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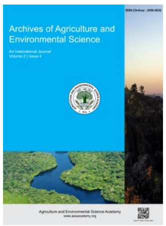

ORIGINAL RESEARCH ARTICLE

Economic analysis of rice (*Oryza sativa* L.) cultivation in Gorkha district of Nepal

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ABSTRACT

A study was conducted to analyze the production economics and factors contributing to the gross return of rice production in the Gorkha district of Nepal in 2020, where a rice block was established under the Prime Minister Agriculture Modernization Project (PM-AMP). Altogether, 76 rice-growing farmers were selected as a sample by using a simple random sampling technique. Primary data were collected by using a pre-tested interview schedule, while secondary data were collected by reviewing related literature. The data was analyzed using descriptive statistics, chi-square, independent sample t-tests, and Cobb-Douglas production function. The results showed that the average landholding was 0.74 ha and the average area under rice cultivation was 0.52 ha, with a productivity of 3 mt ha^{-1}. The findings revealed that the cost of rice production for small farmers was significantly higher (NRs. 171466 ha^{-1}) than that for large farmers (NRs. 132088 ha^{-1}). The study reveals that investment in rice cultivation was economically viable in the study area because the overall B: C ratio was greater than one (1.17). The production function analysis reveals that a 10% increase in expenditure on seeds, total labor, and nutrients, keeping all other variables constant, could increase the gross return of rice by 2.97%, 2.19%, and 0.62%, respectively. The sum of coefficients was 0.56, reflecting a decreasing return to scale. Thus, a 100% increase in expenditure on variables presented in the model caused a 56% increase in the gross return of rice production. The findings suggest that human and bullock labor needs to be replaced by the use of farm machinery. Hence, the cost of cultivation would be reduced with the improvement in production and the gross returns of rice cultivation.

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INTRODUCTION

Nepal being an agricultural country, its economic prosperity and growth depend on the growth of agriculture. Furthermore, agriculture employs around 60.4% of the whole population (NPC, 2020). Rice (*Oryza sativa*) is the most important crop in Nepal, a fundamental source of livelihood and income for more than two-thirds of farm households and is deeply embedded in the country's culture (Joshi and Upadhaya, 2020). Agriculture and forestry's contribution to the nation's GDP is about 27.08% (AICT, 2021), while rice contributes 20% to the AGDP and more than 7% to the GDP (CDD, 2015). Rice is a staple in the diets for more than half the world's population and more than 90% of global rice production and consumption is in Asia (IRRI, 1997). Rice is a major crop among cereal crops and ranks first in terms of area and production. It is grown in all of Nepal's agro-ecological zones, including Terai and inner Terai (60-900 masl), mid-hills (900-1500 masl), and high hills (1500-3050 masl) (CDD, 2015). The area, production, and productivity of rice is 1.45 million ha, 5.55 million mt, and 3.80 mt ha^{-1},respectively

(MoALD, 2021). Similarly, the total area under rice cultivation, production, and productivity of rice in the Gorkha district is 11195 ha, 38611 mt, and 3.45 mt ha^{-1}, respectively. The area under spring rice is around 5% of the total rice cultivated area in Gorkha with a productivity of 4.51 mt ha^{-1}(MoALD, 2021). The trend analysis of the last ten-year data of the area, production, and yield of rice shows slightly increasing trend of production and productivity, while the trend of the area seemed to be decreasing in Nepal (Figure 1) (Gairhe *et al.*, 2021). However, in the Gorkha, the trend analysis of the rice area shows a decreasing trend while production and productivity show a slightly increasing trend (Figure 2). Under the PM-AMP, super zone, zone, block, and pocket are established as per their commercial feasibility (MoAD, 2016). A rice zone and a block are established under PM-AMP in the district with the consideration of the district's scope to enhance production and commercialization of rice farming. So, the issues associated with food insecurity will be minimized in hilly districts like Gorkha.

Joshi and Upadhaya (2020) stressed that there is a huge gap in the yield of rice, which is 45-55% in Nepal. There are many factors responsible for this yield gap, among them an inadequate supply of various essential inputs like quality fertilizer, improved seeds, and agrochemicals, also a lack of adequate irrigation facilities, credit supply, pests and diseases and the high cost of cultivation are major production problems in the case of rice cultivation in Nepal (Joshi *et al.*, 2011). Moreover, the population growth rate is higher than the productivity rate of the crops (Joshi and Upadhaya, 2020). This leads to a food deficit in the country, which can be minimized by increasing rice productivity and minimizing food losses and wastage. Several studies related to economic analysis have been conducted in Nepal, where rice farming is found to be a profitable enterprise. However, there have been limited studies on economic analysis and factors affecting the gross return of rice cultivation in the Gorkha district of Nepal. Economic analysis can provide a better understanding of the existing cost and benefit of the production. It helps to find out the feasibility and profitability of rice farming. In this regard, this research explored the cost and benefit of rice farming along with the estimation of the contribution of different independent variables on gross return. Therefore, the findings could provide potential policy recommendations to improve the production and productivity of rice. However, due to limited time and coverage, the results drawn from the research may not similarly represent the whole district scenario and might not be a generalization for other parts. The relevancy of the information lies in the assumption that the respondents have given true information.

