

Agricultural Mechanization in Assam, India: A Comprehensive Study and Key Determinants

Pramod Chandra Dihingia¹ Bidyajyoti Borah*² and Khan Chand³

¹Department of Agricultural Engineering and Technology, School of Engineering and Technology, Nagaland University, Dimapur- 797112, Nagaland,

²Research Scholar, Department of Economics, North-Eastern Hill University, Shillong

³Department of Agricultural Engineering, School of Agricultural Science, Nagaland University, Medziphema

*borahbidyajyoti@gmail.com

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ABSTRACT

Agricultural mechanization refers to the use of machinery in farming to enhance production, productivity and efficiency. In India, the evolution of agricultural mechanization is a story of gradual progress shaped by socio-economic conditions, technological advancements, and government policies. Assam is predominantly an agro-based economy where the agriculture sector provides a huge amount of income along with generation of employment to the rural population, and also shares a significant contribution to the state's GDP. The study was conducted during April 2022 to December 2023 focussing on evaluation of status of agricultural mechanization in three major districts of Assam viz. Nagaon, Golaghat, and Jorhat with key determinant using both the primary and secondary data with the help of LOGIT regression method. The findings of the study reveal that younger farmers were more inclined to adopt mechanization, as indicated by the negative coefficient for age (-0.03). On the other hand, the positive coefficient for education (0.04) confirmed that mechanization was more widely adopted by farms with relatively educated farmers. The age was a barrier to mechanization adoption, while a positive association was observed between landholding size and the adoption of mechanization. The present status of agricultural mechanization is not sufficient to enhance the level of agricultural production. There remains considerable scope for implementation of agricultural mechanization.

Keywords: Evolution, Agricultural Mechanization, Status and Trend, Determinants, LOGIT regression analysis.

Introduction

India's agricultural and the allied sectors play a crucial role in sustaining 17% of the global population, contributing approximately 20% to the nation's GDP, and growing at an average rate of 2.8%. Approximately, half of the country's population relies solely on agriculture for their living. According to Rao (2024), mechanization in India's agricultural sector stands at 47%, which is lower compared to other developed nations like China (60%) and Brazil (75%). States such as Punjab and Haryana exhibit higher levels of mechanization, ranging between 40% and 45%, while regions like north-eastern states show negligible mechanization. The agricultural landscape is characterized by small and marginal landholdings, which make up around 86% of the total operational holdings, with most farms being less than 2 hectares. This fragmentation of land is a significant determinant limiting the extent of modern farming machinery adoption.

Agricultural mechanization involves the use of farm machinery to enhance farm production, productivity and efficiency. In India, the development of mechanization has been a gradual process, influenced by socio-economic factors, technological innovations, and government policies. Mechanization improves production efficiency, facilitates large-scale farming, and promotes urbanization and commercialization in agriculture. According to Olaoye (2010), successful mechanization depends on socio-economic conditions, infrastructure support, land availability, and the technical skills of the workforce. The demand for key agricultural equipment, basically tractors and power tillers, irrigation pumps along with other tools, has been on the rise in recent years. However, small

landholders in India are facing difficulties to afford modern machinery. As a result, mechanization is mostly adopted by farmers with larger landholdings (Tiwarei et al., 2019). It is crucial to analyse the factors impacting mechanization of farms, considering India's position in the global hunger index (111th among 125 countries) along with the rapid population growth, which is a matter of concern. Hence, to meet the growing needs of food, it is important to adopt modern agricultural techniques to enhance food production since agricultural lands are shrinking day-by-day.

Studies from different countries have provided insights into factors influencing agricultural mechanization. For instance, Rasouli et al. (2006), using multivariate linear regression method, examined the factors affecting the implementation of agricultural mechanization programs nation-wide in Iran. The authors determined that 46.9% ($R^2 = 0.46$) of the variance in mechanization levels could be explained by factors such as household income, total cultivable land, and the area under cultivation. In a similar study, Ayandiji and Olofinsao (2014) in Nigeria used logistic regression approach to study various socio-economic aspects influencing farm mechanization among cassava farmers in Ondo. Their findings revealed that access to extension services and farm machinery positively influenced mechanization adoption, while challenges included limited access to spare parts, skilled labour, and the timely availability of machinery.

