	528.38	537.42	404.07	498.09
	b) Fertilizers, manures value of plant protection	411.22	317.39	395.03	601.83	407.09	598.43	298.89	304.63	219.89	268.81
	c) Depreciation on implements and machineries	6598.43	189.24	203.50	229.41	3509.15	3765.21	109.37	117.29	1898.90	1987.91
	d) Labour cost	15474.21	8230.20	8282.40	10219.6	15921.56	16190.45	9077.41	9819.40	3161.29	4809.90
	e) Other cost (including oil & misc.)	2500.70	-	-	-	1370.08	1423.16	-	-	750.13	811.23
	f) Interest on working capital	1959.04	2172.57	2058.81	1943.05	2228.28	2252.20	2669.58	2546.02	4154.98	4492.18
	g)Interest on fixed capital	859.23	26.03	27.88	31.25	457.61	490.90	15.64	16.67	248.29	259.86
	h) Value of land revenue.	11	11	11	11	11	11	11	11	11	11
3	Cost C	29018.07	24124.68	22889.29	21645.17	28488.88	29041.30	29501.38	28151.13	47863.00	51672.78
4	Gross Income	62916.24	61058.61	62089.78	60560.83	62890.42	62041.99	56511.13	57182.53	35973.21	39101.98
5	Family Labour Income	34492.26	49566.33	50495.99	46905.16	38362.44	36692.19	43800.86	43830.10	25124.65	25963.00
6	Net Income	33898.17	36933.93	39200.49	38915.66	34401.54	33000.69	27009.75	29031.40	-11889.79	-12570.80

Table 9. Income statement of Mechanized and BOF(Rs./ha)

Categories of Farm	Gross Income	Family Labour Income	Net Income
TOF	62916.24	34492.26	33898.17
THF	61370.31	49737.51	37771.76
PTOF	62408.87	37414.46	33606.45
PTHF	56783.89	43812.74	27831.05
BOF	36826.52	25353.29	-12075.51

Table 10. Constraints to adoption of mechanization under various categories of mechanized and BOF (number)

Problems	Level	TOF	THF	PTOF	PTHF	BOF	Total
Spare parts and adequate repairing services in rural areas	Most Serious	10 (9.80)	60 (58.82)	15 (14.71)	9 (8.82)	8 (7.84)	102 (100)
	Serious	7 (7.14)	11 (11.22)	11 (11.22)	23 (23.47)	3 (3.06)	98 (100)
	Less Serious	2 (5.00)	27 (67.50)	11 (27.50)	-	-	40 (100)
Skilled manpower	Most Serious	-	17 (53.13)	-	7 (21.88)	8 (25.00)	32 (100)
	Serious	-	33 (58.93)	-	20 (35.71)	3 (5.36)	56 (100)
	Less Serious	19 (12.50)	91 (59.87)	37 (24.34)	5 (3.29)	-	152 (100)
Maintenance of machinery	Most Serious	11 (9.82)	55 (49.11)	17 (15.18)	18 (16.07)	11 (9.82)	112 (100)
	Serious	6 (5.66)	70 (66.04)	19 (17.92)	11 (10.38)	-	106 (100)
	Less Serious	2 (9.09)	16 (72.73)	1 (4.55)	3 (13.64)	-	22 (100)
Supply of electricity	Most Serious	-	60 (68.97)	5 (5.75)	13 (14.94)	9 (10.34)	87 (100)
	Serious	1 (1.11)	61 (67.78)	9 (10.00)	17 (18.89)	2 (2.22)	90 (100)
	Less Serious	18 (28.57)	20 (31.75)	23 (36.51)	2 (3.17)	-	63 (100)
Availability of machine on time for use	Most Serious	-	61 (71.76)	-	17 (20.00)	7 (8.24)	85 (100)
	Serious	-	49 (79.03)	-	9 (14.52)	4 (6.45)	62 (100)
	Less Serious	19 (20.43)	31 (33.33)	37 (39.78)	6 (6.45)	-	93 (100)
Adequate demand for custom hiring services	Most Serious	4 (7.69)	20 (38.46)	9 (17.31)	13 (25.00)	6 (11.54)	52 (100)
	Serious	7 (9.86)	30 (42.25)	15 (21.13)	14 (19.72)	5 (7.04)	71 (100)
	Less Serious	8 (6.84)	91 (77.78)	13 (11.11)	5 (4.27)	-	117 (100)
Loan repayment due to low income	Most Serious	-	21 (50.00)	-	13 (30.95)	8 (19.05)	42 (100)
	Serious	-	23 (46.00)	5 (10.00)	19 (38.00)	3 (6.00)	50 (100)
	Less Serious	19 (12.84)	97 (65.54)	32 (21.62)	-	-	148 (100)

