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Farm mechanization and factors affecting its adoption among wheat growing farmers in Rupandehi, Nepal

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ABSTRACT

This research aims to discover the factors that affect the adoption of machineries in wheat *(Triticum aestivum)* growing fields of Rupandehi district. There is very little indication of increased rate of mechanization and dissemination of information is low around the study area. The survey was conducted among 120 wheat growing farmers to determine mechanization practices, adoption scenario as well as constraints encountered during the adoption of mechanization. The primary information was collected through the household survey by asking pre-prepared questionnaire, while secondary information was collected through relevant publications. The collected data was processed and analyzed using SPSS, Stata and Ms-Excel, preferential ranking was used to rank the constraints while factors influencing the adoption of new technology during wheat cultivation was analyzed using Stata. The findings show that mechanization during land preparation was highest with the use of cultivator (87.5%) and rotavator (85.8%) but latest technology like super-seeder showed low adoption (12.5%). Similarly, harvesting of wheat was done by combine-harvester (70.8%) and thresher (29.2%). The key constraints identified during adoption of mechanization were unavailability of machineries on time followed by labour shortage. Those factors significantly associated with increment of adoption of new technology were land area under wheat, distance from highway, participation in trainings, involvement in cooperatives and status of land fragmentation. Thus, the study concludes that ensuring availability of machineries and providing trainings on the use of machineries can enhance mechanization among wheat growing farmers ensuring food security in the district.

Keywords: Adoption, food security, mechanization, new technology, wheat

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INTRODUCTION

Nepal produces wide range of cereals among which wheat is the third most important crop, taking up a significant amount of land in terms of both production and geographic coverage (MoALD 2023, Ghimire et al 2023). Despite increased productivity, domestic demand continues to surpass domestic supply, necessitating substantial imports from neighboring countries (Gairhe et al 2019). The rising population growth frequently hinders the sector's expansion and it is expected that future food supplies will not meet the level of demand (Dawadi et al 2023). This gap could be bridged by enhancing average yield through the adoption of suitable farm equipment, introduction of novel crop varieties, exploration of innovative machineries, development of new sowing techniques, and by the implementation of novel fertilization methods that combine FYM with inorganic fertilizers (Yamin et al 2011).

Mechanization is one of the effective methods for increasing agricultural production efficiency, fostering agricultural diversification, decreasing operational time, improving timely farm operation and saving money and resources ie labour and energy (Gauchan and Shrestha 2017). By bringing unused land under cultivation, farm mechanization has increased the area and yield of important crops like maize, rice and wheat by 27.3%, 10.4% and 0.4% respectively (Yamin et al 2011). Although it is one of the key strategies for producing cereal crops in a sustainable manner, very few studies have been reported that assessed the level of mechanization in agriculture in Nepal (Bhandari et al 2023). In Nepal, animal and human power accounts for 40.55% and 33.30% respectively where only 23% of the mechanical power is now in use (Shrestha 2021).

Statistical data shows that the total land area of Rupandehi district is 1,36,000 ha and the cultivable land is 85,122 ha which is 60.2% of the total land area. Wheat is the second-most important crop in the district after rice, taking up 26,118 ha of land, with a benefit-cost ratio (BCR) of 1.87 (Kharel et al 2021). Also, in average, 0.68 ha of land is typically owned by each family, and this number is steadily dropping (Anmol 2017). Since terai region has documented to have higher rates of mechanization as compared to hilly and mountain region of the country, agricultural mechanization has the potential to increase and enhance the region's currently restricted agricultural productivity (Karki et al 2022). We need to enhance the productivity of the wheat as the growing population is expected to occupy the land that is being used for crop yield.

This study aims to find out general status of farm mechanization in wheat, factors that helps to enhance the adoption of the latest technologies and the constraints that appears during its adoption in Rupandehi district. This research will provide valuable insights to the policy makers, government and private institutions as well as farmers about the importance of adoption of the improved technologies during wheat cultivation that contribute to increase its yield and ensures food security throughout the country.