Mwangi and Kariuki (2015) examined the determinants of new agricultural technique adoption by small and marginal farmers in developing countries. Their study concluded that farmers' perceptions of new technologies are critical for adoption. Key factors included human-specific aspects (e.g., education, and age), economic factors (e.g., cultivable land size, and income), technological factor (e.g., ease of use), and institutional factor (e.g., extension services). They highlighted that the impression of these factors varies depending on specific technology being introduced.

Even though, Government of Assam has been concentrating on increment of farm mechanization, farmers of Assam have shown limited adoption of agricultural machinery. This disparity is due to several factors, including the region's small and fragmented landholdings, lack of access to available credit facilities, poor infrastructure, and limited awareness about modern farm equipment. Several barriers hinder the widespread adoption of farm mechanization in Assam, including the lack of credit facilities, marketing barriers like asymmetric information, and ineffective farm extension services. Adoption of modern machinery requires capital investment, which many farmers in the region are unable to afford (Bezbaruah, 1994; Bodosa, 2015). Other studies have also explored the constraints to agricultural mechanization in developing countries. Diao et al., (2016) emphasized that mechanization is more likely to succeed in regions with well-developed input and output markets, as well as access to finance. Pingali (2007) highlighted the role of government policies in supporting mechanization, especially in the context of small farmers. These studies suggest that creating an enabling environment through policy support, infrastructure development, and access to financial services is acute for the successful implementation of modern agricultural technologies in regions like Assam. Therefore, keeping these above mentioned facts of low mechanization in mind, the study has been undertaken (i) to assess the present status of agricultural mechanization in Nagaon, Golaghat, and Jorhat district of Assam, and (ii) to analyse the determinants for adoption of farm mechanization in the study area with and expectation that the concerned authority may follow the outcome of the study for assisting in adoption of agricultural mechanization in the state.

Materials and Methods

Study area

Since it is quite difficult to cover the entire state in a prescribed period, three major districts of greater Brahmaputra Valley Zone of Assam viz. Nagaon, Golaghat, and Jorhat were selected for the present study. The study was conducted during April 2022 to December 2023 covering all cropping seasons. The districts were chosen due to relative advancement in mechanization, as reported by the Department of Agriculture, Government of Assam.

Data Sources

In this study, both primary as well as secondary sources of data were used to analyse the various factors influencing farm mechanization among sample households. For collection of data within each district, advanced and less developed blocks were chosen. From these blocks, one village per block was selected using simple random sampling ensuring that the sample represents diverse farming conditions across the region. To define the suitable

sample size (n), the following formula was used, based on Kanyenji et al. (2020).

$$n_0 = \frac{x^2 ab}{p^2} = \frac{(1.96)^2 * 0.5 * 0.5}{(0.05)^2} = 384 \dots \dots \dots (1)$$

Where,

n_0 = sample size,

x^2 = 95 percent confidence level,

a = estimated share of an attribute that is present in the population,

$b = 1-a$, and

p = desired precision level.

Although the formula suggested a sample size of 384, for reasons of time and convenience, the sample size was reduced to 270 farmers. Therefore, the primary data was gathered from 270 sample farms through personal interviews using a structured, pretested questionnaire. Since the selected villages were of similar size, 45 households were randomly chosen from each village as the ultimate sample units.

Tools used

Prior to the survey, a questionnaire was prepared to conduct interview comprising of socio-economic, demographic, and agricultural variables. Further, the head of each household was interviewed using the structured questionnaire. The questions addressed factors such as age, occupation, income, education, tenancy and land ownership, and the use of agricultural machinery, among other topics. These factors allowed for a general understanding of the farming landscape and the adaptability of farmers to new agricultural technologies. The data was analysed using basic statistical techniques, including percentage and ratios, to evaluate the adoption of mechanization across different socio-economic groups. This study employs a tabular analysis to demonstrate the results of a field survey, along with a LOGIT regression to investigate the factors influencing farm mechanization among sampled households. The LOGIT regression is a type of regression analysis, suitable for a binary dependent variable, was used to explore the relationship between a dichotomous outcome variable, besides one or more independent variable(s) measured at various levels (nominal, ordinal, interval, or ratio).

