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ORIGINAL RESEARCH ARTICLE

# Assessment of agricultural mechanization status in rice production and its challenges in the western Nepal

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**ABSTRACT**

There is a difference of 45% to 55% between the attainable yield and the potential yield of rice. This gap may be due to insufficient inputs and poor mechanization status. In this regard, agricultural mechanization is of the utmost importance to obtain satisfactory yield. This study was conducted to determine mechanization level, power per unit area, probit regression, and challenges faced by farmers to understand the mechanization status in rice cultivation. For this, 98 households in the Pyuthan municipality of Pyuthan district and 87 households in the Bhimdutta municipality of Kanchanpur district were selected using a simple random sampling method. The highest mechanization level was found in the main field tillage (90.92%), followed by threshing (85.24%), the seedbed tillage (52.42%), and irrigation (20.10%). Mechanization is lacking in transplantation, bund preparation, fertilizer application, weeding, and harvesting. Power per unit area was found to be 4.67 hp/ha. Age and family size have a negative impact while male household heads have a positive impact on mechanized tillage and threshing, both statistically significant at a 5% level. The unavailability of farm machinery and land fragmentation were the major challenges in the adoption of farm mechanization. The mechanization status in the study areas is not satisfactory, thus, the strict policy against land fragmentation, dissemination of extension services at the grass root level, and the provision of subsidies for required farm machinery could help the improvement of mechanization status in rice production in Nepal.



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## INTRODUCTION

Agriculture contributes 24.26% to the total Gross Domestic Product (GDP) of Nepal; rice (*Oryzae sativa*) itself contributes 7% to the total GDP, and 20% to the agricultural gross domestic product (AGDP) of the country (Joshi and Upadhaya, 2020). The productivity of rice is 3.76 t/ha (MoALD, 2020). There is a difference of 45% to 55% between attainable yield and potential yield in Nepal (Joshi and Upadhaya, 2020). This yield gap may be due to a lack of appropriate and sufficient inputs, traditional cultivation practices, and unfavorability of the climate. Though 65% of the population is engaged in agriculture, the production is not sufficient for consumption within the country. About $300 million of rice is imported every year mainly from India resulting huge outflow of the national income (Joshi and Upadhaya, 2020). Difficulties in cultivation or the lack of sufficient modern farm machinery are one of the major drivers for the farmers to the non-agricultural work. There is a trend of foreign employment among Nepalese youth which creates a labour bottleneck during peak agricultural operations (Pingali, 2007). The problem

of labour shortage contributes to the increase in labour wages which results in agricultural land remaining fallow (Khanal, 2018; Prabakar *et al*., 2011).

Agriculture mechanization can be the major approach in this regard. It is the application of improved farm implements in agriculture production. Mechanization can be used at any stage of agricultural production (Emami *et al*., 2018). It increases crop productivity, and labour productivity, reduces drudgery, and saves time, eventually increasing the benefit-cost ratio and improving the livelihood of the farmers (Benin, 2005; Pingali, 2007). Baran *et al* (2014) revealed that mechanization in agriculture increases the effectiveness and economic efficiency of technological applications and improves working conditions. On the other hand, the lower degree of mechanization in rice cultivation creates higher production costs, and labour shortages and also consumes time either during field preparation or harvesting. It creates the condition of transplanting old seedlings due to which the yield of rice is reduced (Liu *et al*., 2015; Liu *et al*., 2017). As rice wheat is the dominant cropping system of Nepal, this delay in rice harvesting significantly decreases the yield of subsequent wheat crops.

