**Profitability and Resource Use Efficiency of Rice Production in Chitwan district, Nepal**

**Abstract**

Rice is a primary staple food of Nepalese people. The study aims to investigate the profitability scenario of rice farming along with resource use pattern of farmers within the study area. Multistage sampling technique was employed to obtain the sample for the study. The primary data was obtained from 150 randomly selected respondents using the semi structured questionnaire. Data were analyzed using both the descriptive and inferential statistics. We employed the Cobb Douglas production function model to analyze the resource use efficiency. The positive gross margin (NRs. 39,693.66) and benefit-cost ratio (1.26) showed that rice production was a profitable enterprise, with average productivity of 4.65 mt/ha. The return to scale was found 0.563, which signifies that the production function exhibits diminishing returns to scale. The analysis of resource use efficiency indicated that inputs in rice production were not optimally utilized. Inputs such as seeds and chemical fertilizers were underutilized, whereas machine labor, human labor, organic manure, and pesticides cum irrigation were overutilized. To attain optimal resource allocation, it is imperative to reduce the costs of inputs such as machine labor, human labor, organic manure, and pesticide cum irrigation by 19.267%, 186.995%, 15.818%, and 4.193%, respectively, while the costs of seed and chemical fertilizer need to be increased by 51.476% and 22.915%, respectively. The results obtained from the study can significantly enhance the profitability and optimize the level of resource use in rice production by providing a crucial policy framework that can strengthen the level of domestic rice production. It necessitates the requirement of further research on analyzing the limiting factors that precludes the efficient resource use.

**Keyword:** Productivity, Profitability, Rice, Resource use efficiency, Cobb Douglas

# Introduction

Rice is considered as one of the staple food crops in Nepal, which covers the major portion of cultivated area. However, the low productivity has necessitated the annual import of rice which amounts to nearly USD 300 million (Choudhary *et al.*, 2022). In Nepal, rice is cultivated across three distinct agro-ecological zones: Terai, mid-hills, and high hills, which contributes about 68%, 28%, and 4% to total production, respectively (MoALD, 2020). The yearly per capita consumption of rice was found 138 kg among Nepalese, comprising 52% of total cereal consumption as well as contributes about 16% to agricultural GDP (Yadav and Chaudhary, 2017). Rice is cultivated in an area of 1,477,378 hectares, obtaining a total production of 5,130,625 metric tons, which corresponds to an average productivity of 3.47 metric tons per hectare (MoALD, 2023).

Agricultural production is significantly dependent on the scarce resources, mainly the water and arable land for cultivation, which are essential for food security (Siddique, 2015). The lack of information particularly on profitability and adjustment required in use of inputs to achieve the optimum resource use constraints the capacity of farmer to allocate the resources more judiciously to achieve the optimum production (Thapa *et al.*, 2024). For the sustainable agricultural production, rational use of these constrained resources is important. It is vital to effectively utilize the limited resources and adopt the appropriate technologies to improve farm productivity, which fosters sustainable agricultural practices (Udoh, 2005). For enhancing the agricultural production and profitability level, expansion of the cultivated area is not only the sole approach. It is possible to enhance production as well as profitability by utilizing the resources efficiently, which assists to achieve the optimum production level, thereby improving productivity. However, the irrational use of resources had decreased agricultural production, which ultimately lead to an unavailability of food and poses a significant threat to food security (Etim *et al.*, 2005). Improvement in productivity can be achieved either through technological advancements or by increasing efficiency during production (Tiwari and Dhungana, 2023). Nepalese farmers lack knowledge concerning the economic use of resources (Dhakal *et al.*, 2015). The concept of efficient resource use is very important for improving agricultural production, especially for resource constrained farmers in developing nations (Goni *et al.*, 2013). Optimum resource utilization can assist in fulfilling the rising demand of rice due to population growth by increasing the production and productivity level (Osti *et al.*, 2017).

Farmers who are involved in production process aim to maximize profit and minimize the cost by utilizing the resources efficiently. Irrational use of the resources leads to wastage of time, money, and labor, while also reduces productivity and profitability in agriculture (Subedi *et al.*, 2020). Multiple studies had assessed the resource use pattern across several crop in different geographical regions across Nepal. Subedi *et al.* (2020) examined the profitability and resource use efficiency of rice production in the Jhapa district. Dhakal *et al.* (2019) assessed costs and benefits, as well as the resource use patterns in rice production across various landscapes in the Chitwan district. Sapkota *et al.* (2018) examined how efficiently are resource utilized in maize production in the Palpa district, whereas Dhakal *et al.* (2015) assessed resource use efficiency in mustard production in Chitwan. Similarly, Sapkota and Bajracharya (2018) examined resource use efficiency in potato cultivation in Nepal. All these studies analyzed the resource use pattern in production process, which is important to increase production, productivity, and profitability. As rice being major staple crop of Nepalese people, and Chitwan district recognized as the food basket of Nepal (MoAD, 2016), it is important to evaluate the current resource use pattern in rice cultivation as well as assess the profitability scenario of rice enterprise in Chitwan. Considering the paucity of research on the profitability and resource use pattern of rice farmers within Chitwan district, to draw out reliable conclusion, this study aims to investigate the profitability of rice production and examine the resource use efficiency of rice production in current state, which is essential to increase production and productivity.