Sapkota and Sapkota (2019) stated that rice cultivation was profitable in Kapilvastu because the B: C ratio was greater than one. They found the lowest B: C ratio (1.005) for Radha-4 and the highest (1.312) for the Sawa variety among five different varieties. Sapkota *et al.* (2021) show that organic rice production was more profitable than inorganic rice because the B: C ratio of organic rice (2.2) was higher than inorganic rice (1.9) in Chitwan. A study conducted by Sujan *et al.* (2017) to analyze the resource use efficiency of boro rice production in Bangladesh, reveals that the key production factors, i.e., human labor, irrigation, insecticides, seed, and fertilizer, had a significant effect on yield. They also reported that boro rice production shows decreasing returns to scale, with a value of 0.80. Subedi *et al.* (2020) and Dhakal *et al.* (2019) reported a decreasing return to scale in rice production in Jhapa and in Chitwan, with values of 0.86 and 0.48, respectively. The R-square value was found to be 0.42 in the rice production system in the Chitwan condition (Dhakal *et al.*, 2019). Dahal and Rijal (2019b) estimate the R-square value at (0.33), indicating 33% of the variation in gross return of maize production was due to the variation in independent variables. In the case of rice production in Jhapa, there was a 42% variation in total rice income as explained by explanatory variables (Subedi *et al.*, 2020). Keeping the above-mentioned statistics in view, this study was conducted to analyze the production economics and to estimate the contribution of different inputs to the gross return of rice production.

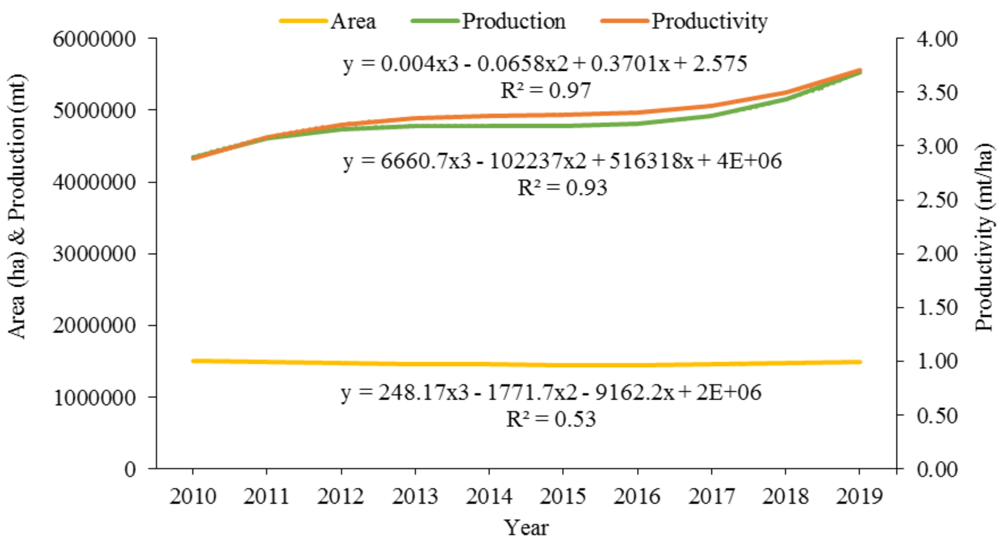

Figure 1. *Trend showing rice area, production and productivity in Nepal. (Source: MoALD, 2021).*