The trend of farm mechanization started in Nepalese agriculture in the early 1970s with the introduction of four-wheeled tractors and later two-wheeled tractors introduced in the 1980s (Biggs and Justice, 2015). These two-wheeled tractors were initially operated in peri-urban areas for vegetable production but later they were spread to rural areas with the involvement of the government sector (Biggs and Justice, 2015). As the tractor is the major source of power used in Nepal, it is the most appropriate criterion to determine the mechanization level. Tractor-powered machinery is widely used for ploughing and threshing in Nepal. The commonly used tractor-powered equipment in tillage for rice cultivation area cultivator, chisel plough, disc harrow, rotavator, leveler, and puddler. It is estimated that there are more than 20,000 two-wheeled tractors in Nepal with sales of 1500 to 2000 per year which made a significant contribution to agricultural productivity (Biggs and Justice, 2015). Agricultural mechanization promotion policy 2014 has also emphasized mechanization for the modernization and commercialization of agriculture. Mechanization is one of the major approaches for satisfactory and sustainable production of rice crops, nevertheless, very few works have been reported that were carried out to determine mechanization status in rice cultivation in Nepal. The crop-specific assessment of mechanization status including each cultivation practice is lacking in Nepal. For the development of mechanization-related policies and the improvement of mechanization status, the crop-specific analysis of the mechanization level and the challenges faced by farmers for the wide-scale adoption of farm machinery is necessary. This paper is uniquely directed to focus on the mechanization status of a major staple crop, rice, in two geographic regions, Terai and Hills, of Nepal. It aims to provide insights into mechanization sources, mechanization level, socioeconomic characteristics that affect mechanization level, power per unit area, and challenges faced by the farmers in the adoption of modern farm machinery in rice cultivation in western Nepal.

## MATERIALS AND METHODS

### Study site

Two districts namely, Kanchanpur of Sudurpaschim province and Pyuthan of Lumbini province were chosen as they are the rice superzone and zone respectively. Kanchanpur district represents the Terai region whereas Pyuthan district represents the hilly region of western Nepal. Pyuthan municipality, Ward 7 of Pyuthan district, and Bhimdatta municipality, Ward 5 of Kanchanpur district were selected as study sites. The research survey was conducted in Tikuri village of Pyuthan district and Bangaun village of Kanchanpur district.

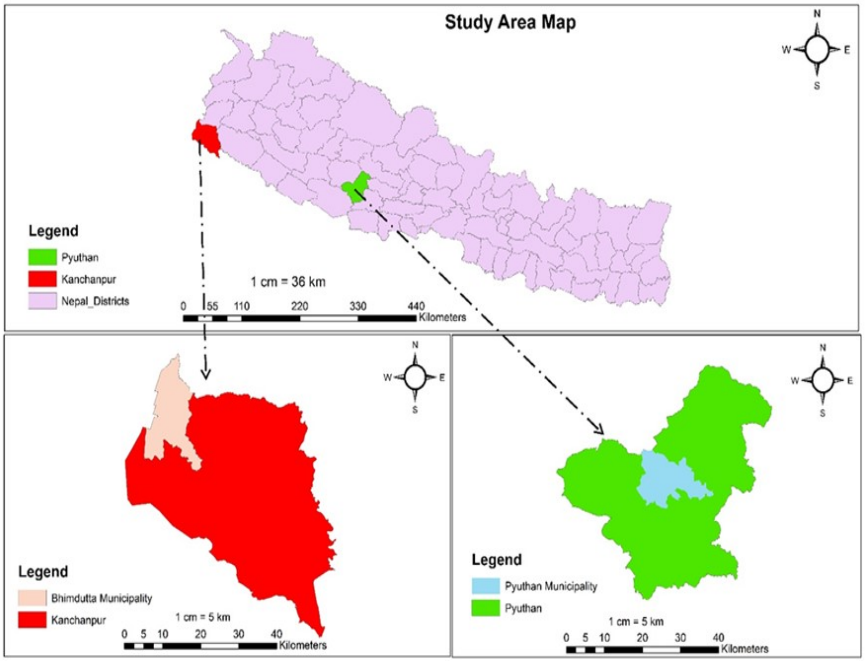


**Figure 1.** *Map of the study site.*

### Sampling design

Ninety-eight households of rice-growing farmers in Tikuri village and eighty-seven households in BanGaun village were randomly selected by using simple random sampling techniques. The scheduled interview was carried out using the pre-tested questionnaire in each selected household from February to March, to know the mechanization status, mechanization sources, and challenges in the adoption of modern machinery equipment.

### Data analysis

Different inferential statistics were used for the data analysis. Data were analyzed in STATA and SPSS and the graph was generated. Z- test was computed to determine whether the mean of different socioeconomic characteristics of Tikuri and Bangaun are significantly different. Probit regression was estimated to know whether the mechanization in tillage and threshing were significantly related to socioeconomic characteristics.

### Mechanization level

Mechanization level is the quantitative index used to determine the mechanization status of agricultural operations. It is the ratio of the total mechanized area to the total area under cultivation and expressed in percentage (Lak and Almassi, 2011). It is computed for specific agricultural operations for particular crops.

