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RESEARCH ARTICLE

A COMPARATIVE ANALYSIS OF PRODUCTION ECONOMICS OF SPRING RICE BETWEEN DEVTAL AND SUWARNA RURAL MUNICIPALITIES OF BARA DISTRICT, NEPAL

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ABSTRACT

The study, conducted in 2023, compared the economics of spring rice production in Suwarna and Devtal RM. Data from 120 households (60 from each RM) were analyzed using MS Excel, SPSS, and other statistical tools. Suwarna averaged 0.932 hectares for rice cultivation, compared to Devtal's 0.687 ha. Most farmers in both RMs used a combination of organic and chemical fertilizers (96.7% in Suwarna, 75.0% in Devtal). Labor practices varied, with Devtal using 105.89 man-days and Suwarna 95.35 man-days. Suwarna's average cultivation cost was NRs 111,093.52, while Devtal's was higher at NRs 118,989.75. Devtal's rice seed price was higher at 26.55 NRs/kg compared to Suwarna's 24.74 NRs/kg. Suwarna had a higher gross margin (NRs 41,112.07) than Devtal (NRs 29,661.85). Suwarna also showed a higher BCR (1.62) than Devtal (1.44), though the difference wasn't statistically significant. Influential factors in Suwarna included seed, tillage, and pesticide costs, with an R^2 value of 0.875. In Devtal, seed, labor, organic manure, and threshing costs were significant, with an R^2 of 0.871. Both RMs showed increasing returns to scale (1.207 in Suwarna, 1.190 in Devtal). The dominant marketing channel was producer-local collector-wholesaler-mills-consumer. Common production constraints were fertilizer availability and seed quality.

KEYWORDS

Spring Rice Production, Agricultural Economics, Fertilizer Use, Cost of Cultivation, Benefit-Cost Ratio (BCR), Production Constraints

1. INTRODUCTION

The Nepalese economy is primarily based on agriculture. The principal source of subsistence and income for more than two-thirds of agricultural households in Nepal comes from rice, which is deeply embedded in the culture of the nation (Joshi and Upadhaya, 2020). It makes up 20% of the agricultural GDP (AGDP) and more than 7% of the overall GDP (CDD, 2015). In terms of area, output, and people's means of subsistence, it ranks first among cereal crops (Sapkota et al., 2021). It is cultivated in the Terai and Inner Terai (67 to 900 meters above sea level), mid-hills (1000 to 1500 meters above sea level), and high hills (1500- 3050 meters above sea level). When compared to the main (Barkhe) season, which lasts for 92 percent of the year, just 7% of the rice-growing land is in the spring (Chaite) season (CDD, 2015).

Spring rice production is an important agricultural activity in many parts of the world. It is known for its ability to provide high yields and to support the livelihoods of small-scale farmers. According to researchers, spring rice is one of the most important crops in Nepal and is grown on over 1.2 million hectares of land.It is grown in the Terai region as well as some mid-hill regions (Acharya et al., 2018). Spring rice is normally planted in Nepal around March or April, and it is typically harvested in July or August. Spring rice is known as Chaite rice since the transplanting month falls inside the Nepali month "Chaitra". For millions of people, especially small-scale farmers who depend on rice farming for a living, the crop is a significant source of food and cash (Bista et al., 2020).

The input costs, yields, market pricing, and government policies all have an impact on the economics of spring rice farming in Nepal. For small-scale farmers, especially those who rely on conventional farming techniques, input costs such as labor, seed, and fertilizer can be a significant barrier. Moreover, market prices can be unstable and erratic, with farmers frequently experiencing poor prices throughout the harvest season due to oversupply (Thapa et al., 2019). Marketing is another important aspect of spring rice production. According to researchers the lack of a proper market infrastructure and information on market prices can be a major challenge for small-scale farmers (Mondal and Saha, 2018). They found that the development of market linkages and the provision of market information can help to improve the profitability of spring rice production.

2. MATERIALS AND METHODS

2.1 Selection of the study area and sample

The study was carried out in two RM under rice zone of PIU Bara, Suwarna and Devtal RM including 7 wards of Devtal and 8 wards of Suwarna rural municipality. PIU has recorded 1764 spring rice-growing farmers across two rural municipalities commanded by rice zone. Consequently, due largely to barriers, a definite number of respondents was selected as representative sample of the whole population. The sample size is obtained from the sampling frame using Yamane's formulae as follows

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with 9% of margin of error. Yamane's Formula for Sample Size Calculation, n =, where, n= Sample Size, N= Population Size, e= sampling error.