Problems	Level	TOF	THF	PTOF	PTHF	BOF	Total
Sufficient funds to meet high initial cost	Most Serious	-	124(73.37)	6(3.55)	29(17.16)	10(5.92)	169 (100)
	Serious	-	15 (68.18)	3 (13.64)	3 (13.64)	1 (4.55)	22 (100)
	Less Serious	19 (38.78)	2 (4.08)	28 (57.14)	-	-	49 (100)
Adequate credit facilities and rigid repayment plan	Most Serious	1 (0.97)	66 (64.08)	10 (9.71)	17 (16.50)	9 (8.74)	103 (100)
	Serious	4 (4.71)	60 (70.59)	7 (8.24)	11 (12.94)	2 (2.35)	85 (100)
	Less Serious	14 (26.92)	15 (28.85)	20 (38.46)	4 (7.69)	-	52 (100)
Small and scattered holding	Most Serious	2(1.18)	121 (71.18)	12 (7.06)	25 (14.71)	10 (5.88)	170 (100)
	Serious	8 (21.62)	13 (35.14)	9 (24.32)	6 (16.22)	1 (2.70)	37 (100)
	Less Serious	9 (27.27)	7 (21.21)	16 (48.48)	1 (3.03)	-	33(100)
Irrigation facilities	Most Serious	4 (2.65)	96 (63.58)	23 (15.23)	25 (16.56)	3 (1.99)	151 (100)
	Serious	1 (2.44)	21 (51.22)	10 (24.39)	7 (17.07)	2 (4.88)	41 (100)
	Less Serious	14 (29.17)	24 (50.00)	4 (8.33)	-	6 (12.50)	48 (100)
Existing Cropping Pattern	Most Serious	-	10 (32.26)	2 (6.45)	11 (35.48)	8 (25.81)	31 (100)
	Serious	-	12 (44.44)	-	12 (44.44)	3 (11.11)	27 (100)
	Less Serious	19 (10.44)	119 (65.38)	35 (19.23)	9 (4.95)	-	182 (100)
Adequate extension service encouraging the use of suitable farms implements and machinery	Most Serious	-	10 (27.78)	5 (13.89)	15 (41.67)	6 (16.67)	36 (100)
	Serious	4 (8.89)	15 (33.33)	8 (17.78)	13 (28.89)	5 (11.11)	45 (100)
	Less Serious	15 (9.43)	116 (72.96)	24 (15.09)	4 (2.52)	-	159 (100)

Figures within parentheses indicate percentage of the total.

3.1.6 Limiting factors to arm mechanization in the study area

Muncheberg (2017) reported on socio-demographic, economic, political and societal factors that faster or hinder the innovation, adoption and diffusion processes in European Agriculture and viewed that at farm level the role of information provided by peers, by public advisory services, was highly ranked and education was considered as a fostering factor [14]. Constraints to the adoption of farm machine differ with their degree of seriousness. The various problems faced by farmers in acquisition and use of machineries were discussed in this section. Table 10 showed various constraints faced by farmers under various categories of mechanized and BOF. Small and scattered land holding and inadequate sufficient funds to meet the initial cost of purchasing were the most serious problem faced by the farmers in the study area as out of total household 170 and 169 numbers of farmers found it most serious in case of small and scattered land holding and high initial cost to purchase the machineries respectively. Absence of irrigation, inadequate credit facilities and unavailable rigid repayment plan, lack of spare parts & inadequate repairing services in rural areas, electricity, availability of machine on time for use were the most serious constraints to adoption while existing cropping pattern adequate extension service encouraging