For each level of advanced machinery adoption, the outcome is coded as either M_0 , (traditional methods, $t = 0$) or M_1 , (modern machinery adoption, $t = 1$). The choice of the explanatory variables is grounded on the status of mechanization of farms. The dependent variable represents the adoption of advanced machinery in farming practices by the selected households ($t = 0, 1$) indicating the use of tractor and other tools by the household. M_0 represents households using traditional methods; M_1 refers to households employing machinery for ploughing.

Given that the dependent variable reflects a categorical progression of farmers' decision-making in adopting farm mechanization, an ordered response model is appropriate (Pfarr et al., 2010). Here, LOGIT model is applied to analyse the effects of various farm related socio-economic factors on machinery adoption and farm mechanization decisions.

The model under consideration can be structured as:

$$A_j = E_j \beta_j + e_j \dots \dots \dots (2)$$

Where,

$A_j = (v \times 1)$ vector of j^{th} adoption of farm mechanization by the respondent

$E_j = (v \times k)$ matrix of the explanatory variables

$\beta_j = (k \times 1)$ vector of the projected coefficients for E_j

$e_j = (v \times 1)$ vector of the error terms [$e_j \sim n(0, \sigma^2_j)$]

The explanatory variables selected for the study is based on prior research and established expectations (Adesina & Forson, 1995; Kumar et al., 2018; Rahman et al., 2020; Addison et al., 2023). Table 1 provides a description of these variables. The status of farm mechanization ($FARM_{MECH}$) is the dependent variable in this LOGIT method of regression analysis (Equation 3). The explanatory variables consist of binary variables and continuous variables representing the household and farm-related characteristics.

$$FARM_{MECH} = \alpha_1 AGE + \alpha_2 GENDER + \alpha_3 EDU + \alpha_4 OCCU + \alpha_5 EXP_{YR} + \alpha_6 TRAINED + \alpha_7 CREDIT + \alpha_8 LIVSTK + \alpha_9 TCL + \alpha_{10} INCOME + \alpha_{11} OWN_{LN} + \alpha_{12} HLC \dots \dots \dots (3)$$

It is hypothesized that the age of the representative head of household may either positively or negatively influence

the adoption of farm machinery. Older farmers, with more experience, may better evaluate the benefits of machinery adoption. However, they may also be more risk-averse than the early generation farmers, leading to a poorer likelihood of adopting modern tools. Household features such as the gender of the representative head and family size could similarly have positive or negative effects on adoption decisions. The education level of the respondent is expected to positively impact the decision-making regarding the adoption of agricultural machinery, as more educated farmers are often better able to access information and make informed decisions about machinery adoption (Mishra et al., 2002).

Table 1: Selected Explanatory Variables

Variables	Abbreviation
Age in years of the respondent	<i>AGE</i>
Gender (Male =1)	<i>GENDER</i>
Level of Education	<i>EDU</i>
Occupation (Yes =1)	<i>OCCU</i>
Farming Experience in years	<i>EXP_{YR}</i>
Trained (Yes =1)	<i>TRAINED</i>
Credit Accessibility (Yes =1)	<i>CREDT</i>
Livestock in numbers	<i>LIVSTK</i>
Total Cultivable Land in Hectare	<i>TCL</i>
Income in Rs.	<i>INCOME</i>
Land Ownership	<i>OWN_{LN}</i>
Hired Labour Cost	<i>HLC</i>
<i>Note: Sample Size (n) = 270; Source: Primary Survey, 2022-23.</i>	

Results and discussion

Evolution of Agricultural Mechanization

Before India gained independence in 1947, agricultural mechanization was minimal. India was a largely agrarian economy, with agriculture accounting for a substantial portion of employment and national income. However, agricultural practices were highly traditional, labour-intensive, and heavily dependent on animal power, mainly bullocks, for tasks such as ploughing, irrigation, and transportation (Sharma, 2019).