A total of 120 spring rice farming households were selected, 60 each from both rural municipalities by simple random sampling method.

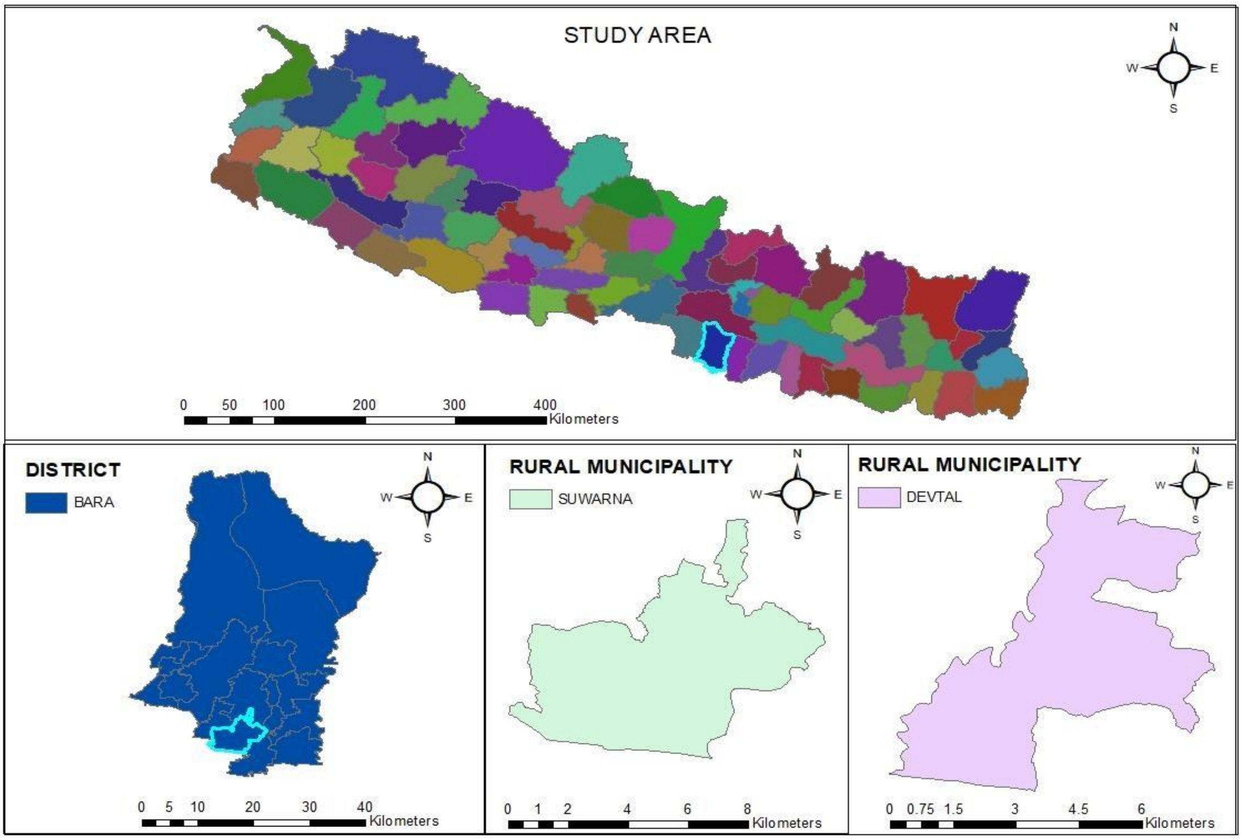

Figure 1: Map of Nepal showing study area in Bara district

2.2 Data collection techniques

The data for the survey research were collected from two RM under the Rice Zone of PMAMP, PIU, Bara. Altogether, seven wards of Devtal and eight wards of Suwarna RM were covered during the data collection of 60 households from each of the rural municipalities.

2.3 Preliminary field visit

A preliminary field visit was undertaken to learn more about the population structure, geographic location, socio-cultural context, current economic situation, as well as the problems of the farmers regarding the cultivation practices of the spring rice. This preliminary field visit helped us to develop the research proposal, questionnaire and allocate the period for the survey.

2.4 Preparation of interview schedule

Farmers were interviewed by the semi-structured interview schedule about the prevalent cultural practices, production, adoption of improved technology, and problems/constraints faced by farmers.

2.5 Pre-testing of interview schedule

The prepared interview schedule was pre-tested prior to the conduction of survey for the reliability and validity of the questionnaire. Pre-testing of interview schedule was carried out in

10 sample spring rice growers selected randomly from the Suwarna and Devtal Rural Municipality. The final interview schedule was then prepared by taking due consideration of the suggestions obtained during pretesting to make the questionnaire more effective.

