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Determinants of Farm Machinery Adoption among Maize Farmers in Khotang, Nepal

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ABSTRACT

Agricultural mechanization is crucial in improving productivity and reducing labor dependency. However, the adoption of machinery in Nepal's hilly regions remains limited. The study was conducted to identify the determinants of farm machinery adoption among maize farmers in Khotang, Nepal. Data were collected from 123 randomly selected farm households through a pre-tested semi-structured interview schedule. Focus Group Discussion (FGD) and Key Informant Interview (KII) were conducted with selected participants. In analyzing data, descriptive statistics and a probit regression model were employed. Consequently, 56.09% of the farmers had adopted at least one type of farm machinery. Power tillers, shellers, and maize planters are the commonly adopted machinery. Regular contact with extension workers and membership in either farmers groups or cooperatives had a highly significant positive effect on the adoption of farm machinery. The most common reasons for non-adoption are high rental costs, lack of technical knowledge and small fragmented landholdings. While, women-specific training is the most needed support reported by women farmers. Hence, this study revealed that institutional and social factors are more important than individual characteristics in adopting mechanization. Strengthening extension services together with farmers groups and cooperatives is an issue of priority in promoting mechanization for maize-based hill farming systems in Nepal.

Keywords: Cooperatives, extension, groups, farming system, mechanization

INTRODUCTION

Agricultural mechanization is considered one of the essential elements in agrarian transformation, especially in the developing world, where it catalyzes productivity enhancement, labor-use reduction, and food security (Paudel et al., 2023; Rai et al., 2024). As agricultural mechanization develops, farm machinery is gradually replacing manual labor and draft animals (Quan & Doluschitz, 2021). In the Global South, agriculture is still by and large labor-intensive. However, rising labor wages, seasonal labor shortages, and

out-migration are sending rapid transformations toward mechanized farming systems (Gauchan & Shrestha, 2017).

Agricultural mechanization is an indicator of agricultural modernization, and farm machinery is the carrier of agricultural modernization (Li et al., 2018; Liu & Tian, 2009). The Government of Nepal formulated the Agricultural Mechanization Promotion Policy in 2014 with the objectives of enhancing productivity by appropriate mechanization, enhancing access to agricultural machinery, promoting women-friendly farm machinery, and improving institutions dealing with mechanization (Shrestha, 2022). In addition, the Agriculture Development Strategy (ADS) of Nepal (2015–2035) emphasized the need for adopting appropriate farm technologies to enhance productivity. The ADS encourages a core program that offers different mechanization alternatives to farmers. This adoption is encouraged through activities such as awareness creation, demand stimulation, support for concessionary financing arrangements, capacity building, and implementation of appropriate taxation policies (MoAD, 2016). Along with the government priorities, the existing socio-economic context, such as the scarcity of agricultural labor along with rising daily wage rates, has enhanced the prospects of farm machinery in Nepal. Moreover, the remittance inflow has increased opportunities for commercialization and investment in farm machinery (Shrestha, 2022).

Maize accounts for a 6.63% contribution to Nepal's total agricultural Gross Domestic Product (GDP). Among cereal crops, maize ranks second after rice in terms of both area and production, covering 940,256 ha with a production of 2,976,490 mt and an average yield of 3.17 mt/ha in 2022/23. During the same year, Nepal showed a high dependence on imported maize and maize-based products. The country imported 435.22 million kg of maize (excluding seed) valued at NPR 16.50 billion, mainly to meet the rising demand for food, feed, and industrial purposes. Furthermore, imports included 3.66 million kg of maize seed worth NPR 668.65 million, indicating reliance on external sources for quality planting material. Imports of processed maize products were also significant, comprising maize starch (9.10 million kg; NPR 524.96 million), maize flour (0.31 million kg; NPR 15.47 million), and corn flakes (0.62 million kg; NPR 169.13 million). This import structure highlights structural gaps in domestic maize production, seed supply, and agro-processing capacity, underscoring the need for policies that strengthen local maize value chains, promote import substitution, and enhance food and feed self-sufficiency in Nepal (MoALD, 2024).

In the mid-hills of Nepal, the farming system is exposed to higher productivity, financial and social risks due to increased degradation, outmigration, high cost of production expansion, and marginal fragile landscapes. To reduce these risks and promote sustainable management of landscapes and overall farming system, measures to risk reduction and improved production is desirable (Zepeda et al., 2023). Hilly belt cover 42% of the national area by ecological belt (MoALD, 2024). Suitability of agricultural mechanization is difficult in Hilly and mountainous areas, and considered as weak places for the

development. However, positive impact on resource-use efficiency and food security is observed with adoption of small agricultural machinery suited for hilly and mountainous areas (Li et al., 2023). As, mechanization is critical in accelerating rural revitalization and increasing agricultural competitiveness (Wu et al., 2025).