# Materials and methods

## Study area

The Chitwan district, situated in the Terai region of Nepal, was selected purposefully for study due to its socioeconomic and environmental characteristics. It is positioned between latitudes 27°21’45” to 27°52’30” North and longitudes 83°54’45” to 84°48’15” East. According to Kansakar and Amatya (1993), the elevation in Chitwan increases to 880 m near the Indian border, with a range of approximately 1876 m in the north and 141 m in the central region. The district has a fertile soil with a conducive climate suitable to cultivate diverse agricultural crops. It has subtropical climate, which is characterized by hot summers and cool winters. The average minimum and maximum temperature of the district was recorded 30.8 and 16.7 degrees, respectively, while the average annual precipitation was 2,666 mm (Paudel *et al.*, 2014).

The district consists of seven local administrative divisions: one metropolitan (Bharatpur Metropolitan City), five urban municipalities (Kalika Municipality, Khairahani Municipality, Madi Municipality, Ratnanagar Municipality, Rapti Municipality), and one rural municipality (Ichchhyakamana Rural Municipality). The selected primary rice-producing regions include the Parbatipur region of Bharatpur Metropolitan, Kalika wards 6 and 2 from Kalika Municipality, the Kathar and Kumroj regions from Khairahani Municipality, the Gadhyauli region from Rapti Municipality, and the Bachhauli region from Ratnanagar Municipality. This selection was made purposefully in consultation with officials from the Agriculture Knowledge Center, Chitwan. The majority of the selected regions were designated as rice zones by the Project Implementation Unit (PIU) of the Prime Minister Agricultural Modernization Project (PMAMP), Chitwan. The map of the study location is presented in Fig.1.