2.6 Household survey

Household survey among the households was conducted to get both quantitative and qualitative data throughout the two local bodies at any time during April and May by visiting each farm personally and interviewing them with the help of a pretested interview schedule.

2.7 Key informant interview

Key informant interview (KII) was conducted with progressive farmers, farmer leaders, managers of private farms, and local extension workers to gather the qualitative data about the overall spring rice production scenario, the change in the cultivation practices over the period, problems being faced by the spring rice growers etc.

2.8 Data analysis

Software programs like Microsoft Excel and the Statistical Package for Social Science (SPSS), Cobb-Douglas Production Function (CPDF) regression model was carried out to find out the technological relationship between the factors used and gross revenue generated from rice production.

2.9 Analysis of socio-demographic and economic data from survey

Descriptive statistics like average, percentage, standard deviation, charts and diagrams were estimated from the socio-demographic and economic data.

2.10 Analysis of production problems of spring rice farmers

Qualitative data were taken into account to prepare the index. Based on responded frequencies, weighted indexes were calculated for the analysis of farmer's perception on the extent of production problems. Farmer's perception to the different production problems were ranked by using five points scale, with ratings of 1 indicating the most critical, 0.8 denoting serious concerns, 0.6 indicating moderate problems, 0.4 signifying relatively minor issues, and 0.2 representing the least severe problems (Ghose, 1981). Then the priority index was calculated by weightage, average mean in order to draw valid conclusion. The index of importance was computed by using the formula:

$$Iimp = \sum \frac{Sifi}{N}$$

Where, Iimp = index of importance, ∑ = summation, Si = Ithscale value

Fi = frequency of ith importance given by the respondents, N = total no.of respondents

Researchers employed the scaling method to recognize the challenges linked to potato production in Nepal's Terai region (Subedi et al., 2019).

The same formula was utilized by Shrestha and Shrestha, (2017) to assess the issues related to maize seed production.

2.11 Economic analysis

2.11.1 Gross margin analysis

Gross Margin, which is determined by deducting the total cost of cultivation from gross return. Analysis of any enterprise may be done quickly and simply using gross margin data. It was calculated using the formula as used by researchers in 2018 during their study in rice (Bwala and John, 2018):

Gross Margin = Gross return – Total Variable Cost

Where, Gross Return = Price of rice × Total rice production

Total variable cost = Summation of all the variable costs

2.11.2 Cost of production

Cost of Production is summation of total fixed cost and total variable cost.

Total cost= $\sum$ of cost of all variable inputs = cost of seed + cost of land preparation + cost of labor + Cost of transplanting + other input costs

Only the variable cost was considered to calculate the cost of production as rice is a short duration crop (Adhikari, 2013).

2.11.3 Benefit-cost ratio

The indication of an agricultural sector's economic viability is the benefit-cost ratio. It is the proportion of gross return to overall cost. BCR was calculated by using the following formula, as used by (Subedi et al., 2020). B/C ratio= Gross Return / Total cost

2.11.4 Production function analysis

The Cobb-Douglas production function, a commonly utilized tool in agricultural research, captures the connection between output and inputs (Dahal and Rijal, 2019). The utilization of the Cobb Douglas production function allowed for the estimation and examination of the technological correlation between various production inputs and the resulting output, which, in this context, pertains to the total income generated (Sapkota et al., 2021b). In this research, it was employed to assess the impact of 8 distinct variables on the variation in rice production. The study utilized the Cobb-Douglas production function, similar to the approach taken by (Subedi et al., 2020), to evaluate the contributions of these independent variables to the overall output.

$Y = aX1^{b1} X2^{b2} X3^{b3} X4^{b4} X5^{b5} X6^{b6} X7^{b7} X8^{b8} e^{\mu}$

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

$\ln Y = \ln a + b1\ln X1 + b2\ln X2 + b3\ln X3 + \ldots + b8\ln X8 + \mu$

Where, Y = Gross returns from rice cultivation

X1 = Seed cost X5 = Chemical fertilizer cost

X2 = Labor cost X6 = Pesticide cost

X3 = Tillage cost X7 = Transportation cost

X4 = Organic Manure cost X8 = Threshing cost

μ = Random disturbance term or error term a = Intercept or constant term e = Base of natural logarithm ln = Natural logarithm b1, b2, b3, ..., b8 = Coefficient of respective variables

When conducting the analysis, independent variables with VIF value higher than 10 were dropped accordingly in both rural municipalities. A Variance Inflation Factor (VIF) exceeding 10 suggests the presence of potentially detrimental collinearity (Franke, 2010).