The colonial government made little effort to promote mechanization, focusing instead on the cultivation of cash crops (e.g., cotton, jute, and indigo) for export purposes, rather than prioritizing food security or innovations in agricultural practices (Roy, 2018). Mechanization was limited to large estates owned by colonial rulers or the Indian elite, who imported machines such as tractors and threshers for sugarcane, cotton, and wheat cultivation. Some of the early agricultural machines introduced in this period are shown in Table 2.

Table 2: Agricultural machinery used in pre-independence period

Agricultural Machines	Activity
Steel plough	Improved the efficiency of ploughing but were limited to a few wealthy farmers
Manual threshers	Introduced in some regions, these devices helped with crop processing but were manually operated.

A major hindrance to mechanization in the pre-independence era was the lack of proper infrastructure facilities, such as roadways and transportation networks, which limited access to modern equipment in rural areas (Sinha, 2017). Furthermore, widespread poverty and the prevalence of small landholdings posed significant barriers, as most farmers could not afford the high cost of machinery. Over 75% of farms' size were less than 2 hectares, rendering the use of large machinery inefficient (Chand, 2016).

In the years following independence, India initially struggled with food shortages, low agricultural productivity, and a rapidly growing population, with mechanization receiving little focus due to limited resources. The Green

Revolution, beginning in the 1960s, marked a crucial turning point in the mechanization of Indian agriculture. With the introduction of high-yielding varieties (HYVs) of wheat and rice created a pressing need to enhance agricultural productivity, leading to the promotion of modern farming technologies (Sainath, 2017). This period saw a sharp increase in the use of tractors, which rose from fewer than 8,000 in 1951 to over 150,000 by 1980, with states like Punjab, Haryana, and Uttar Pradesh benefiting the most (Desai, 2018). Additionally, diesel and electric irrigation pumps became widespread, replacing traditional methods and reducing dependence on monsoons, while innovations such as threshers, combine harvesters, and mechanized irrigation systems further streamlined agricultural operations, especially in post-harvest processes (Kumar, 2021).

The population distribution in terms of agricultural workers in India since 1951 is shown in Table 3.

Table 3: Population and Farm Workers Distribution in India (in Million)

Year	Total Population	Rural Population	Urban Population	Agricultural workers
1951-60	361.1	298.6	62.5	97.2
1961-70	439.2	360.3	78.9	131.1
1971-80	548.2	439	109.2	125.7
1981-90	683.3	525.5	157.8	148
1991-00	846.4	628.7	217.7	185.3
2001-11	1028.7	742.5	286.2	234.1
2011-21	1210.9	833.7	377.2	263.1

Source: Registrar General of India

The figures highlight a steady growth in total population, with urbanization accelerating in recent decades, and the increasing number of agricultural workers up until the early 21st century which is shown in Figure 1.

Table 4 illustrates the distribution of agricultural workers in North-East India based on the 2011 Census, highlighting differences by state, gender, and rural versus urban areas. Assam has the highest number of agricultural workers, totalling 5,906.9 thousand, predominantly in rural areas. Other states like Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and Sikkim show similar trends, with the majority of their agricultural workforce being rural and a smaller fraction in urban settings (Figure 2).