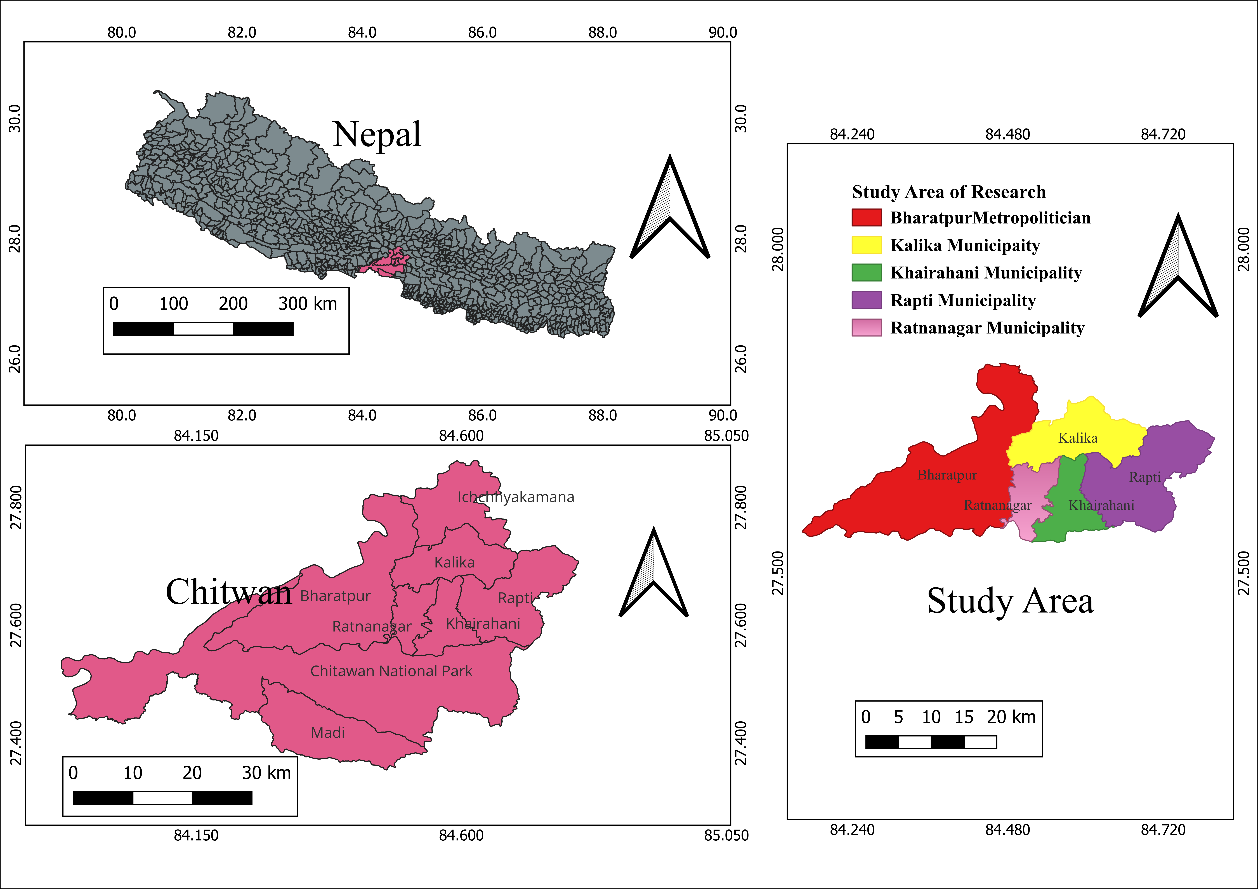


Fig . Map showing the study area

## Sample size and Sampling techniques

This study employed a multistage sampling method. The district was purposefully selected in the initial stage due to its socio-economic and environmental significance. In the second stage, significant rice-producing regions within the districts were identified and purposefully selected with the assistance of officials from the Agriculture Knowledge Centre in Chitwan. At the final stage, we employed the simple random sampling technique to select the respondents from sampling frame, which was prepared in collaboration with agriculture section of each local administrative government. The sampling frame was composed of 1500 respondents from the selected regions within the district. We used the Raosoft software for calculation of sample size, which is considered scientific and standardized tool (Raosoft, 2004). Using confidence interval of 95% and error margin of 8%, the software recommended minimum sample size of 137 for the study. However, we obtained the sample of 150 respondents through simple random sampling technique, which represented 10% of sampling frame population. The sample size from each local level was selected in proportion with the number of respondents included in the sampling frame from the chosen areas of each local administrative regions (Table 1).

Table 1: Determination of sample size in the study

|  |  |  |
| --- | --- | --- |
| Municipality | Sampling frame (N) | Sample size (n) |
| Bharatpur Metropolitan | 323 | 32 |
| Kalika Municipality | 240 | 24 |
| Khairahani Municipality | 315 | 32 |
| Rapti Municipality | 313 | 31 |
| Ratnanagar Municipality | 309 | 31 |
| Total | 1500 | 150 |

## Data collection and analysis

A semi structured questionnaire was created and pretested to assess its efficacy in gathering essential information in accordance with our research objectives. The pretesting occurred before the field survey, involving five farmers from each local level (metropolitan/municipality). Following the evaluation of the developed questionnaire's limitations, corrective measures were implemented. Following the validation of the prepared questionnaire, a field survey was executed. The research employed both primary and secondary data. Primary data were gathered through field surveys, Key Informant Interviews (KII), and direct observations, while secondary data were sourced from government publications, journals, and books. The data which was obtained from field survey was refined and prepared for analysis. We utilized both the descriptive and inferential statistical approach for analysis, which assists in thorough interpretation of the findings. The refinement of data was performed using Microsoft Excel, while Stata version 14.2 was employed for data coding and statistical analysis.

### Estimation of the cost and benefit in rice production

This section examines the advantages and disadvantages of an investment, assessing its value. It assesses whether the benefits derived from the investment justify the associated costs, thereby providing a foundation for informed decision-making. The total cost of production includes both the fixed and variable costs. We used only the variable cost to calculate the total cost involved in rice production. The total costs incurred during production of rice was calculated as:

C total cost of rice production = C machine labor + C human labor + C organic manure + C seed + C chemical fertilizer + C pesticides cum irrigation

The gross return from rice production includes the return which is obtained by selling the rice grain and rice byproduct i.e., straw. The gross return from rice production was calculated as:

Gross return = (Price of rice grain x Quantity of rice grain + Price of rice straw x Quantity of rice straw)

Gross margin was calculated using the formula below:

Gross margin (NRs/ha) = Gross return (NRs/ha) - Total variable cost (NRs/ha)

The undiscounted benefit-cost ratio was calculated as:

Undiscounted Benefit-cost ratio = Gross return / Total variable cost

### Estimation of the resource use efficiency in rice production

We utilized the Cobb-Douglas production function (CDPF) model for estimating resource use efficiency. The CDPF model offers superior estimations of the marginal value product (MVP), which is essential for analyzing the optimal, overuse, and underuse of constrained resources in production (Gujarati, 2009). To estimate resource use efficiency, the CDPF model was specified in the following manner:

Y= αX1b1 X2b2 X3b3 X4b4 X5b5X6b6eu

Where, Y = Gross return obtained from production of rice (NRs/ha)

X1= Machine labor cost (NRs/ha)

X2= Human labor cost (NRs/ha)

X3= Organic manure (NRs/ha)

X4= Seed cost (NRs/ha)

X5= Chemical fertilizer cost

X6= Pesticide cum irrigation cost (NRs/ha)

α = Constant term

u = Random error term

e = base of natural logarithm

b1, b2, b3, b4, b5, and b6 denote the coefficients derived from the regression analysis. We used the logarithmic transformation for both dependent and independent variables to transform the non-linear model to linear model for easy computation of CDPF model. The aforementioned equation after the logarithmic transformation can be presented as follow:

log Y = α + b1logX1 + b2logX2 + b3logX3 + b4logX4 + b5logX5 + b6logX6

The following formulae was used to estimate the efficiency ratio to assess how well the inputs were utilized in rice production.

In the equation above, r denotes the efficiency ratio. It is the ratio of marginal value product (MVP) to marginal factor cost (MFC). MVP is the additional value obtained form an additional unit of inputs in production due to increase in output. MFC refers to the additional costs incurred by farmer due to acquisition of an additional units of inputs. The value of MFC was fixed to one as both the dependent variable and independent variables are converted into monetary value. Equating the MFC value to one facilitates the easy computation of efficiency ratio, which enhances the consistency and comparability in analysis. The MVP can be calculated by using the formula mentioned below:

In the equations presented above, bi denotes the regression coefficient of the input variable Xi derived from the estimation of the production function model, Yi hat represents the geometric mean value of the gross return from rice production, and Xi hat signifies the geometric mean of the ith input utilized in rice production. Decision rule is based on the following criteria:

* r = 1, Resource is efficiently utilized
* r > 1, Resource is underutilized
* r < 1, Resource is overutilized

Ultimately, the estimation of the relative percentage change in the marginal value product (MVP) for each resource utilized in production was assessed to determine the optimal resource allocation, where r = 1 or MVP = MFC, employing the formula presented below.