the use of suitable farms implements and machinery, adequate demand for custom hiring centre and skilled manpower was not found to be the most serious problem faced by the farmers in the study area. This result is conformity in the findings with Berg (2013) that the main factors of mechanization adoption were the high age of farmers, high incidence of tractor use, access to land, high off-farm income and poor extension services Tractors were left to rust instead of putting them in order for use because most of the spare parts were not available locally which was a great limitation to its availability [15]. Again Ayandiji and Olofinsao (2015) studied the socio economic factors affecting farm mechanization by cassava farmers in Ondostate, Nigeria found that access to extension workers and access to farm machines had a positive relationship with adoption and problems faced included were access to spare parts, access to skilled man power, maintenance of farm machines, availability of machines in time required [16]. Similarly, Makki et al. (2017) analyzed the factors affecting draught animal technology in rural Kordofan and used frequency and percentage tables to examine the various factors and found that lack of financial resources, inaccessibility to service, poor technical know-how of the staff of training and extension authorities were he factors affecting farm mechanization [17].

4. CONCLUSION

Mechanization is need based process which provide sufficient time gap for self adjustment of various inputs which ultimately gives positive impact on agricultural production. The present study showed the impacts of mechanization on income in Upper Brahmaputra and Central Brahmaputra Valley zone of Assam. It was observed that highest proportion of male working population was concentrated in the large size-groups, however no distinct relationship was observed between farm size and female working population. Again rate of literacy was higher in case of mechanized and found highest in case of Tractor Ownership Farm which was79.83 per cent and lowest in case of Bullock Operated Farm which was almost 50 per cent in each of the size group. Rate of literacy, thus, seemed to have a positive relationship with the level of mechanization in the study area. Agriculture was still the major source of income to the sample households in the both mechanized and non mechanized farm, Tractor Hired Farm had the highest working force than other categories of mechanized and non mechanized farm. Further, proportion of female workers was higher in case of Bullock Operated Farm in Group I. Type of family comprised of both nuclear and joint families. It had been seen that greater proportion of joint family in Tractor Ownership Farm might be due joint families usually had bigger size of holding and financially sound to bear machineries like tractors Impact of mechanization was found positive on income. Family labour income and net income also had inverse relationship with farm size in each categories of mechanized and Bullock Operated Farm and exception incase of under Group III under Tractor Hired Farm. Family labour income and net income relative proportion of each mechanized farm was higher over Bullock Operated Farm. Irrigation, adequate credit facilities and rigid repayment plan, spare parts and adequate repairing services in rural areas, electricity, availability of machine on time for use were the most serious constraints to adoption while existing cropping pattern adequate extension service encouraging the use of suitable farms implements and machinery, adequate demand for custom hiring centre and skilled manpower was not found to be the most serious problem faced by the farmers.

4.1 Recommendation

The following recommendations had been emerged from the above findings for appropriate policy measure for increasing the benefits of farm mechanization:

1. Farm mechanization in the study area increased the income In case Power Tiller Ownership Farm gross income was highest. In case of Tractor Hired Farm net income was higher than Tractor Ownership Farm. So, hence effort should be given to make available of the tractors amongst the farmers in the study area. Establishment of Farm Machinery Banks for custom hiring along with development of training facilities for the farmers in agricultural machinery use, repair and maintenance.
2. Cooperative management of farm machinery, financing of second hand tractors for small farmers, extension services to advise the suitability of various makes, models and horse powers for farmers having operational holding less than 2 hectares should been given to make economical use machineries amongst the small farmers in the study area

3. Advancing credit for the purpose of purchasing of machineries should be strengthened with simplified forms of norms.
4. Development of adequate infrastructure for supply of spare parts, repairing services and maintenance within the reach of farmer.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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