MATERIALS AND METHODS

The study was carried out in Rupandehi district of Nepal. The majority of the area primarily engages in wheat cultivation across the entire district (Kharel et al 2021). During the main season, wheat was cultivated accross 26,118 ha, resulting in the production of 103,167 MT and productivity of 3.95 MT/ha (MoALD 2023). Out of 16 municipalities, 10 were rural municipalities and 6 were urban municipalities where the survey research was carried out in

Siyari and Kotahimai rural municipalities as they were the potential wheat growing areas of the district.

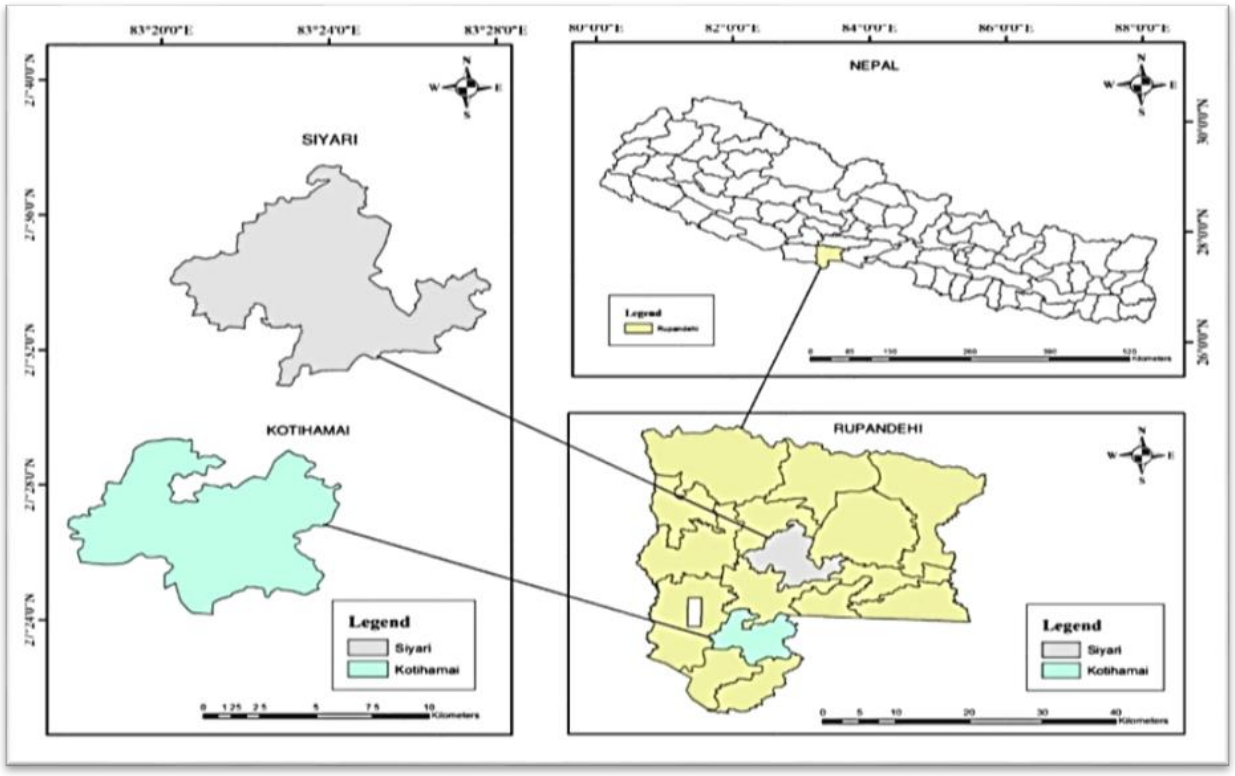

Figure 1. Map of Nepal showing Rupandehi district and study site

A preliminary investigation was conducted to gather various data pertaining to the research's viability. Assessment of the study site was done by direct observation and informal conversations with farmers, AKC and PMAMP. At first, list of the farmers was obtained through the farmer's profile collection at PMAMP and AKC of Rupandehi district and multistage, purposive random sampling was carried out to select the municipality and prospective wheat growing farmers. Out of total wheat growers, 60 farmers were selected from each of the two municipalities. Thus, the sample size comprising 120 respondents and household survey were carried out. Similarly, pre-tested semi-structured questionnaire was asked to the respondents. In addition to the household survey, Focus Group Discussion (FGD) and Key Informant Interview (KII) was conducted with few progressive farmers and members of agricultural cooperatives to validate the reliability and authenticity of the collected data. The data gathered from the farmers using a semi-structured questionnaire survey was considered as the primary data (Bhandari et al 2023). The secondary data was collected from previous survey, annual report of NWRP, journals, articles, CBS, publications from AKC, PMAMP, Krishi diary, newspapers and so on (Ghimire and Kandel 2023).

The observed data was systematically arranged, entered in IBM SPSS Statistics 25 and put forward for analysis. Various other analytical software's like Ms-excel, Stata, etc were used for the analysis of the data obtained. In the statistical analysis, mean, SD, frequency, percentage, etc

were studied using descriptive statistical tools. To analyze the factors affecting the adoption of mechanization, Logit model was used through Stata.

Empirical model