D = (1 – MFC/MVP) x 100

Or, D = (1- 1/r) x 100

In the formula presented above, D denotes the absolute value of the percentage change in MVP for each resource/input (Mijindadi, 1981). Economic optima are attained when marginal value product equals marginal factor cost or when the r equals one. If r ≠ 1, it indicates that resources are not being utilized efficiently; thus, adjustments in the quantity of inputs and production costs are necessary to achieve r = 1.

# Results and Discussion

## Cost and Benefit analysis in rice production

### Cost incurred in rice production

The total variable cost involved in production of rice was calculated NRs. 153,334.98 per hectare. The study showed that the highest share on the total variables cost was accounted by human labor i.e., 40.46%, which is followed by machine labor (24.07%), organic manure (15.24%), pesticides cum irrigation (7.98%), seed (7.42%), and chemical fertilizer (4.83%) (Table 2). Poudel *et al.* (2021) found that the total cost of rice production was NRs. 154,886 per hectare in Gorkha district of Nepal, while the study by Paudel *et al.* (2021) found the total cost amounting NRs. 119,683.8 per hectare in Gorkha, with the major share accounted by human labor, i.e., 75.1%. Yadav *et al.* (2021) found that the total cost of rice production was NRs. 108,214.78 per hectare in Rautahat, Nepal. They reported that the human labor constitutes 52.5% of total variable cost. Human labor cost accounted for 50.57% of total cost, with the total cost amounted to NRS 75,139.84 per hectare in rice production (Dhakal *et al.*, 2019). A study by Sapkota (2019) reported that human labor costs constituted about 46.69% of the total variable cost in rice production. The average production cost in rice production shows an increasing trend, which could be attributed to increased wage rates for human labor (Bhandari *et al.*, 2015) and rising prices for fertilizers and machinery (Sapkota, 2019). One of the effective strategies to reduce the production expenses is by replacing the human labor through mechanization process (Poudel *et al.*, 2021). The decreased share of human labor to total variable cost reported in our findings may indicate the increasing trend toward mechanization. During the study, we observed the farmers preference in adopting several machines such as mechanical threshers and reapers for threshing and harvesting purposes over traditional practices of using human labor for threshing and harvesting.

Table 2: Average variable cost of rice production in the study area

|  |  |  |
| --- | --- | --- |
| Description | Cost per hectare | Percentage |
| Machine labor | 36,914.65 (10,226.04) | 24.07 |
| Human labor | 62,038.38 (9,350.16) | 40.46 |
| Organic manure | 23,362.40 (7,122.64) | 15.24 |
| Seed | 11,370.28 (7,471.86) | 7.42 |
| Pesticides cum Irrigation | 12,235.95 (6,269.03) | 7.98 |
| Chemical fertilizer | 7,413.32 (3,085.425) | 4.83 |
| Total | 153,334.98 (21772.31) | 100.00 |

Note: Figure in parentheses indicate standard deviation

### Gross return in rice production

The gross return from rice cultivation was NRs. 193,028.64 per hectare. The average return from the sale of rice grain was NRs. 142,985.98 per hectare, whereas the average return from the sale of rice byproduct was NRs. 50,042.64 per hectare. The proportion of return from rice grain and straw to the total gross return was 74.08% and 25.92%, respectively (Table 3). Poudel *et al.* (2021) found an average gross return of NRs. 182,612 per hectare in rice production, with the sales from rice grain amounting to NRs. 123,906 per hectare and rice straw amounting to NRs. 58,705 per hectare. This indicates that rice grain and straw contribute 67.85% and 32.15% of the average gross return, respectively. Bhusal *et al.* (2020) found that rice grain and straw account for approximately 72.65% and 27.35%, respectively, of a gross return of NRs. 143049.45 per hectare. Basnet *et al.* (2022) found that farmers obtained the return of NRs. 102,758.52 and NRs. 8,412.71 per hectare by selling rice grain and rice straw, respectively, totaling the gross return amounting to NRs. 111,171.23 per hectare. Paudel *et al.* (2021) reported that the return from rice production was NRs. 152,212 per hectare, which comprises sales from rice grain of about NRs. 121,073.8 per hectare and sales from rice straw of about NRs. 31,138.2 per hectare, i.e., 79.5% and 20.5% of total return, respectively.

Table 3: Average gross return from rice production in the study area

|  |  |  |
| --- | --- | --- |
| Items | Average gross return (NRs/ha) | Percentage of total gross return |
| Rice Grain | 142,985.98 (20081.62) | 74.08 |
| Rice Straw | 50,042.64 (21052.92) | 25.92 |
| Total | 193,028.64 (30031.06) | 100.00 |

Note: Figure in the parentheses indicate standard deviation

### Profitability in rice production

The gross margin was found NRs. 39,693.66 per hectare, with positive undiscounted benefit-cost ratio i.e., 1.26 (Table 4). The findings indicated that the rice production is profitable. The benefit-cost ratio indicates that an investment of one rupee is expected to generate a return of 1.26. Aligning with our findings, Poudel *et al.* (2021) reported a gross margin of NRs. 27,725 per hectare and a benefit-cost ratio of 1.17. Yadav *et al.* (2021) found a gross margin of NRs. 12,012.5 per hectare and a benefit-cost ratio of 1.11. Positive gross margin of NRs. 17,594, with benefit-cost ratio of 1.20 was reported in the study by Acharya *et al.* (2021). Subedi *et al.* (2020) reported a gross margin of NRs. 53,531 per hectare and a benefit-cost ratio of 2.05. Dhakal et al. (2019) reported a gross margin of NRs. 41,435 per hectare and benefit-cost ratio of 1.43. All these findings from several studies points out that rice production is profitable business.