Mechanization level = (mechanized cultivated area / total cultivated area) ×100%

### Power per unit area

Power per unit area is the qualitative index used to determine mechanization status. It is the ratio of the total drawbar power available in the region to the total area under cultivation (Lak and Almassi, 2011). Its unit is horsepower per hectare (hp/ha) or kilowatt per hectare (KW/ha).

Power per unit = total power in the area for cultivation (hp) / total cultivated area (ha)

### Probit regression

We examine factors influencing the adoption of mechanization in different cultivation stages. Specifically, the decision models of mechanization adoption during two critical stages of cultivation: main field tillage and threshing were estimated using two separate probit regression models. Note that the decision to adopt mechanization in each stage is a "yes" or "no" decision, which is numerically represented as 1 and 0, a binary outcome. For the mutually exclusive binary outcomes, our interest is the probability *p* of adoption ("yes" or 1 outcome) over the alternative "no" or 0 outcome that occurs with the probability of *1-p*.

We assume that the observed binary outcome *y* has an underlying latent continuous variable $y^*$ determined by a set of factors:

$$y^* = X'\beta + \varepsilon$$

$y^*$ is not directly observed but the outcome *y* is observed such that:

$$y = \begin{cases} 1 \text{ if } y^* > 0 \\ 0 \text{ if } y^* \leq 0 \end{cases}$$

*X* represents a set of variables (factors or determinants) that influence the decision leading to adoption or non-adoption, $\beta$ represents the extent of the relationship of each determinant (variable) with the adoption decision (outcome 1 over 0), and $\varepsilon$ is the error term assumed to be standard normally distributed (in probit regression case). In a nutshell, fitting the non-linear model using a maximum likelihood framework, probit regression enables us to test the magnitude and directional relationship of each variable with the adoption decision. In the result section, we discuss the details of the variables used and the decision model results.

## RESULTS AND DISCUSSION

### Demographic and socio-economic status

The demographic and socioeconomic characteristics of household heads are presented in Table 1. Most of the households (75%) were dominated by males. The average age of household head and family size was 55.54 years and 6 respectively. Maximum (66%) household heads have got the primary level of education. Agriculture was the primary occupation of 64% of households. Nevertheless, only 30% have got extension facilities. The average land holding was less than one hectare (ha). The area of rice cultivation was relatively greater in Pyuthan (0.71 ha) than in Kanchanpur (0.56 ha). The dominant ethnicity was Brahmin (31%) followed by Chhetri (25%), Janajati (20%), Thakuri (14%), and Dalits (10%). The average annual income of most of the household heads was between 3 to 6 lakhs. The majority of the households (81%) were found to cultivate rice in their land followed by shared land (13%) and rented land (6%). Most of the households were found to practice sequential cropping systems with a percentage of 64%. Only 19% of the households sold surplus rice. This indicates a lack of commercialization in rice farming. Joshi and Upadhaya (2020) also reported that half of the Nepalese farmers grow rice for their consumption, 40% sell surplus production, and only 10% grow rice on a commercial scale. About 59% of farmers were reported to face the problem of a labour shortage during rice cultivation.

### Mechanization status in rice production

The mechanization level for different rice cultivation practices is not satisfactory. More than 50% of the cultivation practices such as bund preparation, transplantation, fertilizer application, weeding, and harvesting lack mechanization. Mechanization in bund preparation, transplantation, and weeding is also lacking in Anuradhapura district of Sri Lanka (Gamlath *et al.*, 2018).