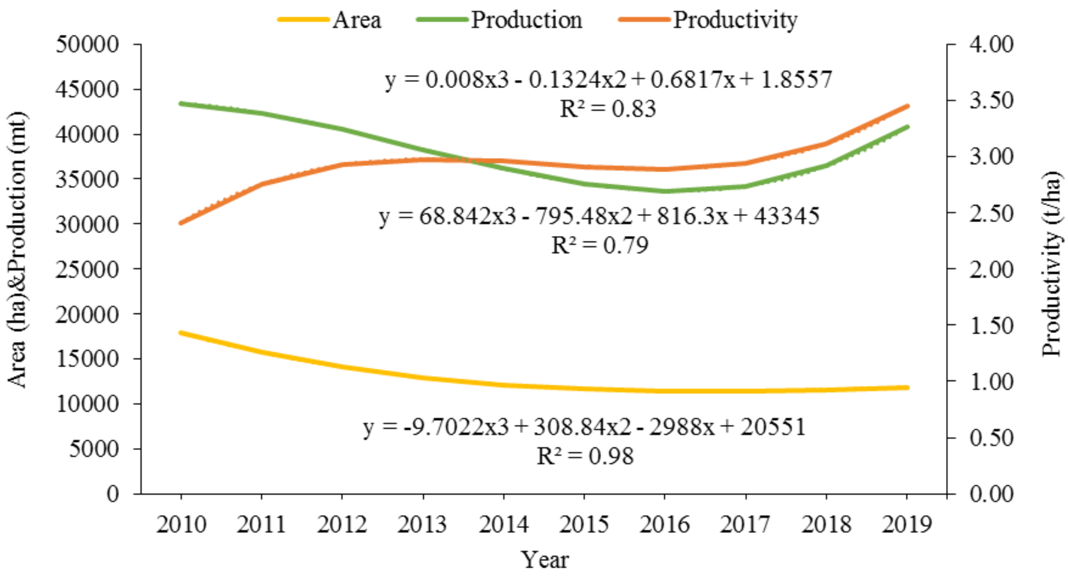

Figure 2. *Trend showing rice area, production and productivity in Gorkha district of Nepal. (Source: MoALD, 2021).*

MATERIALS AND METHODS

Study area

The study was carried out in the Gorkha district. The study was conducted in Sahidlakhan Rural Municipality wards 7 and 8, Bhimsen Rural Municipality ward no. 6 and Gorkha Municipality wards 4 and 6. The site was selected with realizing the potentiality of the district for rice production, where rice block is established under PM-AMP to increase the productivity of rice and put more emphasis on its commercialization. Figure 3 shows the study area.

Samples and sampling methods

The simple random sampling technique was used to select the sample from sampling 400 rice-growing farmers. Firstly, three municipalities were chosen based on market access and topographic difference, secondly, the ward was chosen based on rice block priority, and finally, households were chosen from each ward. Altogether, 76 household samples were selected from the sampling frame, which was representative of the whole population of the study area. From March to June 2020, the primary data was obtained using the pre-tested interview schedule. Focus group discussion (FGD) and key informant interview (KII) were conducted to collect collective information and validate the responses obtained from the household survey. The relevant secondary information was collected from journal articles, books, publications of governmental and non-governmental organizations, cooperatives, etc.

Methods and techniques of data analysis

The qualitative and quantitative data gathered in the field were initially coded. Statistical Package for Social Science (SPSS) and Microsoft Excel were used to enter data and analyze it so that relevant inferences could be drawn. The data was analyzed using descriptive statistics, mean comparisons, frequency distributions, trend analysis, chi-square, and independent sample t-tests. The farmers were categorized into two groups: small farmers and large farmers, based on their average rice (summer and spring) cultivation area, which was 0.52 hectares. Farmers with an area of up to 0.52 ha were categorized as small farmers, while those with an area >0.52 ha were categorized as large farmers. The data was analyzed and compared on this category of farmers to derive the results.

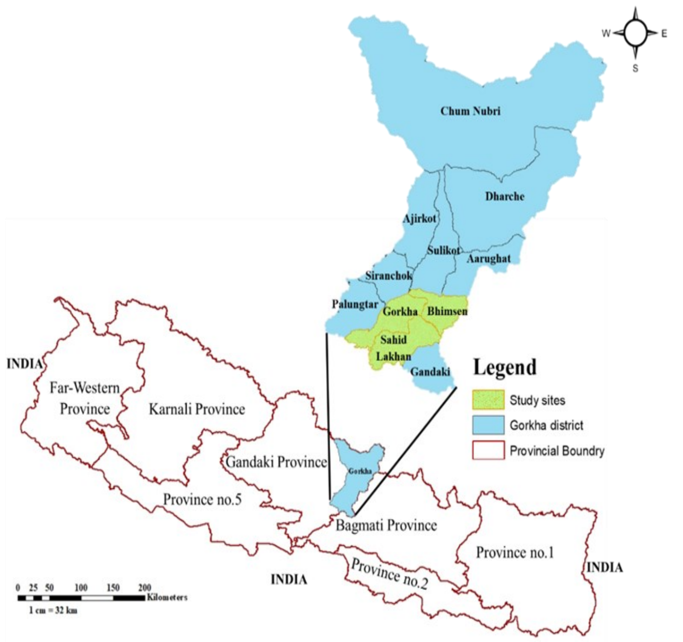

Figure 3. *Map of the study area showing research site.*

Costs of production

The total cost of production is the sum of all fixed and variables cost. In the case of rice, the only variable cost was included to calculate the cost of production as it is a short-duration crop. It was calculated in the following way as used by (Sapkota *et al.*, 2018).