Table 4: Metrics of rice production in the study area

|  |  |
| --- | --- |
| Metrics | Average |
| Total variable cost | 153,334.98 (21,772.31) |
| Total return | 193,028.64 (30,031.06) |
| Gross margin | 39,693.66 (19,093.15) |
| Benefit cost ratio | 1.26 (0.13) |
| Average Productivity | 4.65 mt/ha (0.726) |

Note: Figure in the parentheses indicate standard deviation

### Estimation of resource use efficiency (RUE) in rice production

Resource use efficiency refers to the yield obtained per unit of resources employed under the specified soil and climatic condition (Gautam *et al.*, 2022). Main inputs employed in the production of rice includes machines, human labor, seeds, organic manure, chemical fertilizers, pesticides, and irrigation. We used the CDPF modelling to assess how well the resources were utilized. The result obtained from CDPF model are presented in Table 5. The model showed the good explanatory power, which is evidenced by highly significant F-value of 55.286 at 1% level. It inferred that the independent variables incorporated in the models collectively explained the variation in output.

The r-squared value was calculated 0.699, which indicates that 69.9% of the variation in the gross return obtained from rice production was accounted by the independent variables. The average value of Variance Inflation Factor (VIF) was calculated 1.18, which suggests the absence of multicollinearity among the independent variables. If the multicollinearity exists, it makes the result spurious, altering the interpretation. We employed the Breusch-Pagan test to assess the homoskedasticity of error term. The presence of heteroskedasticity in regression model violates the assumption of classical linear regression assumption, and raises questions on validity of model and econometric analysis. The test reported a chi-square value of 0.73, with a p-value greater than 5% significance level i.e., 0.391, which indicates the failure to reject the null hypothesis of constant variance or homoskedasticity. For testing the normality of the residuals obtained from regression analysis, we employed the Shapiro Wilk test. The test reported a p-value greater than the 5% significance level, i.e., 0.329. The result indicated that the residuals are normally distributed. We also conducted an Ovtest to assess the model specification or omitted variable bias. The p-value of the Ovtest was found 0.08, which was higher than the significance level of 0.05. The null hypothesis of Ovtest could not be rejected, which indicates that the model does no have omitted variables or it is correctly specified. All the prior tests which were conducted confirmed our assumptions for ordinary least square regression. The result showed that machine labor, organic manure, seed, and pesticides cum irrigation were statistically significant at 1%, while the human labor and chemical fertilizers were statistically significant at 5% level. The regression coefficients for machine labor, human labor, organic manure, seed, pesticide cum irrigation, and chemical fertilizers are 0.156, 0.112, 0.101, 0.093, 0.055, and 0.046, respectively. This indicates that a 10% increase in the costs of machine labor, human labor, organic manure, seed, pesticide cum irrigation, and chemical fertilizer, while holding all other variables constant, results in an increase in gross return by 1.56%, 1.12%, 1.01%, 0.93%, 0.55%, and 0.46%, respectively. Poudel *et al.* (2021) reported that a 10% increase in seed, labor, and nutrient costs, while holding other variables constant, increased the return by 2.79%, 2.19%, and 0.62%, respectively. Yadav *et al.* (2021) found that a 100% increase in the costs of tillage and irrigation resulted increase in return by 17.6% and 21.9%, respectively. Subedi *et al.* (2020) found that a 10% increase in human labor, fertilizer costs, and irrigation cum pesticides resulted increase in return by 2%, 3%, and 1.6%, respectively, in rice production. Dhakal *et al.* (2019) also reported that a 100% increase in the cost of machinery and human labor resulted in a rise of 34.8% in income.

Return to scale is calculated by summing up all the coefficients of independent variables which are obtained from the regression analysis. The return to scale was found 0.563, which indicated a decreasing return to scale. This suggested that a 100% increase in all inputs results in increment in gross return by 56.3%. Our findings concur with the findings from Poudel *et al.* (2021), Subedi *et al* (2020), Acharya *et al.* (2020), and Dhakal *et al.* (2019), who also reported diminishing return to scale in rice production. Bam *et al.* (2015) reported decreasing return to scale in wheat production in Kailali, Nepal. Wosor and Nimoh (2012) and Rabbani *et al.* (2013) also found diminishing return to scale in cultivated crops such as chilly and mustard.