**Table 1.** Demographic and socio-economic characteristics of household heads.

| Variables | Pyuthan 07 | | Bhimdutta 05 | | Total | Z-value |
|---|---|---|---|---|---|---|
| | Mean (n=98) | Standard deviation | Mean (n=87) | Standard deviation | Mean (n=185) | |
| Age (years) | 55.54 | 4.79 | 52.61 | 8.53 | 55.54 | 2.83*** |
| Gender (male= 1, otherwise =0) | 0.66 | 0.48 | 0.84 | 0.37 | 0.75 | 2.87*** |
| Family size | 5.99 | 1.06 | 5.03 | 0.91 | 5.54 | 6.63*** |
| Education | | | | | | |
| a. No education (1/0) | 0.07 | 0.26 | 0.09 | 0.29 | 0.08 | 0.49 |
| b. Primary (1/0) | 0.67 | 0.47 | 0.66 | 0.48 | 0.66 | 0.14 |
| c. Secondary (1/0) | 0.20 | 0.41 | 0.19 | 0.39 | 0.20 | 0.17 |
| d. Above secondary (1/0) | 0.11 | 0.32 | 0.06 | 0.23 | 0.09 | 1.23 |
| Off farm activity (Yes=1, otherwise=0) | 0.60 | 0.49 | 0.31 | 0.47 | 0.47 | 4.11*** |
| Extension facilities (Yes=1, No=0) | 0.44 | 0.49 | 0.14 | 0.35 | 0.30 | 4.83*** |
| Total land size (ha) | 0.92 | 0.43 | 0.74 | 0.34 | 0.83 | 3.17*** |
| Area of rice cultivation (ha) | 0.71 | 0.39 | 0.56 | 0.23 | 0.64 | 3.23*** |
| Ethnicity | | | | | | |
| a. Brahmin (1/0) | 0.31 | 0.46 | 0.32 | 0.47 | 0.31 | 0.15 |
| b. Chhetri (1/0) | 0.29 | 0.46 | 0.19 | 0.39 | 0.25 | 1.60 |
| c. Thakuri (1/0) | 0.02 | 0.14 | 0.28 | 0.44 | 0.14 | 5.28*** |
| d. Dalit (1/0) | 0.14 | 0.35 | 0.05 | 0.21 | 0.10 | 2.14** |
| e. Janajati (1/0) | 0.23 | 0.43 | 0.16 | 0.36 | 0.20 | 1.20 |
| Annual income | | | | | | |
| a. Below 1 lakh (1/0) | 0.05 | 0.22 | 0.06 | 0.23 | 0.05 | 0.30 |
| b. 1 to 3 lakhs (1/0) | 0.20 | 0.41 | 0.15 | 0.36 | 0.18 | 0.88 |
| c. 3 to 6 lakhs (1/0) | 0.55 | 0.49 | 0.67 | 0.47 | 0.61 | 1.69* |
| d. Above 6 lakhs (1/0) | 0.19 | 0.39 | 0.13 | 0.33 | 0.16 | 1.13 |
| Land tenure status | | | | | | |
| a. Own land (1/0) | 0.77 | 0.43 | 0.85 | 0.36 | 0.81 | 1.38 |
| b. Rented land (1/0) | 0.03 | 0.17 | 0.09 | 0.29 | 0.06 | 1.69* |
| c. Shared land (1/0) | 0.20 | 0.41 | 0.06 | 0.23 | 0.13 | 2.90*** |
| Distance from the market (km) | 1.02 | 0.15 | 1.86 | 0.69 | 1.41 | 11.12*** |
| Agriculture as a primary occupation (Yes=1, No=0) | 0.58 | 0.49 | 0.70 | 0.46 | 0.64 | 1.72* |
| Cropping system | | | | | | |
| a. Sequential cropping (1/0) | 0.91 | 0.29 | 0.34 | 0.48 | 0.64 | 9.63*** |
| b. Crop rotation (1/0) | 0.09 | 0.29 | 0.65 | 0.48 | 0.36 | 9.46*** |
| Sell surplus rice (Yes=1, No=0) | 0.15 | 0.36 | 0.23 | 0.42 | 0.19 | 1.38 |
| Annual income from selling rice (Nrs) | 3581.63 | 8629.75 | 4632.18 | 10056.95 | 4075.68 | 0.76 |
| The problem of labor shortage (Yes=1, No=0) | 0.73 | 0.44 | 0.42 | 0.49 | 0.59 | 4.50*** |
| Types of labor used | | | | | | |
| a. Family labor (1/0) | 0.16 | 0.37 | 0.77 | 0.42 | 0.45 | 10.42*** |
| b. Family and Hired labor (1/0) | 0.84 | 0.37 | 0.23 | 0.42 | 0.55 | 10.42*** |
| The total cost of hiring labor/season of rice production (Nrs) | 25520.41 | 12712.71 | 1509.19 | 2414.38 | 14228.65 | 18.33*** |
| The total cost of using tractor-powered machinery/season of rice production (Nrs) | 2953.06 | 1509.14 | 5803.45 | 1901.29 | 4293.51 | 11.19*** |

[Note: *, **, *** indicate 10%, 5% and 1% level of significance respectively].