2.11.5 Return to scale analysis

Returns to scale signify the quantitative shift in production when all input factors are altered simultaneously and proportionally (Adhikary, Acharya, & Lamichhane, 2017). To assess the returns to scale in rice production, the coefficients of the independent variables (b1+b2+….bn) from the Cobb-Douglas production function model were summed, following the methodology employed by (Acharya et al., 2019).

A constant return to scale if b1+b2+….bn = 1.

A decreasing return to scale if b1+b2+….bn < 1.

An increasing return to scale if b1+b2+….bn > 1.

3. Results And Discussion

3.1 Landholding status of the respondents

The average land holding size in the study area was found to be 0.831 ha. Suwarna RM emerges as the municipality with larger average landholding sizes. The average landholding in Suwarna RM averages approximately 0.944 hectares, surpassing Devtal RM's average of 0.717 hectares. The calculated p-value of 0.06 indicates statistical significance at the 10% significance level, underscoring a significant discrepancy in landownership between the two regions.

Furthermore, Suwarna RM maintains an average of approximately 0.932 hectares of land dedicated to rice cultivation, whereas Devtal RM reports a lower average of 0.687 hectares. The p-value of 0.04 indicates statistical significance at the 5% significance level, highlighting a significant contrast in the allocation of land for rice farming. The total landholding and area under rice cultivation is slightly greater than the findings of research conducted by (Poudel et al., 2021).

Interestingly, land under spring rice cultivation exhibits no significant difference between Suwarna and Devtal RM statistically as both RM display relatively similar averages, with Suwarna RM at 0.597 hectares and Devtal RM at 0.580 hectares. Lastly, Suwarna possesses a higher average of approximately 0.882 hectares compared to Devtal's 0.687 hectares in terms of land under main season rice cultivation. However, this difference does not reach statistical significance at the 5% level.

Table 1: Landholding status of the households in the study area (in hectares)

Land holding categories	Rural Municipalities			t-test p value
	Suwarna	Devtal	Total	
Total Owned Land Area	0.944±0.70	0.717±0.60	0.831±0.66	0.06*
Land Under Rice Cultivation	0.932±0.68	0.687±0.61	0.809±0.65	0.04**
Land Under Spring Rice Cultivation	0.597±0.47	0.580±0.61	0.588±0.54	0.866
Land Under Main Season Rice Cultivation	0.882±0.63	0.687±0.61	0.784±0.62	0.089

*, **, *** indicate significance at 10%, 5% and 1% α level respectively.

Source: (Field Survey, 2023)

3.2 Agronomic practices of the study area

This section deals with the comparison of two rural municipalities for some of the common agronomic practices like cropping pattern, variety used, irrigation measures, weeding frequency and agri-inputs.

3.3 Cropping pattern

A majority of households in both regions adhere to the "Rice-Wheat-Spring Rice" cropping pattern, with 53.33% in Suwarna RM and 65% in Devtal RM. Our finding corresponds with the findings of a previous study conducted in the broader Terai region by Regmi et al., (2023). However, the cropping pattern "Rice-Wheat-(Spring Rice+Maize)" displays a subtle variation, with Suwarna RM exhibiting a slightly higher prevalence at 33.33% compared to Devtal RM's 26.67%. The "Rice-Wheat-(Spring Rice+Maize+Vegetable)" pattern, which includes vegetables alongside the staple crops, is adopted by a smaller fraction of households in both RM, with Suwarna RM showing a somewhat higher proportion at 13.33% compared to Devtal RM's 8.33%.

Table 2: Cropping pattern of the respondents in the study area

Variable		**Rural Municipalities**			Chi-square value	p value
		Suwarna	Devtal	Total		
	Rice-Wheat-Spring Rice	32(53.33)	39(65)	71(59.167)		
Cropping Pattern	Rice-Wheat-(Spring Rice+ Maize)	20(33.33)	16(26.67)	36(30)	1.827	0.401
	Rice-Wheat-(Spring Rice + Maize +Vegetable)	8(13.33)	5(8.33)	13(10.83)		

Figures in parentheses indicate percentage.

Source: (Field Survey, 2023)

3.5 Varieties adopted

All respondents in our study uniformly adopted the Hardinath-1 variety of spring rice, indicating a consistent and prevalent choice of rice variety within the rice zone. Hardinath-1 variety is gaining popularity in most spring rice growing areas and has largely replaced older rice varieties (Khatiwada, and Upreti, 2008). Also, it may be the variety of choice due to its high yielding nature as suggested by the findings of varietal trial conducted by (Subedi et al., 2018).