Khotang district is characterized by a maize-dominant farming system integrated with livestock, where farm households depend on a mixed livelihood strategy combining agriculture with remittance and off-farm income sources. Although maize-based farming remains central to household food security and livestock feeding, a considerable portion of income and labor comes from non-agricultural activities such as wage labor, migration, and remittances. This diversified livelihood strategy reflects both limited agricultural productivity and the need to manage economic risk, influencing farmers' decisions on labor allocation, technology adoption, and investment in agriculture (Zepeda et al., 2023).
From a production standpoint, the yield gap in Khotang is particularly notable. In Koshi province, maize is cultivated on 284,340 ha, yielding 972,073 mt with an average productivity of 3.42 mt/ha. In contrast, Khotang district alone cultivates 31,845 ha of maize but produces only 56,684 mt, resulting in a much lower yield of 1.78 mt/ha. Despite being among the districts with the largest maize cultivation area in the province, Khotang's productivity remains far below that of districts across the terai, hill, and mountain regions (MoALD, 2024). The Government of Nepal initiated Prime Minister Agriculture Modernization Project (PMAMP) with the aim to increase agriculture productivity by ensuring better access to modern machinery via subsidy and credit arrangements, coupled with capability enhancement programs (Rai et al., 2024). However, farm machinery adoption is still found to be low in hill districts like Khotang. Considering Nepal's rugged terrain, especially in the hill regions, there is an urgent need to strengthen and expand the use of locally appropriate technologies that lower time, labor, and production costs while also promoting women's empowerment and reducing gender inequality (Paudel et al., 2020). Most of the available literature on agricultural mechanization in Nepal has focused on other regions of Nepal, while empirical data from Khotang is still missing. This study aims to fill this gap by identifying the factors affecting the adoption of farm machinery among maize farmers, reasons for not adopting farm machinery and support desired by women farmers in the adoption of farm machinery in Khotang, Nepal. Understanding these factors is crucial for creating targeted policies and intervention strategies that speed up the mechanization process and improve agricultural productivity.

MATERIALS AND METHODS

Study area

Khotang is one of the hill districts in eastern region and lies in Province No. 1 (Koshi Province). The farming system in this district is dominated by crops like potatoes, millet, and maize, especially in the mid-hill areas. Agricultural mechanization has been progressively gaining traction in recent years; although traditional farming methods through animal and human power remain predominant.

Sampling technique and sample size

This study focuses on all maize-growing farm households in the chosen Rupakot Majuwagdi municipality and Halesi Tuwachung municipality in the Khotang district. Population was estimated to 1200 farm households. Employing, sample size calculation method by Daniel (1999), 123 households was taken for the study. This sample covers multiple ward of both municipality and includes farm households within PMAMP command area. A random sampling technique was used to select the households for this study. Later divided into two groups of adopters and non-adopters. The primary data were collected from the farmers of the study area through face-to-face interview schedules with semi-structured questionnaire. To add qualitative insights to the survey, four FGDs were conducted. Two groups were for women farmers and two for men in a group of 6-8 members, held separately. Similarly, eight Key Informant Interviews (KIIs) were conducted with people who had institutional or practical knowledge about agricultural mechanization. Informants included: PMAMP officials, Custom Hiring Center (CHC) managers, progressive farmers and executives of farmers group and cooperatives. The secondary data were extracted from publication of statistical information from Ministry of Agriculture and Livestock Development (MoALD), Agriculture Knowledge Center (AKC), and PMAMP and research papers published by different authors.

Empirical method

Probit model (using STATA 17) was employed to identify the determinants of farm machinery adoption among maize farmers in Khotang, Nepal.

Model specification:

$Pr(Y=1) = f(b_0+b_1x_1+b_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6+b_7x_7+b_8x_8+b_9x_9)$
Where,
$Pr(Y=1)$= Probability of adoption of farm machinery
X_1= Gender (dummy); X_2= Age (continuous); X_3= Education (continuous); X_4= Income (continuous); X_5= Contact (dummy); X_6= Membership (dummy); X_7= Credit (dummy); X_8= Labor (dummy); X_9= Experience (continuous)
b_0 = Regression coefficient
$b_1, b_2 \ldots\ldots\ldots\ldots b_9$=Probit coefficient

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 presents the descriptive statistics of the variables used in the study. The average age of respondent was 44.44 years. On average, farmers had 7.84 years of formal education. The mean annual household income was NPR 491203.3. More than half of the respondents (55.28%) were male and 58.53% of the respondents had regular contact with extension

workers. Similarly, 74.79% of the respondents were members of farmers' groups or cooperatives. Only 18.69% of farmers reported having access to credit, whereas a large majority (88.61%) had access to agricultural labor. The average farming experience in maize cultivation was around 34.13 years, indicating that most respondents were experienced growers. Regarding the dependent variable, about 56.09% of respondents had adopted at least one type of farm machinery.