The highest level of mechanization was found in main field tillage with 90.92% followed by threshing with 85.24%. Seedbed tillage has a mechanization level of 52.42%. Only 20.10% mechanization level found in irrigation. Mechanization is completely lacking in seedbed tillage and irrigation in Pyuthan district. Most of the households use pump sets for irrigation in Kanchanpur. But in the case of Pyuthan, almost all of the households use canals for irrigation in the rice field. Joshi and Upadhaya (2020) also reported that only 20% of Nepalese farmers have adopted mechanization in agriculture. This is very less as compared to developed countries like the USA (95%), Brazil (75%), and China (57%) (ICAF, 2017). Even India has twice the mechanization level than that of Nepal, that is 40%. There were 10 power tillers and 3 four-wheeled tractors in the study site of Pyuthan district with a power per unit area of 3.29 hp/ha. The government has distributed power tillers to the farmers in Pyuthan. As a power tiller is suitable for hilly regions, it is common in Pyuthan. In the study site of Kanchanpur district, 3 power tillers and 6 four-wheeled tractors were reported with a power per unit area of 6.63 hp/ha. The power per unit area is constantly increasing in India since 1971/72, and it reached 1.841 KW/ha in 2012/13 (UNESCAP, 2020). The main reason behind this is the establishment of several farm machinery manufacturing companies that export 10% tractors (UNESCAP, 2020). According to Kaur (2017), there were only 8% of tractor users and 26% iron plough users in Nepal. Gamlath *et al.* (2018) reported power per unit area of 42.07 hp/ha in Anuradhapura district of Sri Lanka which is far greater as compared to Nepal.

## Mechanization sources in rice production

In the case of rice cultivation, electrically-powered sources are mainly used for irrigation in Nepal. The pump set is commonly used for irrigation in the rice field in Kanchanpur. Households of 68.97% were found to use pump sets with the ownership of

**Table 2.** Mechanization level (%) and power per unit area (hp/ha) of different rice cultivation practices in the study areas.

| Rice cultivation practices | Pyuthan 07 | | | Bhimdutta 05 | | | Total |
|---|---|---|---|---|---|---|---|
| | Total rice cultivated area (ha) | Mechanized rice cultivated area (ha) | Mechanization level (%) | Total rice cultivated area (ha) | Mechanized rice cultivated area (ha) | Mechanization level (%) | Mechanization level (%) |
| Seedbed tillage | 0.071 | 0.00 | 0.00 | 0.033 | 0.032 | 96.97 | 52.42 |
| Main field tillage | 0.641 | 0.447 | 69.73 | 0.527 | 0.519 | 98.48 | 90.92 |
| Bund preparation | 0.641 | 0.00 | 0.00 | 0.562 | 0.00 | 0.00 | 0.00 |
| Transplantation | 0.641 | 0.00 | 0.00 | 0.527 | 0.00 | 0.00 | 0.00 |
| Fertilizer application | 0.641 | 0.00 | 0.00 | 0.527 | 0.00 | 0.00 | 0.00 |
| Weeding | 0.641 | 0.00 | 0.00 | 0.527 | 0.00 | 0.00 | 0.00 |
| Irrigation | 0.712 | 0.00 | 0.00 | 0.562 | 0.209 | 37.19 | 20.10 |
| Harvesting | 0.712 | 0.00 | 0.00 | 0.527 | 0.00 | 0.00 | 0.00 |
| Threshing | 0.712 | 0.423 | 59.41 | 0.527 | 0.518 | 98.29 | 85.24 |
| Power per unit area | | 3.29 hp/ha | | | 6.63 hp/ha | | 4.67 hp/ha |