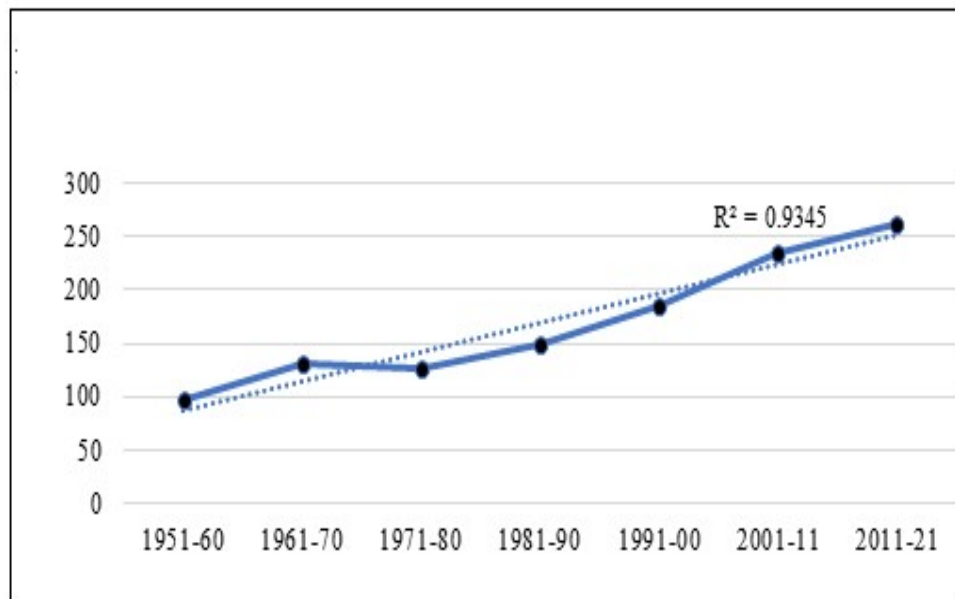


Figure 1: Growth pattern of Agricultural worker in India since 1951

Overall, the North-East region has 8,643.2 thousand agricultural workers, with rural areas overwhelmingly contributing to this figure. When compared to India's total agricultural workforce of 265,427.3 thousand, the North-East's contribution remains relatively modest, representing about 3.49% of male and 3.04% of female workers.

Urban agricultural workers in the region account for an even smaller percentage of the national total.

Table 4: Distribution of Agricultural Workers in North-East India according to 2011 Census

States	Rural (in Thousand)				Urban (in Thousand)				Total in Thousand
	Male	% Share	Female	% Share	Male	% Share	Female	% Share	
Assam	4173.3	75.6	1659.5	57.8	55.5	34.6	18.4	18.3	5906.9
Arunachal Pradesh	167.1	3.03	164.5	5.74	4.11	2.56	3.08	3.08	338.8
Manipur	329	5.96	285.1	9.94	44.1	27.49	30.6	30.5	688.9
Meghalaya	375.2	6.8	303.3	10.58	8.43	5.25	6.06	6.04	693
Mizoram	117.3	2.13	93.9	3.27	34.6	21.55	25.5	25.4	271.3
Nagaland	278.6	5.05	293.7	10.2	12.61	7.86	15.5	15.5	600.6
Sikkim	75.1	1.36	66.2	2.31	1.04	0.65	.93	0.92	143.3
NE Total	5515.9	100	2866.5	100	160.5	100	100.2	100	8643.2
India Total	157827.5	3.49	94255.4	3.04	7677.7	2.09	5666.6	1.76	265427.3

Source: Author's own estimation from the source Registrar General of India.

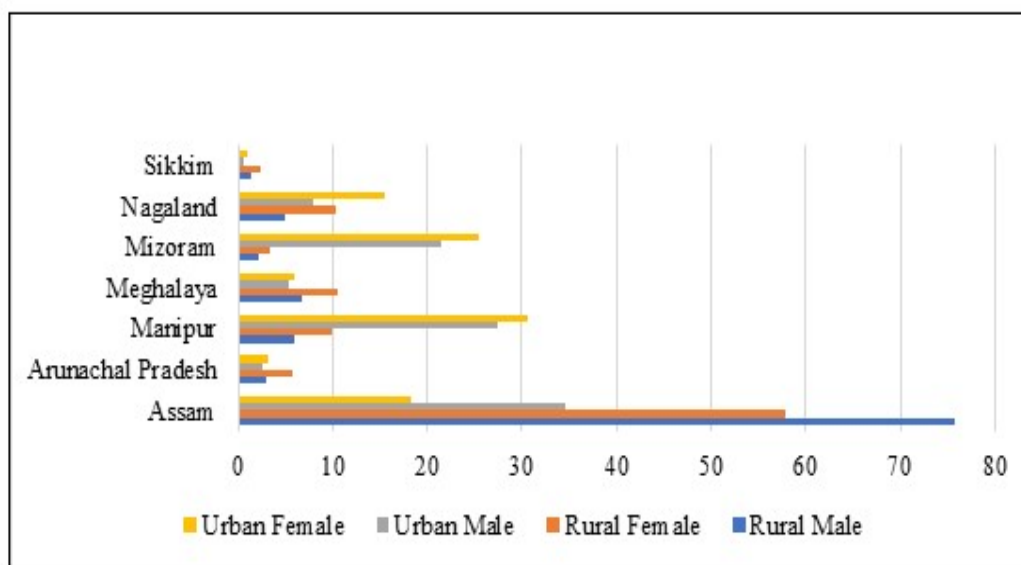


Figure 2: Distribution of Agricultural Workers in North-East India according to 2011 Census