IBM SPSS Statistics 25 was used for the descriptive analysis. To ascertain the characteristics influencing wheat-growing farmer's adoption of the new machineries, a logit model was used. Additionally, the logit model was used to estimate the marginal effect of each independent variable in order to determine the effect of each individual variable on the adoption of machineries.

Specification of model

$Z=In[P_i/(1-P_i)$

$Z=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+b_{10}X_{10}+b_{11}X_{11}+b_{12}X_{12}+b_{13}X_{13}+b_{14}X_{14}+b_{15}X_{15}+U$ where,

P_i = probability of adoption and non-adoption of latest technology

P_i = 1, defines adoption

P_i = 0, defines non-adoption

Dependent variable:

Z_i = Probability of adoption of farm mechanization

Independent variable:

X_1 = Age

X_2 = Gender

X_3 = Education

X_4 = Ethnicity

X_5 = Family type

X_6 = Economically active

X_7 = Job

X_8 = Land under wheat

X_9 = Annual income

X_{10} = Wheat cultivation years

X_{11} = Distance from highway

X_{12} = Participation in training

X_{13} = Cooperatives

X_{14} = Subsidy

X_{15} = Land fragmentation

a = Intercept

b_1 to b_{15} = Regression coefficients of the dependent variables

U = Error term

Expressions derived from the logit model's marginal effect were used to assess the marginal likelihood of the factors influencing the use of the newest technology.

$dZ/dQ = \beta_i [P_i(1-P_i)]$ where,

β_i = Estimated logit regression coefficient with respect to the ith factor

P_i = Estimated probability of adoption of mechanization by farmers

RESULTS

Descriptive Statistics of socio-economic information

Summary statistics and explanation of the parameters are presented in Table 1. As observed, each parameter is described below:

Table 1. Socio Demographic information in the study area

Parameters	Frequency	Percent
Gender		
Male	80	66.7
Female	40	33.3
Age		
Age between 0 to 15	4	3.3
15 to 60	106	88.3
Above 60	10	8.3
Ethnicity		
Brahmin or Chhetri	32	26.7
Aadibasi or Janajati	23	19.2
Madhesi	65	54.2
Education		
Illiterate	31	25.8
Primary Level	67	55.8
Secondary to higher Secondary Level	16	13.3
Bachelors or above	6	5
Type of Family		
Nuclear	67	55.8
Extended	53	44.2
Occupation		
Business	13	10.8
Labour	22	18.3
Private or Government jobs	21	17.5
Foreign employment	37	30.8
Agriculture	27	22.5
Annual income		
Up to Rs. 500,000	67	55.8
Rs. 500,001- Rs. 1,000,000	44	36.7
Greater than Rs. 1,000,001	9	7.5
Total	120	100

Source: Field Survey, 2023

Gender: The comprehensive examination of the distribution revealed that most of the respondents (80%) were dominated by male where the study by (Bhandari et al 2023) shows (75%) respondents were males.