3.6 Irrigation system

In both rural municipalities, Suwarna and Devtal RM, our study found that the sole system of irrigation adopted for agricultural purposes was underground water boring. Shallow tubewell played a crucial role in ensuring irrigation security, particularly during drought periods (Bhandari, 2001).

3.7 Inputs used

In comparing the mean values of various agricultural inputs between Suwarna Rural Municipality and Devtal RM, distinct patterns emerged. Suwarna reports a slightly higher average use of FarmYard Manure (FYM) per hectare (60.22 quintal) compared to Devtal (54.42 quintal). On the other hand, Devtal exhibits a slightly higher mean in Urea application per hectare (195.52 kg) compared to Suwarna (181.77 kg). A similar trend is observed with DAP) where Suwarna's mean (124.26 kg) is lower than Devtal's (160.17 kg), suggesting a relatively greater reliance on chemical fertilizers in Devtal. Both municipalities exhibit similar mean values for Potash per hectare, with Suwarna at 52.09 kg and Devtal at 49.37 kg.

In terms of seed usage, Devtal tends to use a slightly larger amount on average (45.20 kg) compared to Suwarna (40.78 kg. Regarding labor utilization, Devtal reports a higher mean value (105.89 man-days) compared to Suwarna (95.35 man-days), also indicating statistically significant differences in labor utilization between the two rural municipalities with p value of 0.024.The average use of machines for purposes like land preparation, threshing in quite similar in both the rural municipalities.

Labor is the key input in rice production, involved in everything from getting the seedbed ready to harvesting and threshing the crop (Joshi, Maharjan, and Piya, 2011). Also, the overall findings are similar to the results of research conducted in similar areas by Dhakal, Bhandari, Joshi, Aryal, Kattel, and Dhakal, (2019) and Joshi et al., (2011).

Table 3: Inputs used in spring rice cultivation per ha in the study area

Input parameters (In-ha)	**Rural Municipalities**			t-test p value
	Suwarna	Devtal	Total	
Land	0.597±0.47	0.580±0.61	0.588±0.54	0.866
FYM (quintal)	60.22 ± 21.68	54.42 ± 34.42	57.32 ± 28.79	0.271
Urea (kg)	181.77 ± 52.08	195.52 ± 112.81	188.65 ± 87.76	0.393
DAP (kg)	124.26 ± 45.77	160.17 ± 195.69	142.22±142.66	0.169
Potash (kg)	52.09 ± 23.002	49.37 ± 21.39	50.73 ± 22.16	0.504
Seed (kg)	40.78 ± 10.33	45.20 ± 23.79	42.99 ± 18.39	0.190
Labor (man-days)	105.89 ± 30.45	95.35 ± 18.75	100.62 ± 25.73	0.024**
Machine (hr)	15.29 ± 5.24	15.89 ±6.84	15.59 ± 6.07	0.591

*, **, *** indicate significance at 10%, 5% and 1% α level respectively

Source: Field Survey (2023)

3.8 Economics of production

3.8.1 Average cost of production

The total variable cost of production in the study is NRs. 115041.64 which is similar to the variable cost of rice production in areas with similar agricultural landscape according to the findings of (Sapkota et al., 2021b). In comparing the cost parameters associated with rice production between Suwarna and Devtal RM, several key observations emerge.

Firstly, when it comes to seed costs, Suwarna RM exhibits a lower average cost of NRs. 2325.167, in contrast to Devtal RM's NRs. 3526.26. This difference is statistically significant at 1% significance level. The reason behind this is due to significantly higher access to subsidies of the farmers in Suwarna RM as mentioned previously. The seed cost is slightly lower than the seed and seed treatment cost reported by (Ajay et al., 2020). Which may be due to the inclusion of cost of seed treatment along with seed. However, in other cost categories such as tillage operations, organic manure, chemical fertilizers, pesticide, threshing, and transportation, the two municipalities do not display statistically significant differences between the two RM. When considering cost of tillage operations, both RM exhibit remarkably similar mean values, with Suwarna RM at NRs. 18990.23 and Devtal RM at NRs. 18956.78. In terms of organic manure costs, Suwarna RM again shows slightly lower expenses with an average of NRs. 24343.21 per hectare compared to Devtal RM's NRs. 27119.57.