$$\text{Total Cost} = \text{£ of cost of all variable inputs}$$

$$= \text{cost of seed} + \text{cost of fertilizer} + \text{cost of land preparation} + \text{cost of labour} + \text{cost of other inputs.}$$

Gross return

The return obtains from grains as well as from byproducts (i.e., straw) is the gross return. It was estimated by following the formula as used by (Dhakal *et al.*, 2019).

$$\text{Gross returns} = \{(\text{price of rice seed} \times \text{total amount of rice seed}) + (\text{price of rice byproduct} \times \text{total amount of rice byproduct})\}$$

Gross margin

The gross margin is different from the gross return, which was calculated by subtracting the total cost of cultivation from the gross return. Gross margin analysis provides a simple and quick decision for analyzing any enterprise. It was calculated by using the formula used by (Sapkota *et al.*, 2018).

$$\text{Gross margin} = \text{Gross return} - \text{Total variable cost}$$

Benefit-cost ratio

The benefit-cost ratio is the indicator for the economic performance of any firm, including the agricultural sector quickly and easily. It is the ratio between gross return and total cost. BCR was calculated by using the following formula, which is also used by (Subedi *et al.*, 2020).

$$\text{Benefit} - \text{cost ratio} = \frac{\text{Gross return}}{\text{Total variable cost}}$$

Cobb-Douglas production function

The Cobb-Douglas production function is widely used to accomplish a large number of research in agriculture and represents the relationship of output to inputs (Dahal and Rijal, 2019a). In this study, it was used to estimate the contributions of three independent variables in explaining the variation of the dependent variable of rice production. The following form of the Cobb-Douglas production function was used to determine the contribution of independent variables to output, similarly as adopted by (Subedi *et al.*, 2020).

$$Y = aX_1^{b1} X_2^{b2} X_3^{b3} e^{\mu}$$

The above equation was transformed into log-linear form as follows:

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + \mu$$

Where,

Y = Gross returns from rice cultivation (NRs. ha^{-1})

X_1 = Seed cost

X_2 = Labor cost

X_3 = Nutrient cost (FYM+ fertilizer)

μ = Random disturbance term or error term

a = Intercept or constant term

e = Base of natural logarithm

ln = Natural logarithm

b_1, b_2 and b_3 = Coefficient of respective variables

Returns to scale

Returns to scale refer to the quantitative change in production when all factors of production or inputs are changed simultaneously and in the same proportion (Adhikary *et al.*, 2017). The returns to scale of rice production were estimated by summing the coefficients of independent variables i.e. $b_1+b_2+....b_n$ from the Cobb-Douglas production function model in a similar manner as used by (Acharya *et al.*, 2019).

If $b_1+b_2+....b_n = 1$, indicates a constant return to scale.

If $b_1+b_2+....b_n < 1$, indicates a decreasing return to scale.

If $b_1+b_2+....b_n > 1$, indicates an increasing return to scale.

Problems of rice production

Based on field observation and informal talks with the related stakeholders, the major problems associated with rice production and faced by the rice growers in the district were identified. Multiple responses were taken from farmers to identify the major problems related to rice production in the study area. The problems of having a maximum frequency were considered more important. The problems were ranked according to the frequency of individual problems obtained from the household survey.

RESULTS AND DISCUSSION

Socio-demographic characters (continuous variable)

The studied socio-economic continuous variables were age, family size, male number, female number, economically active, and dependent population. There was no significant difference between small and large farmers in these variables except for the female number (Table 1). The average age of the respondents was found to be 48 years. The average family size was 7.38, which is higher than the national average household size (4.88). In the case of economically active people and dependent populations, the difference was not significant among small and large farmers, with an overall mean of 4.75 and 2.63, respectively. Similarly, the percentage of the economically active population and dependency ratio found was 64.36% and 0.55 in the study area. Similarly, Bhattarai (2019) reported that 61% of the households were economically active people.

Socio-demographic characters (categorical variable)

The categorical variables presented in Table 2 are not significantly different between small and large farmers. On average, there were 85.5% male and 14.5% female as household heads. The study area was dominated by Janajati (44.7%) followed by Brahmin (39.5%) and Chhetri (15.8%). Only agriculture was the main occupation for more than half (51.3%) of the households, and the remaining households had other occupations along with agriculture as a source of income.