Age: Majority of the respondents (88.3%) were economically active (15 to 59 years) while Agri-census 2021 shows (61.96%) of the total population of the country were under this category (National Statistics Office 2023).

Ethnicity: In this study, the largest ethnic group within the respondent pool were Madhesi community contributing an impressive (54.2%) followed by Brahmin or Chhetri group (26.7%) and Aadibasi or Janajati (19.2%). Comparing the findings of (Bhandari et al 2023), there was notable contrast with majority of the respondents from Tharu or Chaudhary community (53%) followed by Brahmin or Chhetri (17%) and Dalit (16%).

Education: Analysis of the data obtained divulge that (55.6%) of the respondents had primary level education where (25.85%) were illiterate followed by (13.3%) with secondary to higher secondary education while the research by (Kandel et al 2021) contradicts this study showing only (7.6%) attending up to higher secondary level and (8.3%) of the respondents being illiterate.

Type of family: The study outlines that (55.8%) of the respondents have nuclear family followed by (44.2%) with extended family structure.

Occupation: Majority of the people were observed to go foreign country for employment (30.8%), while by Agriculture (22.5%) which contradicts with the findings of (Rajasree et al 2017) where almost all the respondents (>90%) were involved in Agriculture.

Annual income: Majority (55.8%) of the household have annual income less than Rs. 5000,000 while (36.7%) have income from Rs. 500,001 to Rs. 1,000,000 and the remaining (7.5%) of the respondents have income greater than Rs. 1,000,001 where none of the respondents have annual income greater than Rs. 200,001 in the study of (Rajasree et al 2017). It may be due to the reason that most of the people practice agriculture as their main occupation leading to the less returns.

Status of machineries and farm equipment used by the respondents

After analyzation of the data, the adoption of machineries during land preparation and harvesting was found to be 100%, all of the respondents used either cultivator (87.5%) or rotavator (85.8%) or both (1.7%) during land preparation. Similarly, the farmers used either thresher (29.2%) or combine harvester (70.8%) during harvesting and there was high percentage of adoption of harvesters than threshers which may be due to more dissemination of information related to technology adoption. While the research conducted by (Aryal et al 2021) showcased that (65%) used threshers and only (23%) used combine harvester. Super-seeder which is the new technology was adopted by only (12.5%) of the respondents which is assumed to be due to the less availability of the particular machine.

Table 2. List of machines used by the respondents

Machine	Adopter	Non-adopter
Cultivator	105(87.5)	15(12.5)
Rotavator	103(85.8)	17(14.2)
Super-seeder	15(12.5)	105(87.5)
Thresher	35(29.2)	85(70.8)
Combine harvester	85(70.8)	35(29.2)
Knapsack sprayer	48(40)	72(60)
Mini-tiller	0(0)	120(100)
Sickle	35(29.2)	85(70.8)
Irrigation Pump-set	58(48.3)	62(51.7)
Straw-reaper	50(41.7)	70(58.3)

Note: Figure in parenthesis indicates percentage (%)
Source: Field survey 2023

Ranking of the problems faced during adoption of machineries

Table 3. Ranking of the problems faced during adoption of machineries

Problems	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Weight-age**	**Index value**	**Rank--ing**
Labour shortage	44(36.7)	7(5.8)	23(19.2)	30(25)	16(13.3)	78.6	0.655	II
High cost of machineries	5(4.2)	28(23.3)	15(12.5)	25(20.8)	47(39.2)	55.8	0.465	V
Unavailability of the machineries on time	39(32.5)	18(15)	31(25.8)	13(10.8)	19(15.8)	81	0.675	I
Lack of knowledge to use machines	4(3.3)	32(26.7)	34(28.3)	34(28.3)	16(13.3)	66.8	0.550	IV
High cost on renting	29(24.2)	34(28.3)	13(10.8)	22(18.3)	22(18.3)	77.2	0.640	III