Similarly, when it comes to chemical fertilizers and pesticide expenses, Suwarna RM and Devtal RM demonstrate comparable mean values, NRs. 23247.77, NRs. 26171.57 for chemical fertilizers and NRs. 4038.21, NRs. 3758.12 for pesticides, respectively. Threshing costs also show only slight differences, with Suwarna RM at 5362.98 and Devtal RM at 4845.99. Lastly, labor expenses are higher in Suwarna RM with NRs. 30726.28 compared to Devtal RM's NRs. 18956.78. Human labor, the rental value of owned land, the cost of irrigation, the price of seeds, the cost of FYM, and the cost of machinery were significant input variables that affected the cost of production (Tiwari, 2015).

Table 4: Average cost of production (NRs.) per ha in the study area

Cost parameter	Rural Municipalities			t-test p value
	Suwarna	Devtal	Total	
Seed	2325.2±876.7	3526.3±1736.2	2925.7±1498.1	<0.01**
Tillage operation	18990.2±6645.9	18956.8±9068.8	18973.5±7916.8	0.982
Organic Manure	24343.2±24553.2	27119.6±34072.8	25731.4±29604.8	0.61
Chemical fertilizers	23247.7±25119.5	26171.6±28785.2	24709.7±26940.9	0.554
Pesticide	4038.2±1548.4	3758.1±1885.9	3898.2±1723.9	0.376
Threshing	5362.9±3159.8	4845.9±3205.4	5104.5±3179.9	0.375
Transport	2059.7±1753.2	1921.5±1655.2	1990.6±1699.2	0.658
Labor	30726.3±7486.6	32690.1±13059.3	31708.2±10645.1	0.314

*, **, *** indicate significance at 10%, 5% and 1% α level respectively

Source: (Field Survey, 2023)

3.8.2 Economic indicators of production

The analysis of the financial aspects of rice production between Suwarna and Devtal Rural Municipalities revealed that there is no statistically significant difference in the total variable cost of rice cultivation between the two regions, with Suwarna RM incurring an average cost of NRs 111,093.52 while Devtal RM's average is slightly higher at NRs 118,989.75. However, a notable distinction arises in the farm gate price of rice seed, where Devtal's seed is priced at an average of 26.55 NRs per kilogram, statistically significant than Suwarna's average of 24.74 NRs per kg.

In terms of straw price, Suwarna RM had an average price of 282.81 NRs per quintal, while Devtal's average was slightly higher at 325.29 NRs per quintal. The analysis showed no significant differences in gross returns, indicating that the total revenue generated from rice and straw sales did not significantly vary between Suwarna RM (152,205.59 NRs) and Devtal RM (148,651 NRs). However, returns from grain was significantly higher in Suwarna RM (p value < 0.01) while return from straw was statistically significant at 10%. According to Bhusal et al., (2020), the return from rice production was primarily made up of grains and then straw which is aligned with findings of our research.

Suwarna RM had a higher gross margin, averaging NRs. 41,112.07, in contrast to Devtal's NRs 29,661.85. However, these differences were not statistically significant. Similarly, while Suwarna RM had a higher Benefit Cost Ratio (BCR) (1.62) than Devtal RM (1.44), the difference was not statistically significant.

According to researchers they discovered a BCR bigger than one, which made the production of rice in Kathmandu economically viable (Sapkota et al., 2018). The positive gross margin and BCR exceeding one both suggest that the investment is financially sound, signifying the potential for a smooth and profitable operation (Sapkota et al., 2021). The BCR (1.53) in our study was greater than BCR in Rautahat district (1.11) as per the findings of (Sapkota et al., 2021).

Table 5: Economic indicators of spring rice production per ha in the study area

Parameters	Rural Municipalities			t-test p value
	Suwarna	Devtal	Total	
Variable Cost(NRs)	111093.5±49048.1	118989.8±73921.9	115041.6±62223.4	0.489
Seed Price (NRs/kg)	24.7±3.7	26.6±2.9	25.6±3.5	0.004***
Straw price (NRs/qn)	282.8±200.5	325.3±211.1	304.1±206.1	0.261
Gross returns (NRs)	152205.6±27435.3	148651±53756.8	150428.6±42533.8	0.649
Grain returns (NRs)	131698±26249.7	131056.9±7896	131337.5±19051	0.021**
Straw returns (NRs)	20507.6±7896.8	17594.6±9843	39477.4±9005.3	0.083*
Gross margin (NRs)	41112.1±55075.3	29661.8±55488.5	35386.9±55348.9	0.259
BC Ratio	1.62±0.73	1.44±0.57	1.53±0.66	0.136

*, **, *** indicate significance at 10%, 5% and 1% α level respectively

Source: (Field Survey, 2023)

3.8.3 Production function analysis

Cobb Douglas Production Function (CDPF) analysis was conducted for studying the linkage between various factors affecting the returns from spring rice production in the study area. The regression model was adopted due to highly significant F-ratio, demonstrating a strong overall fit at the 1% level of significance.