Table 5: Estimated value of coefficients and related statistics of Cobb-Douglas production function

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Return | Coefficient | | Std.Err | t-value | p-value | 95% confidence interval | | | Sig |
| Machine labor | 0.156 | | 0.028 | 5.51 | 0.000 | 0.1 | | 0.212 | \*\*\* |
| Human labor | 0.112 | | 0.047 | 2.38 | 0.019 | 0.019 | | 0.204 | \*\* |
| Organic manure | 0.101 | | 0.025 | 5.65 | 0.000 | 0.012 | | 0.19 | \*\*\* |
| Seed | 0.093 | | 0.01 | 9.01 | 0.000 | 0.072 | | 0.113 | \*\*\* |
| Pesticide cum irrigation | 0.055 | | 0.017 | 3.20 | 0.002 | 0.021 | | 0.008 | \*\*\* |
| Chemical fertilizer | 0.046 | | 0.018 | 2.58 | 0.011 | 0.011 | | 0.082 | \*\* |
| Constant | 6.215 | | 0.631 | 9.71 | 0.000 | 4.878 | | 7.372 | \*\*\* |
| Mean dependent variable | | | | 12.158 | SD dependent variable | | | | 0.162 |
| R-squared | | | | 0.699 | Number of observations | | | | 150 |
| F-test | | | | 55.286 | Prob > F | | | | 0.000 |
| Akaike crit. (AIC) | | | | -286.558 | Bayesian crit. (BIC) | | | | 265.484 |
| Variance Inflation Factor (VIF) | | | | 1.17 | Shapiro Wilk test | | | | Prob>z =  0.3291 |
| Breusch Pagan Test | | chi2(1) = 0.73, Prob >Chi2 = 0.3914 | | | Ovtest | | F (3,40) = 2.30,  Prob>F = 0.0804 | | |

Note: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

We calculated the marginal value product (MVP) and efficiency ratios of several inputs which are employed in rice production. The findings revealed inefficient use of the resources (Table 6). The efficiency ratio of seed and chemical fertilizer was found greater that one, which implied that these inputs were underutilized. However, the efficiency ratio of inputs such as machine labor, human labor, organic manure, and pesticide cum irrigation were less than one, which indicates that these inputs were overutilized. There is necessity to make an adjustment in an input usage, where the uses of certain inputs were needed to be increased while some are required to decrease for obtaining the optimal allocation. Our findings revealed that machine labor, human labor, organic manure, and pesticides cum irrigation should be reduced by 19.267%, 186.995%, 15.818%, and 4.193%, respectively, while the use of seed and chemical fertilizers should be increased by 51.476% and 22.915%, respectively, to achieve optimal resource allocation.

Subedi *et al.* (2020) found the underutilization of inputs like seed, inorganic fertilizers, and irrigation cum pesticides, while they reported the overutilization of human labor and tractor power in the cultivation of rice. Dhakal *et al.* (2019) conducted a study to analyze the resource use efficiency in rice cultivation, where, they found the underutilization of resources such as seed, fertilizer, machinery and bullocks, and transportation, while the inputs such as farm-yard manure, labor, and pesticides were found overutilized. Sapkota *et al.* (2018) reported the excessive use of farm-yard manure, human labor, and tractor power, whereas they reported the underuse of seed and fertilizer in maize seed production. Dhakal *et al.* (2015) found the underutilization of resources like seed, fertilizer, and irrigation cum insecticides, while they reported overutilization of tractor power and human labor in cultivation of mustard. Khanal *et al.* (2020) reported the overuse of human labor in maize production.

Table 6: Estimation of resource use efficiency of rice production in the study area

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Variables | Coefficient | Geometric mean | MVP | MFC | r | Efficiency | D = (1-1/r) |
| Machine labor | 0.156 | 35,461.813 | 0.838 | 1 | 0.838 | Overused | -19.267 |
| Human labor | 0.112 | 61,264.546 | 0.348 | 1 | 0.348 | Overused | -186.995 |
| Organic manure | 0.141 | 22295.492 | 0.863 | 1 | 0.863 | Overused | -15.818 |
| Seed | 0.093 | 8,601.177 | 2.061 | 1 | 2.061 | Underused | 51.476 |
| Pesticide cum irrigation | 0.055 | 10,922.434 | 0.960 | 1 | 0.960 | Overused | -4.193 |
| Chemical fertilizer | 0.046 | 6,758.420 | 1.297 | 1 | 1.297 | Underused | 22.915 |
| Gross return |  | 190,597.204 |  |  |  |  |  |

# Conclusion

Efficiency involves maximizing the outcomes from efforts. By utilizing the scarce resources more efficiently, farmers could enhance their incomes and savings, thereby improving their profitability. Optimizing agricultural practices hinges on the critical concept of resource use efficiency. The study evaluates the profitability of rice enterprises along with the efficiency of resource utilization in rice cultivation within the study area. The investigation accessed the way in which farmers can optimize their resource usage by pinpointing underutilized and overutilized resources. The positive gross margin and benefit cost ratio suggest that rice production is economically viable in the study area. The analysis of resource use efficiency indicated that inputs employed in rice cultivation were not utilized to their fullest potential. There was a notable underutilization of resources like seeds and chemical fertilizers, whereas resources such as machine labor, human labor, organic manure, and pesticides and irrigation were excessively utilized. The findings necessitate optimal resource allocation, leading to enhanced production and profitability, thereby improving a farmer’s livelihood. Therefore, achieving the rational use of resources would enhance the economic viability of the rice enterprise, leading to greater profitability and improved food availability.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

# References

Acharyaa, P., Regmi, P. P., Gauchan, D., KC, D., & KC, G. (2021). Comparative analysis of cost, return, profitability and labor use in mechanized and traditional rice farms in Nepal. *Food & Agribusiness Management (FABM)*, 2(1), 17-22.