Status of Agricultural Mechanization in the study area

The growth of agricultural mechanization in Assam has been relatively slow, with farm power demand increasing due to the large-scale introduction of Shallow Tube Well irrigation. This shift has highlighted the need for mechanization to supplement the inadequate bullock draught power, which cannot meet the growing demand for cultivation across expanded agricultural areas. The availability of mechanical power in the state remains significantly insufficient. Currently, there are 678 four-wheel tractors, 5,002 power tillers, 1,10,477 M.B. ploughs, 17,926 paddy weeders, 2,032 dry land weeders, 722 seed drills, 149 bullock-drawn puddlers, 4,723 paddy cultivators, 465 harrows, and 1,67,449 other implements in use. The density of tractors is 0.26 per thousand hectares, and that of power tillers is 0.51 per thousand hectares, illustrating the need for further investment in farm machinery (Agri Vision 2025).

Use of various agricultural machinery has become essential to increase efficiency and enhance productivity of the

crops under cultivation. Table 5 provides information regarding the different agricultural machinery used during different periods since 1950s. The use of tractors was just merely 0.174 per thousand hectare of GCA in 1951-54 which increased marginally to 1.142 per thousand hectares during 2017-20. Similarly for power tiller it was just 0.019 per thousand hectare of TCA during 1971-74 which increased marginally to 0.437 per thousand hectares during 2017-20. Use of pump sets was 0.053 per thousand hectare of TCA during 1951-54 which increased to 9.444 per thousand hectares during 2017-20. Although the use of pump sets in absolute terms has increased tremendously during 1991-94 but in terms of per thousand TCA the number is less. From the Table 5 it is seen that use of tractors, power tillers and pump sets has been although on the rise continuously but it is very slow and almost negligible over the period of years. All this indicates the minimal use of mechanization that has been taking place in the state of Assam. Such minimal and marginal increase of use in farm machinery provide as a hindrance to increase the yield of agricultural crops.

Table 5: Farm Machinery used (Number)

Year (TE)	Tractors	Power Tillers	Pump sets
1951-54	412 (0.174)	NA	126 (0.053)
1961-64	489 (0.187)	NA	127 (0.049)
1971-74	683 (0.246)	54 (0.019)	552 (0.198)
1981-84	799 (0.236)	451 (0.133)	1450 (0.428)
1991-94	623 (0.170)	1342 (0.365)	14204 (3.866)
2001-04	1468 (0.398)	1904 (0.516)	12136(3.292)
2011-14	824 (0.200)	4064 (0.987)	15083 (3.664)
2017-20	4781 (1.142)	1830 (0.437)	39533 (9.444)

Source: Directorate of Agriculture, Government of Assam, Various Issues of Statistical Handbook of Assam

Note: *Figures in the parentheses represent per thousand hectare of total cropped area TCA, *Not Available NA

Farm machineries are utilized throughout all stages of agricultural production, from land preparation and sowing to harvesting and threshing. The extent of machinery adoption in farming operations can be gauged by the availability and use of resources such as ploughs, bullock and machine labour, as well as agricultural tools and equipment. Farmers typically rely on tractors, power tillers, rotavators, wetland puddlers, and earth levelers for tasks like tilling, sowing, and threshing (Table 6). In Nagaon district, farmers tend to use more advanced machinery compared to those in Golaghat and Jorhat districts. However, some farmers still employ bullock-driven ploughs, though on a limited basis. Although machines are widely used for tilling and sowing, most farmers, being marginal or small-scale, opt to rent the equipment due to limited capital. Even for threshing, many have transitioned to mechanized methods, with the exception of Chamua village in Kaliapani Block, where only 5 percent of farmers use threshers. Machine-assisted threshing is significantly faster than traditional methods.