This study shows that only 21.1% were illiterate, and the reaming respondents were educated which affects the adoption of modern production practices. The study shows that farmers who were involved in the farmer's group and have contact with the extension workers had access to training. Only one-fifth of the respondent, participate in the extensions training program

Table 1. Socio-economic and demographic characteristic of sampled households (continuous) in Gorkha.

Description	Small farmers (n_1=44)	Large farmers (n_2=32)	Overall (n=76)	Mean difference	t- value
Age of HH head	47.20	49.56	48.19	-2.35	-0.841
Family size	7	7.90	7.38	-0.90	-1.425
Male	3.63	3.81	3.71	-0.17	-0.465
Female	3.36	4.09	3.67	-0.73	-1.870*
Economically active[1]	4.63	4.90	4.75	-0.26	-0.623
Dependent population[2]	2.36	3	2.63	-0.63	-1.553

[1]: Economically active population percentage =(average active population/average family size)*100 =(4.75/7.38)*100 = 64.36%; [2]: Dependency ratio =(average of dependent population/ average active population) =(2.63/4.75) = 0.55; Note: * indicate level of significance at 10%; Source: Household survey, 2020.

Table 2. Socio-economic and demographic characteristic of sampled households (categorical) in Gorkha.

Description	Small Farmers (n_1=44)	large farmers (n_2=32)	Overall (n=76)	Chi-square value
Gender				
Male	38(86.4)	27(84.4)	65(85.5)	0.059
Female	6(13.6)	5(15.6)	11(14.5)	
Ethnicity				
Brahmin	18(40.9)	12(37.5)	30(39.5)	0.373
Chhetri	6(13.6)	6(18.7)	12(15.8)	
Janajati	20(45.5)	14(43.8)	34(44.7)	
Main family occupation				
Agriculture only	24(54.5)	15(46.9)	39(51.3)	4.583
Agriculture and others	20(45.4)	17(53)	37(48.7)	
Family type				
Nuclear	21(47.7)	12(37.5)	33(43.4)	0.789
Joint	23(52.3)	20(62.5)	43(56.6)	
Education status				
Illiterate	9(20.5)	7(21.9)	16(21.1)	1.541
Primary level	26(59.1)	18(56.2)	44(57.9)	
Secondary level	8(18.2)	5(15.6)	13(17.1)	
Higher level	1(2.3)	2(6.2)	3(3.9)	
Participation on training	8(18.2)	10(31.2)	18(23.7)	1.175
Training on rice farming	1(2.3)	2(6.2)	3(3.9)	0.733
Spring rice growing	30(68.2)	25(78.1)	55(72.4)	0.916

Note: Figures in parentheses indicate the percentage; Source: Household survey, 2020.

related to crop and livestock production, of which, only (3.9%) farmers received training on rice farming. The farmers of the study area did not receive extension and training programs on modern techniques of rice farming due to the lack of extension workers and sufficient training and extension activities. In the study, area 72.4% of households grow spring rice while others did not grow. The reason behind this include lack of irrigation water, long-distance irrigation canal, maize production for feeding livestock, and short storability of the spring rice.

Land holding, cultivated land, and land under summer and spring rice

The overall mean of total land holding, cultivated land, and land under summer rice and spring rice was found to be 0.74, 0.71, 0.37, and 0.14 ha, respectively (Table 3). A study found a similar value of average land holdings in Gorkha (Bhattarai, 2019). The result reveals that land holding, cultivated land, and land under summer and spring rice were significantly different between small and large farmers at 1% level of significance.

Cost of production

The study revealed that the cost of the cultivation of small farmers was significantly higher than that of large farmers, which is in line with the findings of Bhusal *et al.* (2020). The cost of cultivation was higher for small farmers, mainly due to higher labor costs owing to their small land holding, and fragmented and scattered land. The total variable cost of the cultivation was found to be NRs. 154886 ha^{-1} (Table 4). Our finding is higher than the findings of (Thapa *et al.*, 2018; Sapkota *et al.*, 2021) in Chitwan and Dang conditions, with the average cost of cultivation of NRs. 115770 ha^{-1} and NRs. 116311 ha^{-1}, respectively. The higher cost of the cultivation was associated with the requirement of huge labor for different agronomic operations like uprooting, planting, weeding, harvesting and threshing, and the use of bullocks for land preparation. Furthermore, the study area being a hilly district of Nepal, the unavailability of machinery for rice cultivation also increases the cost of the cultivation (Bhusal *et al.*, 2020). Similarly, time series analysis of the cost of cultivation shows the increasing trend of the average cost of production due to the high wage rate of human as well as bullock labor (Bhandari *et al.*, 2015), and inflating the price of fertilizer and machinery costs is also responsible for the higher variable cost (Sapkota and Sapkota, 2019).