Note: Figure in parenthesis indicate percentage (%)
Source: Field survey, 2023

The foremost problem behind mechanization is lack of availability of machineries at the peak time with index value 0.675 followed by labour shortage with index value 0.655, high cost of rental services of machines with index value 0.64, lack of technical knowledge about the use of machines with index value 0.675 and the least mentioned problem was high cost of machines when buying new machines with index value 0.465.

Factors affecting the adoption of farm mechanization in the study area

The factors influencing the use of the newest technologies were evaluated using logit regression analysis, and the findings are shown in Table 3. At the 1% level, the model's wald test (LR Chi.Sq) revealed that it had strong explanatory power. As indicated in Table 3, the regression coefficients were also used to drive the marginal effect. Statistically significant variables are described as below:

Table 4. Logit regression analysis and marginal effect for factors affecting the use of combine harvester

Variables	Coefficient	SE	P Value	dy/dx	SE (dy/dx)
Age	-1.313	0.961	0.172	-0.186	0.134
Gender	-0.519	0.673	0.441	-0.078	0.106
Education	0.028	0.062	0.653	0.004	0.009
Ethnicity	0.295	0.369	0.423	0.042	0.054
Family type	-0.586	0.787	0.457	-0.083	0.109
Economically active	-0.244	0.252	0.333	-0.035	0.035
Job	-0.065	0.204	0.751	-0.009	0.029
Land area under Wheat	1.792**	0.803	0.026	0.253	0.101
Annual income	0.769	0.543	0.156	0.109	0.075
Wheat cultivation years	0.298	0.473	0.529	0.042	0.067
Distance from Highway	-0.756**	0.358	0.035	-0.107	0.052
Participation in trainings	1.478**	0.603	0.014	0.230	0.098
Involvement in Cooperatives	0.172**	0.621	0.782	0.025	0.092
Subsidy scheme	1.265	0.780	0.105	0.152	0.079
Land fragmentation	-0.986*	0.360	0.006	-0.139	0.053
Constant	4.689	3.465	0.176		

Observation = 120, LR Chi.Sq.= 51.28, Prob>Chi.Sq = 0.000, Log Likelihood= -46.79, Pseudo R2= 0.35
Note: Figures in parenthesis indicate p value, ***, ** and * indicates significance at 1%, 5% and 10% significance respectively
Source: Field survey 2023

Land area under wheat: Result outlined that the area of land under wheat was found to be statistically significant at 5% level of significance and has positive association in the adoption of wheat. When all other factors are held equal, the likelihood of using a combine harvester rises by 25.3% for every unit increase in the area planted to wheat. This might be due to the fact that combine harvester is used often in those land where wheat where is grown in larger area. This is consistent with the findings of (Bhandari et al 2023) and (GC et al 2019).

Participation in training: Findings showed that there is statistically significant association between participation in training related to wheat cultivation and/or machine learning and combine harvester adoption. This condition is opposite to the result obtained by (Atinafu et al 2022) while it align with the findings of (Kebede and Tadesse), this might be due to the fact that the frequency of training is more in Rupandehi.

Involvement in Cooperatives: As per results, membership in cooperatives has positive and significant association with the adoption of combine harvester where there is 2.5% increase in combine harvester's adoption with one unit increase in involvement in cooperation.

Distance from highway: Results showed that distance from highway is statistically significant with the adoption of combine harvester, as adoption of the machine increases by (10.7%) with a unit rise in area of land (non-fragmentation).