<http://dx.doi.org/10.26480/fabm.01.2021.17.22>

Acharya, P., Regmi, P. P., Gauchan, D., Bahadur, D., & Bahadur, G. (2020). Comparative study on technical efficiency of mechanized and traditional rice farm in Nepal. *Journal of Agriculture and Natural Resources*, 3(2), 82-91.

<https://doi.org/10.3126/janr.v3i2.32484>

Bam, R., Mahara, G., Khanal, K., Kattel, R., & Bhattarai, S. (2023). Analysis of Resource Use Efficiency and Profitability of Wheat Production in Kailali District, Nepal. *Agro-Biodiversity for Life and Environment, 24*, 11-21.

<https://doi.org/10.3126/aej.v24i01.57885>

Basnet, B., Luitel, G., Sah, A., Baral, S., & Ghimire, M. (2022). Analysis of profitability and effect of factors of production in paddy cultivation in Morang, Nepal. *Archives of Agriculture and Environmental Science*, *7*(3), 425-431.

<https://doi.org/10.26832/24566632.2022.0703017>

Bhandari, N. B., Bhattarai, D., & Aryal, M. (2015). Cost, Production and Price Spread of Cereals Crops in Nepal: A time series analysis.

[www.mrsmp.gov.np](http://www.mrsmp.gov.np)

Bhusal, S., Karn, R., Jha, R. K., & Ojha, A. (2020). Economics of rice production in Pyuthan district of Nepal. *Journal of Agriculture and Natural Resources*, *3*(1), 88-94.

<https://doi.org/10.3126/janr.v3i1.27099>

Choudhary, D., Banskota, K., Khanal, N. P., McDonald, A. J., Krupnik, T. J., & Erenstein, O. (2022). Rice subsector development and farmer efficiency in Nepal: implications for further transformation and food security. *Frontiers in Sustainable Food Systems*, *5*, 740546.

<https://doi.org/10.3389/fsufs.2021.740546>

Dhakal, R., Bhandari, S., Joshi, B., Aryal, A., Kattel, R. R., & Dhakal, S. C. (2019). Cost-benefit analysis and resource use efficiency of rice production system in different agriculture landscapes in Chitwan district, Nepal. *Archives of Agriculture and Environmental Science*, *4*(4), 442-448.

<https://doi.org/10.26832/24566632.2019.0404011>

Dhakal, R., Bhandari, S., Joshi, B., Aryal, A., Kattel, R. R., & Dhakal, S. C. (2019). Cost-benefit analysis and resource use efficiency of rice production system in different agriculture landscapes in Chitwan district, Nepal. *Archives of Agriculture and Environmental Science*, *4*(4), 442-448.

<http://dx.doi.org/10.26832/24566632.2019.0404011>

Dhakal, S. C., Regmi, P. P., Thapa, R. B., Sah, S. K., & Khatri-Chhetri, D. B. (2015). Resource use efficiency of mustard production in Chitwan district of Nepal. I*nternational Journal of Applied Sciences and Biotechnology, 3*(4), 604-608.

<https://doi.org/10.3126/ijasbt.v3i4.13525>

Etim, N.A. E.J. Udoh and T.T. Awoyemi, (2005). Measuring Technical efficiency of urban farms in Uyo Metropolis. Global Journal of Agricultural Science, 4: 19-95. <https://doi.org/10.4314/gjass.v4i1.2248>

Gautam, D., Dhakal, S. C., Kattel, R. R., & Khanal, N. P. (2022). Resource use efficiency (RUE) in lentil production in Terai and inner Terai regions of Nepal. *Journal of Nepal Agricultural Research Council, 8*, 72-87.

<https://doi.org/10.3126/jnarc.v8i.44865>

Goni, M., Umar, A. S. S., & Usman, S. (2013). Analysis of resource-use efficiency in dry season vegetable production in Jere, Borno State, Nigeria. *Journal of Biology, Agriculture and Healthcare*, *3*(19), 18-23.

Gujarati, D., Porter, D. C., & Gunasekar, S. (2009). Basic econometrics. Tata McGraw-Hill Education.

Kansakar, D. R., & Amatya, S. C. (1993). *Shallow Groundwater Resources of the Terai, Chitwan District, Central Development Region, Nepal* (No. 29). NEP/86/025, Technical Report.

Khanal, K., Adhikari, K. B., Dhakal, S. C., & Marahatta, S. (2020). Resource use efficiency of maize production with and without irrigation system in Kaski, Nepal. Journal of Agriculture and Natural Resources, 3(2), 287-295.

<https://doi.org/10.3126/janr.v3i2.32524>

Mijindadi, N. B. (1981). Production efficiency on farms in northern Nigeria.

MoAD. (2016). Food and Nutritional Security in Nepal. Ministry of Agricultural Development, Department of Agriculture, Hariharbhawan, Lalitpur.

MoALD, (2020). Statistical Information of Nepalese Agriculture. Ministry of Agriculture and Livestock Development, Kathmandu, Nepal.

MoALD, (2023). Statistical Information of Nepalese Agriculture. Ministry of Agriculture and Livestock Development, Kathmandu, Nepal.

Olukosi, J. O., Isitor, S. U., & Ode, M. O. (2006). Introduction to agricultural marketing and prices: Principles and applications living Books Serves.

Osti, R., Riwan, M., Assefa, A. K., Zhou, D., & Dinesh, B. (2017). Analysis of resource-use efficiency in monsoon and spring rice production in Nepal. *Pakistan Journal of Nutrition*, *16*, 314-32.