Adoption status of farm machinery

Table 2 shows the adoption rate of different types of farm machinery among farmers. Among the various machines, the power tiller was the most commonly adopted (55.28%). This was followed by shellers (46.34%) and maize planters (39.83%), which were also relatively common. In contrast, only 17.07% of farmers adopted threshers, and very few (1.62%) had adopted harvesters.

Table 1. Descriptive statistics of variables for adoption of farm machinery in the study

Variable	Description	Mean	SD
Independent variable			
Gender	Gender of the respondent (1 if male, 0 if female)	0.5528	0.4992
Age	Age of the respondent (year)	44.4471	13.1848
Education	Formal education of the respondent (year)	7.8455	4.5539
Income	Annual income of the household (NPR)	491203.3	702320.1
Contact	=1 if respondent has regular contact with extension workers, 0 otherwise	0.5853	0.4946
Membership	=1 if respondent is member in farmer's groups or cooperatives, 0 otherwise	0.7479	0.4359
Credit	=1 if access to credit, 0 otherwise	0.1869	0.3914
Labor	=1 if access to labor, 0 otherwise	0.8861	0.3188
Experience	Respondents experience in maize farming (year)	34.1300	12.5860
Dependent variable			
Farm machinery	=1 if respondent adopt at least one farm machinery, 0 otherwise	0.5609	0.4982

Overall, adoption status of farm machinery revealed that the adoption of farm machinery is mostly limited to land preparation, planting, and shelling, while mechanization in farm operations such as harvesting and threshing remains very low.

Determinants of farm machinery adoption

Probit model estimation on factors affecting the adoption of farm machinery among the maize farmers is presented in Table 3. The model was significant at 1% level of significance, indicating that it had strong explanatory power. Results reveled that the institutional factors such as regular contact with extension workers and membership in an

agricultural cooperative or farmer group positively and significantly affected the probability of adoption of farm machinery.

Table 2. Adoption status of farm machinery used in the study

Machinery	Description	Mean	SD
Maize Planter	=1 if adoption, 0 otherwise	0.3983	0.4915
Sheller	=1 if adoption, 0 otherwise	0.4634	0.5006
Thresher	=1 if adoption, 0 otherwise	0.1707	0.3778
Power Tiller	=1 if adoption, 0 otherwise	0.5528	0.4992
Harvester	=1 if adoption, 0 otherwise	0.0162	0.1269

Probability of adoption of farm machinery increases by 47.93% among farmers with regular extension contact. This is possibly because access to extension service reduces the knowledge gap and perceived risk of new practices among farming communities. This emphasizes how important extension agents are in acting as conduits of information, training, and awareness about new technologies. Result is in line with previous studies (Khanal et al., 2025; Mdoda et al., 2025; Mhango & Chibomba, 2025; Onuwa et al., 2023; Obayelu & Ajayi, 2018). Similarly, probability of adoption of farm machinery increases by 41.98% among farmers with membership in agricultural cooperatives or farmers group.

Table 3. Determinants of farm machinery adoption in the study

Variables	Coef.	Std. Err.	p-value	dy /dx	Std.Err. (dy/dx)
Gender	0.2445	0.3099	0.430	0.0966	0.1220
Age	0.0359	0.0296	0.225	0.0142	0.0117
Education	-0.0096	0.0424	0.820	-0.0038	0.0168
Log(income)	0.3147	0.3256	0.334	0.1245	0.1287
Contact	1.2848***	0.3255	0.000	0.4793	0.1058
Membership	1.1181***	0.4231	0.008	0.4198	0.1361
Credit	-0.4083	0.3603	0.257	-0.1617	0.1408
Labor	-0.0145	0.4660	0.474	-0.1281	0.1721
Experience	-0.0145	0.0291	0.616	-0.0057	0.0115
_cons	-3.9470**	1.9815	0.046		

Summary statistics: Number of observations= 123; LR chi2(9)=58.34; Prob>chi2=0.0000; Pseudo R2= 0.3459; Log likelihood=-55.170.
Note: **, *** indicate significant at 5%, 1% level of significance, respectively.