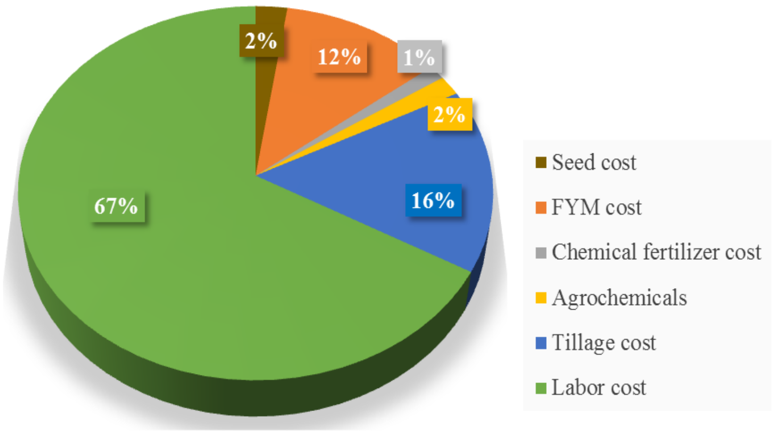

Figure 4. *Contribution (%) of variable resources to total cost of rice cultivation. (Source: Household survey, 2020).*

Table 3. Total land holding, cultivated land and land under summer and spring rice in Gorkha.

Variables in hectare	Small farmers (n_1=44)	Large farmers (n_2=32)	Overall (n=76)	Mean difference	t-value
Land holding	0.53	1.03	0.74	-0.50	-5.586***
Cultivated land	0.51	0.99	0.71	-0.48	-5.928***
Summer rice	0.21	0.58	0.37	-0.37	-10.669***
Spring rice	0.08	0.21	0.14	-0.12	-4.124***

Note: *** indicates level of significance at 1%; Source: Household survey, 2020.

Table 4. Cost of production of rice (NRs. ha^{-1}) in Gorkha.

Variables (NRs. ha^{-1})	Small farmers (n_1=44)	Large farmers (n_2=32)	Overall (n=76)	Mean difference	t-value
1. Cost of inputs (NRs.)					
Seed	3589	3748	3656	-159	-0.422
FYM	19759	17049	18618	2709	0.751
Chemical fertilizer	2146	1641	1934	504	1.540
Agrochemicals[1]	2373	3092	2676	-718	-1.346
2. Tillage cost: (Nrs.)[2]	25734	23084	24618	2650	1.430
3. Labor cost (Nrs.)[3]	117862	83472	103382	34390***	4.634
Total	171466	132088	154886	39377***	4.266

Notes: Figures in parentheses indicate percentage, *** indicates level of significance at 1%; Source: Household survey, (2020); [1]: Agrochemical include pesticides, fungicides, herbicides and micronutrient; [2]: Nursery and main land preparation cost; [3]: for nursery and main land preparation, uprooting and transplanting, weeding, manure application, harvesting and threshing;

The labor cost contributed the most to the total cost, accounting for 67% of the total cost (Figure 4). Following this finding, Bhandari *et al.* (2015) also reported that human and bullock labor costs account for 60% of the in total cost. Bhusal *et al.* (2020) suggest that labor costs account for a higher portion as a huge amount of labor is required from seed to seed production. This study shows that the labor cost is significantly higher for smaller farmers than for large farmers. Our study shows, the cost of manure is 90% higher than that of chemical fertilizer. The reason behind this scenario was, the readily available of FYM and poor availability of chemical fertilizer in time and quantity, which led to the low application of fertilizers (Dhakal *et al.*, 2019). Adding to this, due to a lack of knowledge about the balanced use of chemical fertilizers, the majority of farmers simply perceive urea as a fertilizer and use only urea in their fields.

Gross return from production

The gross return of rice cultivation includes the return from the grain and straw. The total return from rice production was (NRs.182612 ha^{-1}), which is significantly higher for small farmers than for large farmers (Table 5). The higher return for small farmers was associated with higher productivity, which is 16% more than the productivity of large farmers. The return from grain was 67.85%, while straw contribute 32.15% to the gross return. (Table 5). This finding is supported by Bhusal *et al.* (2020), which reported that grains and straw contributes 72.65% and 27.35%, respectively to gross return. A study conducted in Chitwan shows total return was higher than the findings of our study for inorganic rice (NRs. 217380 ha^{-1}) and organic rice (NRs. 210000 ha^{-1}) (Sapkota *et al.*, 2021), while Sapkota *et al.* (2018) found lower return (NRs.163114 ha^{-1}) in Kathmandu.