Table 6: Percentage of Sample Farmers as per use of Agricultural Machinery

Districts		Nagaon		Golaghat		Jorhat	
Blocks		Khagorijan	Rupahihut	Gomariguri	Kakodonga	Titabor	Kaliapani
Equipment	Ownership Status	Rowmari	Borghat	Athgaon	Sumoni	Bebejia	Chamua
Traditional Plough	Owned	1.00	4.00	20.00	8.00	0.00	32.00
	Hired	0.00	0.00	0.00	0.00	0.00	0.00
Tractor/Power Tiller	Owned	0.00	2.00	2.00	4.00	10.00	0.00
	Hired	100.00	94.00	68.00	88.00	90.00	70.00
Rotavator	Owned	0.00	2.00	2.00	0.00	10.00	0.00
	Hired	100.00	94.00	68.00	92.00	90.00	70.00
Wetland	Owned	0.00	2.00	0.00	0.00	6.00	0.00

Puddler	Hired	100.00	94.00	64.00	90.00	94.00	4.00
Earth	Owned	0.00	0.00	0.00	0.00	0.00	0.00
Leveller	Hired	100.00	0.00	85.00	0.00	90.00	0.00
Machine	Owned	0.00	1.00	0.00	1.00	2.00	0.00
Thresher	Hired	100.00	96.00	72.00	90.00	92.00	5.00
Source: Field Survey, 2022-23.							

Adoption of Agricultural Mechanization and its Determinants

In order to examine the determinants of farm mechanization very important factors of the sample households i.e., age, gender, education level, primary occupation, farming experience, whether trained or untrained, the access to institutional credit, livestock, land holdings, income and hired labour cost were used. Table 7 displays descriptive statistics of these factors as explanatory variables considering the respondents associated or not-associated to agricultural mechanization.

Table 7: Descriptive Statistics-Adoption of Agricultural Mechanization

Variables	Mean	Std. Dev.	Minimum	Maximum	M ₀	M ₁
AGE	43.45	12.34	21	74	44.56	45.98
GENDER	0.95	0.25	0	1	1	0.89
EDU	8.12	2.80	0	15	6.95	9.12
OCCU	2.11	0.97	1	6	0.72	0.71
EXP _{YR}	33.02	8.24	6	51	21.43	25.91
TRAINED	0.08	0.21	0	1	0.15	0.12
CREDIT	0.19	0.42	0	1	0	0.18
LIVSTK	9	4.12	0	20	9	7
TCL	8.73	12.26	3.12	204	6.02	9.36
INCOME	39865	43516	5390	324623	18650.5	50346.94
OWN _{LN}	2.45	0.79	1	4	1.23	1.25
HLC	789.19	555.33	0	3190	655.49	962.85
n=270					96	174

Source: Author's Estimation, Field Survey, 2022-23.

The average or mean age of sample household heads is analogous between user and non-user of farm machinery. However, the mean years of education, farming experience, and total household income are higher among those who have used farm machinery compared to no-machinery users.

Table 8: Correlation

Variables	AGE	GEN	EDU	OCCU	EXP _{YR}	TRAINED	CREDIT	LIVSTK	TCL	INC	OWN _{LN}	HLC
AGE	1.00											
GEN	-0.05	1.00										
EDU	0.07	0.43	1.00									
OCCU	-0.23	-0.09	-0.25	1.00								
EXP _{YR}	0.94	-0.03	0.07	-0.18	1.00							
TRAINED	0.01	-0.03	0.04	0.11	0.04	1.00						
CREDIT	0.15	0.04	0.09	0.03	0.14	0.15	1.00					
LIVSTK	-0.08	0.11	-0.18	0.16	-0.03	-0.10	0.06	1.00				
TCL	0.16	0.08	0.16	0.13	0.24	0.14	0.42	0.05	1.00			
INCOME	0.19	0.12	0.41	-0.22	0.38	0.13	0.28	-0.20	0.39	1.00		
OWN _{LN}	-0.09	-0.07	-0.04	0.17	-0.11	0.07	0.14	-0.01	0.16	-0.04	1.00	
HLC	-0.05	-0.02	0.01	0.28	0.06	0.25	-0.07	-0.10	-0.08	0.12	0.09	1.00

A notable distinction between the two groups is seen in their access to credit facilities and total landholding size, with users having better access and larger land sizes. Additionally, differences in the cost of hired labour are evident

between farmers who have adopted modern machinery and those who have not.