This is possibly because cooperatives often play a role in disseminating information, joint purchasing or hiring of machines, and even accessing subsidies and credit. They build social capital and trust, which are indeed crucial for collective action in technology

diffusion. This finding informs the approach of various government programs, such as PMAMP, which normally work through farmer groups and cooperatives for technology dissemination. Result is consistent with the previous studies (Blekking et al., 2021; Donkor et al., 2023; Geffersa, 2023; Manda et al., 2020; Olagunju et al., 2021; Pandey & Mishra, 2025). Meanwhile, gender, age, education, income, and credit access did not have a statistically significant effect on adoption in this model. Though counterintuitive, this may indicate that in the Khotang context, institutional factors like extension and social networks are stronger drivers of adoption than individual characteristics of the households. For example, the insignificance of credit access may suggest that PMAMP's subsidy programs are particularly effective in lowering financial barriers to entry, such that personal access to credit is less of a determining factor.

Reasons for not adopting farm machinery

Table 4 presents the reasons stated by farmers for non-adoption of farm machinery. The major barriers are high rental costs, lack of technical knowledge about farm machinery usage and benefits, and cultivation on small fragmented lands. These results are consistent with previous studies (Kandel et al., 2021; Khatiwada et al., 2021; Kalwar et al., 2026; CSISA, 2021), which reported challenges of difficult terrain, small terraces, and limited access compound the economic and knowledge barriers across Nepal's hilly regions in adoption of farm mechanization.

Table 4. Reasons for not adopting farm machinery (n=54)

Barrier	Frequency
High rental costs	45
Lack of technical knowledge	40
Small landholding	38
Machinery not suitable for small farms	26
Non-availability during growing season	16
Lack of repair workshop	14

Overall, the results advocate that to minimize high rental costs, subsidies for initial procurement from custom hiring and agricultural cooperatives and farmers group can be made accessible. Effective extension services and training should be made accessible to reduce the knowledge barriers. Similarly, issue of small landholdings can be minimized by promoting scale-appropriate machinery and institutional innovations like group-based farming.

Desired support by women farmers to adopt farm machinery

Table 5 presents the support desired by women farmers to facilitate their participation in agricultural mechanization. The results revealed that training specified to women is the most desired support, reported by all 55 women farmers. Then, followed by subsidized rental service (54) and promotion of small-scale machinery (40).

Table 5. Desired support by women farmers (n=55)

Desired support	Frequency
Women-targeted training	55
Subsidized rentals	54
Promote small-scale machinery	40

The results emphasized the need for capacity building, skill development, and confidence building for effective adoption of farm machinery. Further, subsidized rental would allow women to overcome their financial limitations and increase access to ownership/rental capacity. In addition, results emphasizes that women farmers prefer farm machinery that is light, cheap, and suitable for small farms and small landholdings. Overall, findings suggest that increasing women's access to agricultural mechanization training, facilitating affordable mechanization services, and promoting gender-friendly technologies is essential for inclusive and sustainable agricultural mechanization in the present context (CSISA, 2021).

CONCLUSION

The results revealed that that adoption of farm machinery is limited to power tillers, shellers, and maize planters, while the adoption of harvesters and threshers is low. Probit model estimates that institutional factors affect the adoption of farm machinery. In the study area, two institutional factors such as regular contact with extension workers and membership in farmers' groups and cooperatives affected the adoption of farm machinery, positively. While, other socio-economic variables such as age, education, income, and access to credit were found to be insignificant. The result highlights that institutional linkages and collective action are significant factors affecting the adoption of farm machinery in the current context. Therefore, efforts should be on strengthening extension services and promoting farmers group/cooperative-based machinery ownership. Similarly, the results revealed that high rental cost is the major barrier to adoption of farm machinery. This is followed by limited technical knowledge among farmers and cultivation on small and fragmented lands. The results also report that women-focused training programs are the most desired need of women farmers, highlighting gender-responsive capacity-building initiatives in advancing mechanization. This is followed by desire for subsidized rental services, which could reduce economic barriers and allow equitable access to farm machinery. Addressing these economic, technical, and structural constraints through inclusive and targeted policy measures is essential for improving mechanization uptake and overall agricultural productivity.

AUTHORS' CONTRIBUTIONS

Bishal Rawat: Conceptualization; Validation; Formal analysis; Investigation; Data curation; Visualization; Writing-original draft.
Anish Bilash Panta:: Writing-original draft; Writing-review and editing.

Sushmita Bhatta: Conceptualization; Methodology; Software; Validation; Formal analysis;

Binayak Prakash Mishra: Investigation; Data curation; Writing-original draft; Writing-review and editing; Visualization.

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