**Table 3.** Mechanization sources in rice cultivation.

| Power sources in mechanization | Pyuthan 07 (n=98) | | Bhimdutta 05 (n=87) | |
|---|---|---|---|---|
| | Used Frequency (%) | Ownership Frequency (%) | Used Frequency (%) | Ownership Frequency (%) |
| A. Electric power | | | | |
| 1. Electric water motor | 0 (0.00) | 55 (56.12) | 40 (45.98) | 76 (87.36) |
| 2. Pump set | 0 (0.00) | 0(0.00) | 60 (68.97) | 11 (12.64) |
| B. Tractor powered machinery | | | | |
| 1. Chisel plough | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| 2. MB plough | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| 3. Cultivator | 48 (48.97) | 3 (3.06) | 60 (68.97) | 6 (6.89) |
| 4. Disc harrow | 40 (40.82) | 3 (3.06) | 81 (93.10) | 6 (6.89) |
| 5. Rotavator | 42 (42.86) | 3 (3.06) | 82 (94.25) | 6 (6.89) |
| 6. Leveler | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| 7. Puddler | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| 8. Transplanter | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| 9. Combined harvester | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| 10. Thresher | 37 (37.76) | 3 (3.06) | 81 (93.10) | 6 (6.89) |
| C. Draft power | | | | |
| 1. Wooden plough | 50 (51.02) | 30(30.61%) | 8 (9.19) | 4 (4.59) |
| 2. Wooden leveler | 50 (51.02) | 30(30.61%) | 8 (9.19) | 4 (4.59) |
| 3. Threshing | 61 (62.24) | 30(30.61%) | 0 (0.00) | 0 (0.00) |

(Note: Figures in the parenthesis indicate the percentage).

**Table 4.** Determinants of mechanization in main field tillage and threshing in rice cultivation.

| Variables | Mechanization during main field tillage | Mechanization during threshing |
|---|---|---|
| Age | -0.0523** (0.0207) | -0.0609** (0.0264) |
| Family size | -0.400** (0.164) | -0.654** (0.183) |
| Education | -0.367 (0.314) | -0.970** (0.364) |
| Ethnicity | -0.275 (0.292) | -0.0641 (0.346) |
| Rice cultivated area | -1.137* (0.645) | 4.335** (1.076) |
| Land tenure status | 1.809** (0.569) | 0.737 (0.515) |
| Primary occupation | 0.257 (0.304) | 0.190 (0.329) |
| Annual income | 0.0594 (0.350) | -0.227 (0.448) |
| Gender | 0.949** (0.389) | 1.285** (0.404) |
| Extension access | -0.0635 (0.370) | -0.0243 (0.406) |
| Distance from market | 1.256** (0.219) | 1.346** (0.383) |
| Constant | 1.137 (1.186) | 2.001 (1.613) |
| Chi-square statistics | 123.96 | 143.67 |
| geprob> chi-square) | 0.0000 | 0.0000 |
| Pseudo-$R^2$ | 0.52 | 0.59 |
| *N* | 185 | 185 |

[Note: *, ** indicate 10% and 5% level of significance respectively].

**Table 5.** Description of the variables used in the Probit model.

| Variables | Type | Description | Value | Expected sign |
|---|---|---|---|---|
| Dependent variables | | | | |
| Mechanized main field tillage | Dummy | Farmers using tractor for main field tillage | 1 if farmer uses tractor for main field tillage and 0 otherwise | |
| Mechanized threshing | Dummy | Farmers using tractor-powered thresher | 1 if farmer uses thresher and 0 otherwise | |
| Independent variables | | | | |
| Age | Continuous | Age of household head in years | Number | +/- |
| Family size | Continuous | Number of family members | Number | +/- |
| Education | Dummy | Education of household head | 1 for secondary/above secondary education and 0 otherwise | + |
| Ethnicity | Dummy | Ethnicity of household head | 1 if ethnicity is Brahmin/Chhetri and 0 otherwise | +/- |
| Area of rice cultivation | Continuous | Area of rice cultivation in hectare | Number | + |
| Land tenure status | Dummy | Land tenure status for rice cultivation | 1 if cultivation is on own land and 0 otherwise | + |
| Primary occupation | Dummy | Primary occupation of household head | 1 of primary occupation is agriculture and 0 otherwise | + |
| Annual income | Dummy | Annual income of household head in NPR | 1 if annual income above NPR 300K and 0 otherwise | +/- |
| Gender | Dummy | Gender of household head | 1 for male and 0 for female | +/- |
| Extension access | Dummy | Excess to extension facilities related to rice cultivation | 1 if access and 0 otherwise | + |
| Distance from market | Continuous | Distance of house from market in KM | Number | +/- |