The LOGIT model results, summarized in Table 9, are statistically significant at the 1 percent level of significance. The pseudo R² value of the model (=0.219) suggests that 21.9 percent variation in the adoption of modern farming equipment can be attributed to the independent variables included in the analysis.

Table 9: Estimates: LOGIT Regression

<i>Variables</i>	<i>Coefficient</i>	<i>Odds Ratio</i>	<i>Z-Score</i>
<i>AGE</i>	-0.03 (0.18)	0.96 (0.02)	-1.59
<i>GEN</i>	-0.65 (0.52)	0.53 (0.31)	-1.30
<i>EDU</i>	0.04 (0.05)	1.06 (0.06)	1.04
<i>OCCU</i>	-0.16 (0.31)	0.92 (0.25)	-0.52
<i>EXP_{YR}</i>	0.06* (0.03)	1.14** (0.03)	2.13
<i>TRAINED</i>	-0.03 (0.44)	0.98 (0.43)	-0.10
<i>CREDT</i>	-0.12 (0.42)	0.90 (0.36)	-0.31
<i>LIVSTK</i>	-0.10* (0.05)	1.03** (0.05)	-3.01
<i>TCL</i>	0.00002 (0.00006)	1.000 (0.00005)	0.46
<i>INCOME</i>	0.13 (0.25)	1.16 (0.33)	0.45
<i>OWN_{LN}</i>	0.0003 (0.0003)	1.005 (0.0004)	0.99
Pseudo R ²	0.219		
Observations (n)	270		

Notes: i. Figures in parentheses indicate standard error; ii. **, and * indicate significance at 1%, and 5% respectively.

Source: Author's Estimation, Field Survey, 2022-23.

Out of the four significant variables, two are found to have significant positive effect on the implementation of modern equipment in farming practices in Assam. Coefficients of land size, and experience of farmers are positive and significant. While, livestock has significant negative effect on the agricultural mechanization. Other variables (education of household total income of household, ownership of land, and hired labour cost) also have positive association with the adoption level but not statistically significant.

The odds ratio for farmers' experience stands at 1.14, indicating that for each additional year of farming experience, the likelihood of adopting agricultural mechanization rises by 1.14 times as compared to the no-machinery adoption, assuming all other factors remain constant. Conversely, an increase in livestock ownership by one unit reduces the odds of adopting mechanized farming by 1.03 times compared to non-users. The positive coefficient associated with the educational level suggests that the adoption of agricultural mechanization is more common among farmers with higher educational attainment in the study area. This implies that as education levels rise, there is a corresponding increase in the likelihood of adopting mechanization for various agricultural practices.

Conclusion

Mechanization is a necessity-driven process that creates ample time for the adjustment of different inputs, eventually leading to a positive effect on agricultural productivity. The results from twelve explanatory variables revealed that younger farmers were more inclined to adopt mechanization, as indicated by the negative coefficient for age (-0.03). On the other hand, the positive coefficient for education (0.04) confirmed that mechanization was more widely adopted by farms with relatively educated farmers in the valley. The study concluded that age was a barrier to mechanization adoption, while a positive association was observed between landholding size and the adoption of mechanization. Though the use of farm machinery has been on the rise but such negligible rise is not sufficient to raise the production of agricultural outputs as well as farmers' efficiency. Such a unhurried growth of modern farming acts as a hindrance and one of the probable reasons for sluggishness in cropping pattern diversity. Thus, there remains considerable scope for the improvement of the productive capacity of those crops further, through prudent use of land and water resources and extensive use of modern agricultural inputs so that production and profitability could be increased which would be beneficial for the farmers and cultivators.

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