<http://dx.doi.org/10.3923/pjn.2017.314.321>

Paudel, B., Acharya, B. S., Ghimire, R., Dahal, K. R., & Bista, P. (2014). Adapting agriculture to climate change and variability in Chitwan: Long-term trends and farmers’ perceptions. *Agricultural Research*, *3*, 165-174.

<http://dx.doi.org/10.1007/s40003-014-0103-0>

Paudel, S., Parajuli, S., Mahatara, B., Budhathoki, S., & Kattel, R. R. (2021). Economics of rice production under rice zone in Gorkha District, Nepal. *International Journal of Agriculture and Applied Sciences, 2*(1), 145-150.

<http://dx.doi.org/10.52804/ijaas2021.2119>

Poudel, U., Kattel, R. R., Gurung, B., Shrestha, S., Paudel, A., & Paudel, A. (2021). Economic analysis of rice (Oryza sativa L.) cultivation in Gorkha district of Nepal. *Archives of Agriculture and Environmental Science*, *6*(4), 489-497.

<https://doi.org/10.26832/24566632.2021.0604011>

Rabbani, M. G., Sheema, A. A., Islam, M. S., & Hasan, H. K. (2013). Profitability and resource use efficiency of mustard production: evidence of farmers' practices in Mymensingh District of Bangladesh. International Journal of Applied Research in Business Administration and Economics, 2(3), 37-46.

Raosoft, I., (2004). Sample size calculator. Retrieved February 3, 2023 from <http://www.raosoft.com/samplesize.html>

Sah, R., Dhakal, S. C., Marahatta, S., & Tiwari, U. (2024). Resource Use Efficiency and Profitability of Rice Production in the Terai Belt of Nepal. Asian Journal of Agricultural Extension, Economics & Sociology, 42(11).

<https://doi.org/10.9734/ajaees/2024/v42i112591>

Sapkota, M., & Bajracharya, M. (2018). Resource use efficiency analysis for potato production in Nepal. *Journal of Nepal Agricultural Research Council*, *4*, 54-59. <http://dx.doi.org/10.3126/jnarc.v4i1.19690>

Sapkota, M., Joshi, N. P., Kattel, R. R., & Bajracharya, M. (2018). Profitability and resource use efficiency of maize seed production in Palpa district of Nepal. *SAARC Journal of Agriculture*, *16*(1), 157-168.

<http://dx.doi.org/10.3329/sja.v16i1.37431>

Sapkota, S. (2019). Benefit Cost Analysis of Different Rice Varieties in Kapilvastu District, Nepal. International Journal of Applied Sciences and Biotechnology, 7(2), 222–226, <https://doi.org/10.3126/ijasbt.v7i2.24210>

Siddique, M.N. (2015). Water-A Limiting Resource for Sustainable Agriculture in Bangladesh.

Subedi, S., Ghimire, Y. N., Kharel, M., Sharma, B., Shrestha, J., & Sapkota, B. K. (2020). Profitability and resource use efficiency of rice production in Jhapa District of Nepal. *International Journal of Social Sciences and Management*, *7*(4), 242-247.

<https://doi.org/10.3126/ijssm.v7i4.32487>

Subedi, S., Ghimire, Y. N., Kharel, M., Sharma, B., Shrestha, J., & Sapkota, B. K. (2020). Profitability and resource use efficiency of rice production in Jhapa District of Nepal. *International Journal of Social Sciences and Management*, *7*(4), 242-247.

<http://dx.doi.org/10.3126/ijssm.v7i4.32487>

Thapa, R., Dhakal, S. C., & Subedi, S. (2024). Profitability and resource use efficiency of rice seed production: A case of Chitwan, Nepal. Cogent Food & Agriculture, 11(1), 2444341.

<https://doi.org/10.1080/23311932.2024.2444341>

Tiwari, N. P., & Dhungana, S. Resource Use Efficiency of Wheat Seed Production. (2023). A Case from Chitwan, Nepal. *Agro Ekonomi*, *34*(1), 56-69.

<https://doi.org/10.22146/ae.82798>

Udoh, E. J. (2005). Technical inefficiency in vegetable farms of humid region: An analysis of dry season farming by urban women in South-South Zone, Nigeria. *Journal of Agriculture and Social Sciences*, *1*(2), 80-85.

<https://api.semanticscholar.org/CorpusID:195794526>

Wosor, D. K., & Nimoh, F. (2012). Resource use efficiency in Chili Pepper production in the Keta municipality of Volta Region of Ghana. *Elixir Production Management*, *47*(1), 595-598.

<https://www.elixirpublishers.com/articles/1678702008_201502088.pdf>

Yadav, P. K., Sapkota, N., & Sapkota, S. (2021). An economic analysis of rice production in Rautahat district of Nepal. *Food and Agri Economics Review (FAER)*, *1*(1), 1-9.

<http://doi.org/10.26480/faer.01.2021.01.09>

Yadav, R.B., & Chaudhary, B. (2017). Cultivation of spring and boro season rice in Nepal. Rice Science and Technology in Nepal. In M.N. Poudel, D.R. Bhandari, M.P. Khanal, B.K. Joshi, P. Acharya & K.H. Ghimire (Eds.), Rice Science and Technology in Nepal (pp. 242-250). *Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar.*