Table 5. Gross returns from rice production (NRs. ha^{-1}) in Gorkha.

Returns (NRs.)	Small farmers (n_1=44)	Large farmers (n_2=32)	Overall (n=76)	Mean difference	t-value	p-value
Rice grain	131966 (68.02)	112823 (67.58)	123906 (67.85)	19143	2.324**	0.023
Straw	62038 (31.98)	54123 (32.42)	58705 (32.15)	7915	1.717*	0.090
Total	194005 (100)	166946 (100)	182612 (100)	27058	2.307**	0.024

Notes: Figures in parentheses indicate the percentage ** and * indicate level of significance at 5% and 10% respectively. Source: household survey, 2020.

Table 6. Gross margin (NRs. ha^{-1}) and gross profit ratio of rice production in Gorkha.

Variables	Small farmers (n_1=44)	Large farmers (n_2=32)	Overall (n=76)	Mean difference	t-value
Gross margin (NRs.)	22539	34857	27725	-12318	-1.083
Gross profit	0.07	0.18	0.12	-0.10	-1.998**

Notes: ** and * indicate level of significance at 5% and 10%, respectively; Source: Household survey, 2020.

Table 7. Benefit-cost ratio of rice production in the Gorkha.

Variables	Small farmers (n_1=44)	Large farmers (n_2=32)	Overall (n=76)	Mean difference	t-value
B:C	1.13	1.26	1.17	-0.13	-1.763*

Note: * indicate level of significance at 10%; Source: Household survey, 2020.

Table 8. Estimated value of coefficients and related statistics of Cobb-Douglas production function of rice production in Gorkha.

Variables	Coefficient	Standard error	t- value	p-value
Seed cost	0.279***	0.448	3.981	0.000
Total Labor cost	0.219**	0.07	2.292	0.025
Nutrients (FYM+ Fertilizer) cost	0.062*	0.095	1.676	0.098
Constant	2.89***	0.037	6.453	0.000
F-value	13.064			
R square	0.362			
Adjusted R-square	0.335			
Return to scale	0.56			

Notes: ***,** and * indicates level of significance at 1%, 5% and 10%, respectively; Source: Household survey, 2020.

Gross margin and gross profit ratio

The gross margin is the gross return less total variable cost. The average gross margin was (NRs. 27725.87 ha^{-1}), which is comparatively higher in the case of large farmers than small farmers (Table 6). In line with this finding, Sapkota and Sapkota (2019) also reported a gross margin of NRs. 24112.5 ha^{-1} in Sawa variety of rice in Kapilvastu, Nepal. The overall gross profit ratio is 0.12, which was significantly higher (0.18) for large farmers and lower (0.07) for small farmers (Table 6). Similarly, Bhusal *et al.* (2020) find out gross profit ratio is higher (0.34) than our findings.

Benefit-cost ratio

The overall benefit-cost ratio of rice cultivation was slightly greater than one, i.e., 1.17, which indicates that rice farming in the Gorkha district is economically feasible (Table 7). The average B: C ratio in the study area is slightly lower (1.18) than in Kapilvastu (Sapkota and Sapkota, 2019) but higher (1.15) than in Chitwan (Adhikari, 2011). In the case of the farmer's category, the B: C ratio for large farmers was significantly higher than that for small farmers. Similar to this Bhusal *et al.* (2020) also reported that the benefit-cost ratio was higher for large farmers than small farmers in the Pyuthan district as the input use efficiency is higher for large farmers.

Production function analysis

The estimated F value (13.064) was statistically highly significant at 1%, indicates all the independent variables included in the model have good explanatory power to explain the variation in rice production. Subedi *et al.* (2020) also reported a similar significant F value (13.87) at 1% level for rice production in the Jhapa. The R-square value, which is the value of the coefficient of determination, was 0.362 that indicates 36.2% of the variation in the rice returns was due to the variation in explanatory variables. Dhakal *et al.* (2019) reported a similar result to this in the rice production system in the Chitwan condition with an R-squared value (0.42). Furthermore, Dahal and Rijal (2019b) obtained R-squared value of 0.33 in maize farming in Sindhuli. The estimated value of the coefficient and the related statistics of Cobb Douglas production functions are presented in Table 8. Of all the explanatory variables included in the model i.e., seed cost, total labor cost, and FYM+ Fertilizer cost were found to be significant at 1%, 5%, and 10% levels of significance respectively (Table 8). The regression coefficient of the seed cost, total labor cost, and nutrients cost were 0.297, 0.219, and 0.062, respectively, which indicates that 10% increase in seed cost, labor cost, and nutrients cost keeping all other variables constant, the gross return could be increased by 2.97%, 2.19%, and 0.62%

Table 9. Ranking of the present problems of rice production.