3.9 Suwarna RM

In case of Suwarna RM, the model's R^2 value of 0.875 indicates that it has robust explanatory power, with 87.5% of the variations in total income from rice production explained by the included explanatory variables. Examining individual explanatory variables, seed cost, tillage cost, chemical fertilizer, and pesticide cost have statistically significant impacts on total income from rice production. A 100% increase in seed cost is associated with a 31.3% increase in total income, with a significant impact at the 1% level. Researchers found seed cost to be significant in total income of rice (Poudel et al., 2021).

Similarly, a 100% increase in tillage cost results in a 27.5% increase in total income, significant at the 10% level. Chemical fertilizers and pesticide cost have substantial effects, with a 100% increase in their costs leading to a 19.6% and 50.9% increase in total income, respectively, both significant at the 1% level. Chemical fertilizers cost significantly affected income at 1% level of significance (Subedi et al., 2020). Pesticide cost was highly significant in study conducted by (Dhakal et al., 2019).

In contrast, organic manure, transportation cost, and threshing cost do not demonstrate statistically significant impacts on total income. An increase in organic manure cost by 100% is associated with only a negligible 0.8% decrement in total income, with no statistical significance. Transportation cost shows a minor effect with a 100% cost increase resulting in only a minimal 0.3% reduction in total income, which is not statistically significant. Labor cost was included in the model as an explanatory variable but later removed it due to a high Variance Inflation Factor (VIF) value, which exceeded 10.

Table 6: Cobb-Douglas production function of rice production in Suwarna RM						
Explanatory variables	**Coefficient**	**Standard error**	**t value**	**p value**	**tolerance**	**VIF**
Constant	1.43	0.917	1.56	0.125		
Seed cost	0.313	0.126	2.497	0.016**	0.184	5.445
Tillage cost	0.275	0.137	2.011	0.05*	0.148	6.774
Organic Manure	-0.008	0.025	-0.329	0.743	0.707	1.415
Chemical Fertilizers Cost	0.196	0.066	2.974	0.004***	0.736	1.359
Pesticide Cost	0.509	0.101	-0.343	<0.001***	0.876	1.142
Transportation Cost	-0.003	0.009	5.061	0.733	0.286	3.493
Threshing Cost	-0.048	0.11	-0.419	0.677	0.489	2.043
No of observation	120					
R2	0.875					
Adjusted R2	0.858					
F-value	51.882***					

*, **, *** indicate significance at 1%, 5% and 10% α level respectively

Source: (Field Survey, 2023)

3.10 Devtal RM

In the context of Devtal RM, the model's R^2 value of 0.871 highlights its robust explanatory capacity, explaining approximately 87.1% of the variations in total income derived from rice production through the included explanatory factors of variable cost. A doubling of seed cost leads to a substantial 15.8% rise in total income, significant at the 5% level. Similarly, a 100% increase in labor cost results in a 44.8% increase in total returns, significant at the 1% level. Organic manure and threshing cost, when doubled, contribute to a significant 2.2% and 52.8% total income increase, respectively, both at the 5% and 1% level. Labor cost and FYM, chemical fertilizers and pesticide cost was significant at 1% and 5% respectively as analyzed by Sapkota et al., (2021b). Transportation cost only causes a minor 1.1% increase in total income with a 100% increase, not statistically significant. Doubling chemical fertilizers and pesticide cost results in a negligible 1.2% and 1.1% increase respectively, lacking statistical significance.

Table 7: Cobb-Douglas production function of rice production in Devtal RM						
Explanatory variables	**Coefficient**	**Standard error**	**t value**	**P value**	**Tolerance**	**VIF**
Constant	1.288	0.784	1.644	0.106		
Seed cost	0.158	0.079	2.010	0.05**	0.269	3.717
Labour cost	0.448	0.117	3.825	<0.001***	0.136	7.326
Organic Manure	0.022	0.010	2.253	0.029**	0.711	1.407
Chemical Fertilizers Cost	0.012	0.056	.211	0.833	0.663	1.509
Pesticide Cost	0.011	0.068	.156	0.877	0.358	2.789
Transportation Cost	0.011	0.011	1.011	0.317	0.921	1.085
Threshing Cost	0.528	0.133	3.956	<0.001***	0.424	2.356
No. of observation	120					
R2	0.871					
Adjusted R2	0.853					
F-value	49.975***					
Returns to scale	1.190					

*, **, *** indicate significance at 1%, 5% and 10% α level respectively

Source: (Field Survey, 2023)

3.11 Returns to scale

Suwarna and Devtal RM demonstrate a favorable production scenario with increasing returns to scale. In Suwarna RM, the returns to scale value of 1.207 indicates that when all production inputs are expanded proportionally, the total output experiences a more significant increase. Similarly, in Devtal RM, the returns to scale value of 1.190 signifies a comparable trend of higher output growth when input factors are scaled up in proportion.