12.64% in Kanchanpur district. Aryal (2021) reported that 76% of households in Nepal used irrigation pumps with ownership of 21.8% which is slightly greater than the Kanchanpur district. Borings were set up in different places in Bhimdutta municipality and pump sets were used to extract water from the boring. But mechanized irrigation was completely lacking in Pyuthan municipality. This might be due to the lack of hand pumps in Pyuthan district and undulated topography. Fewtractor-powered machineries such as cultivators, disc harrows, rotavators, and threshers were reported in the study sites. All of these implements were in greater numbers in Kanchanpur district than in Pyuthan. About 68.97%, 93.10%, 94. 25% and 93.10% of households used a cultivator, disc harrow, rotavator, and thresher respectively. Only, 6.89% of households owned these implements in Kanchanpur. In the case of Pyuthan, 48.97%, 40.82%, 42.86%, and 37.76% of households were found to use cultivators, disc harrows, rotavators, and thresher respectively, and 3.06% households owned these implements. Other implements like chisel plough, MB plough, leveler, puddler, transplanter, and combined harvester were lacking in both sites. Khanal (2020) also reported that only 10.5% of households used heavy machinery in Palpa district of Nepal. The collapse of Nepal's first and only agricultural tool factory "Krishi Aujar Karkhana" over the past two decades might be one of the reasons for the poor availability and adoption of modern agricultural tools in Nepal (Bidari, 2022). According to FBC (2006), mechanical power is concentrated in the Terai region of the country with a share of 92.28% of the total available mechanical power. Draft power was more common in Pyuthan as compared to Kanchanpur. It may be due to undulated land topography, land fragmentation, and lack of road access to drive a tractor. Almost every household used draft power for seedbed preparation in Pyuthan.

About 51.02% of households were found to use draft-powered wooden plough and levelers, and 62.24% of households use the same power for threshing in Pyuthan. Households of 30.61% owned draft-powered implements in Pyuthan. Shrestha (2012) also revealed that hill agriculture is mainly dependent upon human and animal power. Only 9.19% of households used draft-powered implements for ploughing, and 4.59% owned such implements in Kanchanpur. Shrestha (2012) reported 51% used animal-drawn iron plough in the Terai region. But this figure is far less in our finding because of the increased use of mechanical power in the Terai region within a decade. Threshing by using draft power was not reported in Kanchanpur district. The possible reasons behind this might be a significant decrease in the households rearing bulls for draft purposes, and also the introduction of tractor-driven threshers in the Terai region.

## Challenges in farm mechanization in rice production

There were lots of challenges in the adoption of farm mechanization in rice production. Some of the challenges were presented in Figure 2. The unavailability of farm machinery was the major challenge followed by land fragmentation and lack of knowledge on farm mechanization. In the case of Pyuthan, lack of knowledge on farm mechanization was the major challenge. Agriculture Mechanization Promotion Policy, 2014 has also identified limited knowledge of farmers, land fragmentation, and geographic difficulties as the key challenges for agriculture mechanization (MoAD, 2014). The average area of land per household is only about one hectare in Asia which hinders efficient farm mechanization (UNESCAP, 2020). Most of the farmers were found to practice traditional agriculture in Pyuthan. Most of them used bulls for tillage and threshing. Tractor-powered tillage implements were available in Pyuthan, nevertheless, draft power was common as most of the household reared bulls. Lack of investment in farm machinery due to poor economic status was also an important challenge for mechanization in rice cultivation. Therefore, agriculture policies should focus on such farmers while improving access to farm machinery (Aryal, 2021).

## Determinants of farm mechanization in rice cultivation

Age and family size have a negative and significant impact on both mechanized main field tillage and threshing at a 5% level of significance. Education has a negative and significant impact on mechanized threshing at a 5% level of significance (Table 4 and 5). These findings are in consistence with the findings of GC *et al.* (2019). The area of rice cultivation has positive and statistically significant at a 5% level on mechanized threshing while negative impact on mechanized tillage at a 10% level of significance. This negative relation is due to the use of draft power for main field tillage in a relatively larger area in Pyuthan district. Farmers cultivated on their land have a positive and significant impact on mechanized threshing at a 5% significance level. Households having a male as a head have a positive and statistically significant impact on both mechanized tillage and threshing at a 5% significance level. Aryal (2021) also reported male headship having access to extension services related to farm mechanization, positively influenced farm mechanization. Distance from the market has also a positive and significant impact on mechanized tillage and threshing at a 5% level. GC *et al.* (2019) also reported a positive relationship between land tenure status and distance from the market with mechanized cultivation.