Problems of rice production	Frequency	Rank
Poor access to improved seed, fertilizer and agrochemical in time, quality and quantity	36(47.4)	I
Labor shortage and lack of mechanization	24(31.6)	V
Lack of technical knowledge and support	33(43.3)	III
Lack of proper irrigation and drainage facilities	27(35.5)	IV
Damage of crop by diseases, pests and wild animals	35(46.1)	II
Land fragmentation	13(17.1)	VI

Note: Figures in parentheses indicate the percentage; Source: household survey, 2020

respectively. Similarly, 10% increase in expenditure on human labor and fertilizer resulted in 2% and 3% increase in returns of rice production in Jhapa respectively (Subedi *et al.*, 2020). However, (Sapkota *et al.*, 2018) found that 10% increase in seed cost and labor cost resulted in 3.8% and 3.6% increase in maize seed production income respectively in the Palpa district. Total labor cost if increased by 10%, the gross return would increase by 2.19%. Similarly, with an increase in FYM+ Fertilizer cost by 10%, there would be 0.62% increase in the gross return, with all other variables remaining the same.

Returns to scale

The sum of coefficients of independent variables present in the above model was 0.56, which is less than one, reflecting decreasing returns to scale (Table 8). Cen percentage increase in all explanatory variables included in this model exhibited a 56% increase in gross returns from rice production in the study area. Similar to this, Subedi *et al.* (2020) reported a decreasing return to scale in rice production in Jhapa with a value of 0.86. Dhakal *et al.* (2019) also reported a decreasing return to scale in rice production in Chitwan with a value of 0.48.

Problems of rice production

The study area's farmers face several problems related to production. The problems of rice cultivation identified in the study area are presented in Table 9. The result shows that, among production problems, poor access to improved seeds, fertilizer, and agrochemicals in time, quality, and quantity is perceived as the most important problem, followed by damage from diseases, pests, and wild animals, resulting in inefficient utilization of production inputs. Similarly, lack of technical knowledge and support, lack of proper irrigation and drainage facilities, and labor shortage and lack of mechanization were major problems, which ranked 3rd, 4th and 5th positions, respectively followed by land fragmentation (Table 9). Lack of availability of fertilizer in time and quantity is the most important problem, followed by a lack of availability of quality seed that leads to low productivity (Sapkota *et al.*, 2018).

Conclusion

Agriculture is the main source of income for the majority of households, and most of them are engaged in agriculture only as their main occupation. This study shows that the productivity of rice is lower than the national average due to the persistence of the traditional system of rice farming, indicating an area for improvement. Therefore, providing essential inputs on time, quality, and quantity, which is a major problem in rice production, helps to increase production and productivity. The study shows that investment in rice cultivation was economically viable because the overall B: C ratio was greater than one. The benefit-cost ratio is higher for large farmers when compared with small farmers because farming on a large scale minimizes the cost of cultivation. The cost of the cultivation is high due to the high wage of the labor and the requirement of massive amounts of labor for agronomic operations due to the scarcity of farm machinery. Hence, plans and policies need to focus on farm mechanization by considering the geographical limitations. This helps to increase the use of the farm machinery by replacing human and bullock labor, which in turn reduces the labor cost. The findings of this study show a huge opportunity for enhancing productivity and gross return. It would be better to increase the cost on seed, fertilizer, and labor to develop rice farming as a commercial enterprise, which would fill the yield gap. Based on the findings of this study, it is suggested that, training and extension activities focusing on scientific production technology is needed. This helps to move towards modern practices of farming leaving the traditional system behind.

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ABBREVIATIONS

%	Percentage
AFU	Agriculture and Forestry University
AGDP	Agriculture Gross Domestic Product
AICT	Agriculture Information and Training Centre
AKC	Agriculture Knowledge Center
BCR	Benefit Cost Ratio
CDD	Crop Development Directorate
FGD	Focus Group Discussion
GDP	Gross Domestic Product
ha	Hectare
IRRI	International Rice Research Institute
KIS	Key Information Survey
MoAD	Ministry of Agriculture Development
MoALD	Ministry of Agriculture and Livestock Development
Masl	Meter Above Sea Level
mt	Metric ton
mt ha^{-1}	Metric ton per hactare
NPC	National Planning Commission
PMAMP	Prime Minister Agriculture Modernization Project
SPSS	Statistical Package for Social Science
t ha^{-1}	Ton per hectare

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