Land fragmentation: Result showed that less fragmented land with more area has been found to use combine harvester as compared to more fragmented land; it is significant at (1%) level of significance. The probability to adopt combine harvester is (13.9%) with one unit increase in land area.

DISCUSSION

The present study aimed to investigate the factors associated with the technology adoption during wheat cultivation. The findings provide valuable insights about the scenario of mechanization, issues encountered during its adoption along with different factors that directly affected the adoption process. According to the study, all respondents in the area practiced mechanization (Table 2) during land preparation, cultivator (87.5%) or rotavator (85.8%) or both (1.7%) while both rotavator and cultivator were adopted by (82.9%) in the study by (Kandel et al 2021). This may be due to the fact that the importance of both machines was analyzed by the growers in the latter study as compared to the former. Similarly, the main problem exposed during machinery adoption (Table 3) was unavailability of the machineries on time which can be reduced by providing subsidies to the farmers to increase the number of machines that ultimately overcome the problem of labour shortage. As high cost of machineries was found to be least problem during machinery adoption, it was found to be the foremost reason in the research conducted in Jhapa district by (Kandel et al 2021) which may be due to the reason that most of the respondents in the latter research practiced the use of machines on rent than buying on their own. Likewise, education was found to be non-significant (Table 4) with technology adoption which is consistence with the findings of (Laxmi and Mishra 2007), the reason behind it may be that most of the respondents were illiterate and only had primary education. Also, subsidy scheme has non-significant association with the technology adoption (Table 4) unlike the findings of (Atinafu et al 2022). This discrepancy may be due to less practice of subsidy by the government and less involvement in the cooperatives that leads to less adoption of new machineries in Rupandehi district. Findings of the data (Table 4) demonstrated that less the distance of wheat field from the highway, more is the chance of adopting advanced technology like combine harvester which contradict with the result of (Mishra et al 2023). The reason behind it might be that availability of roadways near to the field increases the tendency of adoption of mechanization (combine harvester). Likewise, annual income was found to be non-significant (Table 4) with the adoption of combine harvester and it is in contradiction with the research conducted in Ethiopia by (Atinafu et al 2022). It might due to the fact that most of the people in Rupandehi have income source other than farming. Furthermore, age have non-significant association with the adoption of new technology (Table 4) which is not correlated with the findings of (Laxmi and Mishra 2007). Also, membership in cooperatives positively and significantly determines the probability of adoption of combine harvester which is alike the result of (Atinafu et al 2022) which is probably due to the fact that cooperatives provide custom hiring and renting of machineries.

CONCLUSION

In conclusion, the findings from the study revealed that 87.5% wheat farmers are using cultivators, 85.8% are using rotavator while 70.8 % are using combine harvester, thus indicating high adoption. And, unavailability of machineries proved to be the main problem during adoption process. With more access to machinery, particularly through government subsidies or cooperative based rental program would help address the unavailability of machinery at critical times. Similarly, participation in trainings, involvements in cooperatives, non- fragmented land and distance from highway have found to be crucial in promoting the adoption of advanced machinery like combine harvester. This implies that encouraging more training programs on using machineries, focusing on including more farmers in cooperatives and practicing wheat cultivation in large non-fragmented land could be important approaches for better adoption of machineries. Furthermore, age, gender, education and ethnicity have no significant relation with adoption, so, policies should be made to improve machinery adoption for all age group irrespective of their gender, education or ethnicity. Moreover, this research showed that trainings and involvement in cooperatives have significantly positive influence on adoption of combine harvester. So, government and associated formal institutions should carry out provision of frequent trainings on machinery handling and encouragement to the farmers to involve in cooperatives.

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Authors' Contributions

Author Ranabhat S being the main author has involved from pre-liminary questionnaire preparation, report writing to the article writing for publication, Bastola A has been involved in questionnaire preparation, data entry and report writing while Shrestha A and Tiwari N were engaged in data analysis and report writing.

Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

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