3.12 Marketing channel

The research explores how agricultural products are sold and distributed; uncovering the various channels, they reach consumers. The most prevalent channel in both regions is the "Producer-local level collector-wholesaler-mills-consumer" pathway, with 41.67% in Suwarna and 63.33% in Devtal RM. In contrast, Suwarna RM has a higher percentage of spring rice grain sold through the "Producer-local level collector-mills-consumer" channel (23.33%) compared to Devtal RM (21.67%). Conversely, Devtal RM has a slightly lower percentage of grain sold directly from producers to consumers (10%) compared to Suwarna (16.67%).

Farmers in the region marketed their harvest to various entities, with 35% of the produce being sold to local traders, 20% to millers, 25% to cooperatives, and the remaining 20% directly to consumers (Airee et al., 2020). Also, in a study conducted by researchers in 2005, it was found that the most common marketing channel involved four stages: from the producer to the wholesaler, then to the retailer, and finally reaching the consumer involving middle man (Singh, 2005). Similarly, a study in 2010 discovered that the primary purchasers of rice from producers were wholesalers and millers (Takele, 2010).

Table 8: Marketing channel of spring rice produced in the study area

Marketing Channel	Rural Municipalities		
	Suwarna	Devtal	Total
Producer-consumer	10(16.67)	6(10)	16(13.33)
Producer-local level collector-consumer	11(18.33)	3(5)	27(22.5)
Producer-local level collector-mills-consumer	14(23.33)	13(21.67)	14(11.67)
Producer-local level collector-wholesaler-mills-consumer	25(41.67)	38(63.33)	63(52.5)

Figures in parentheses indicates percentage

Source: (Field Survey, 2023)

3.13 Production constraints for spring rice growers

Both municipalities faced similar challenges, with the top constraint being the lack of availability of fertilizers in the required quantity and at the right time. Suwarna RM had an index score of 0.58, while Devtal RM scored slightly higher at 0.63, both ranking as the highest constraint in their respective regions. The second most significant constraint was the shortage of quality seeds, with Suwarna RM scoring 0.53 (II) and Devtal RM 0.56 (II). The incidence of diseases and insect/pest problems ranked as the third most prevalent constraint in both regions, with Suwarna RM at 0.46 (III) and Devtal RM at 0.49 (III). Land fragmentation and the lack of mechanization were identified as the fourth most prominent constraints in both municipalities, with Suwarna RM scoring 0.43 (IV) and Devtal RM also scoring 0.47 (IV). Lastly, the lack of proper irrigation and drainage systems was noted as the fifth major constraint. Suwarna RM had an index score of 0.41 (V), while Devtal RM scored slightly higher at 0.43 (V). The most prominent production challenge was the insufficient availability of fertilizers in the required quantities and at the right time, with the scarcity of high-quality seeds following closely behind as an important issue (Sapkota et al., 2021b).

Table 9: Production constraints for spring rice production in the study area

Production constraints	Rural Municipalities			
	Suwarna		Devtal	
	Index	Rank	Index	Rank
Lack of availability of fertilizers in required quantity and time	0.58	I	0.63	I
Lack of availability of quality seed	0.53	II	0.56	II
Incidence of disease and insect/pest	0.46	III	0.49	III
Land fragmentation and lacking of mechanization	0.43	IV	0.47	IV
Lack of proper irrigation and drainage	0.41	V	0.43	V

Source: (Field Survey, 2023)

4. Conclusion

Our analysis of the economics of spring rice production revealed significant variations between Suwarna and Devtal RM, including cost structures, income returns, and gross margins. Suwarna RM displayed significantly higher returns from grain as well as from rice by-product, ultimately contributing to a favorable gross margin and Benefit Cost Ratio (BCR) compared to Devtal RM. The critical factors influencing income variations included seed cost, tillage cost, chemical fertilizer, pesticide cost, labor cost, organic manure, and threshing cost. Both Suwarna and Devtal RM displayed increasing returns to scale, indicating the potential for higher output growth with proportional scaling of input factors. The assessment of production constraints underscored the shared challenges of fertilizer availability, high-quality seed sourcing, and disease and pest concerns that need attention and intervention to bolster spring rice production in these rural municipalities.

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