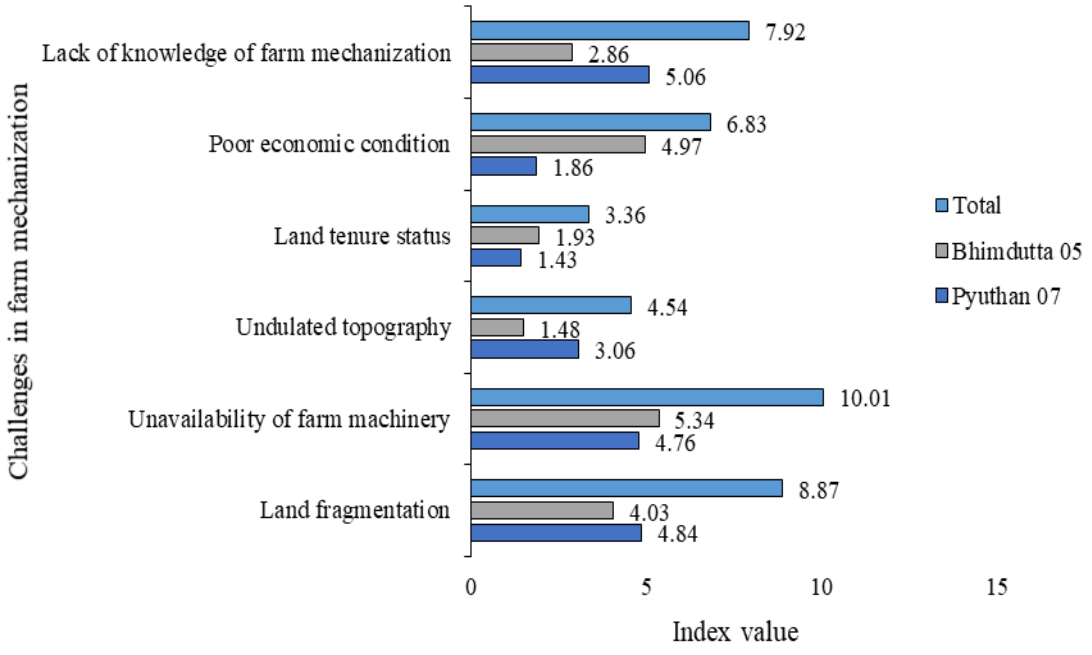


**Figure 2.** *Challenges in farm mechanization in rice production in the study area.*

## Conclusion

To sum it up, most of the households, mainly in the Pyuthan district, are still dependent on draft power for rice cultivation. Their farming method is labour intensive which might increase the cost of production. Tractor-powered implements are limited in the Terai region. Power tiller has become common in the hilly region as it performs well in small areas and undulated topography. Most of the intercultural operations in rice cultivation like bund preparation, transplantation, fertilizer application, weeding, and harvesting lack mechanization. Power per unit area is insufficient for satisfactory mechanized cultivation. Modern tractor-powered implements are not available in the study area. The ownership of farm machinery is very low which might be due to the poor economic condition of the farmers. Land fragmentation and the unavailability of farm implements hinder mechanization in rice cultivation. One of the major challenges to poor adoption of farm mechanization is the lack of knowledge on it. Thus, the dissemination of extension services on mechanized rice cultivation could help in the improvement of mechanization status. They cannot afford expensive farm implements. Therefore, the provision of subsidies for required farm machinery could help in the wide adoption of mechanization in rice production.

## Conflict of interest

All the authors declare that there is no conflict of interest regarding the manuscript.

## Authors contribution

Sagar Bhandari: Conception and design, analysis, interpretation, drafting the manuscript and critically revising it, Aditya Khanal: data analysis and critical review, Pankaj raj Dhital: critical review, Sanat K.C. and Ramita Badu; data collection and drafting the manuscript, Sarita Bhandari: drafting the manuscript and critical review.

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## Data availability statement

The data related to this research can be available publicly at https://doi.org/10.6084/m9.figshare.20073614.

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