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Analysis of Resource Use Efficiency and Profitability of Maize Seed Production in the Rolpa District of Nepal

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HIGHLIGHTS

- Female farmers are increasing due to male out-migration, and youth engagement in agriculture is low.
- Maize production is financially viable despite high labor costs.
- Farmyard manure and tillage are overused, while seed, fertilizer, and management inputs are underutilized.
- Maize farmers face challenges like insect infestations, disease spread, and inadequate irrigation resources.

Abstract

This study aimed to assess the profitability and resource use efficiency of maize seed production in the Rolpa district of Nepal. Primary data were collected from a sample of 67 maize growing farmers involved in maize seed production, selected randomly from the sampling frame with a confidence level of 95% and a margin of error of 5%, using Raosoft. Additionally, secondary information was obtained through a review of relevant literature. Descriptive statistics and the Cobb-Douglas production function were employed for data analysis. The results indicated that maize seed production in the study area was profitable, evidenced by a gross margin of 17,160.6 NRs/ha and a benefit-cost ratio of 1.12. The productivity level was estimated at 15.46 quintal/ha. Moreover, the return to scale of maize seed production was calculated to be 0.79, suggesting a decreasing return to scale. The analysis of allocative efficiency indices highlighted the need for optimizing resource allocation. Specifically, increasing costs on seed, chemical fertilizers, and management by 94.03%, 99.30%, and 60.25% respectively would lead to optimal resource allocation. Conversely, costs related to human labor, farmyard manure (FYM), and tillage should be reduced. This research contributes to a better understanding of the profitability and resource utilization in maize seed production in the Rolpa district of Nepal. The findings provide valuable insights for farmers and policymakers to make informed decisions regarding resource allocation and enhance the overall efficiency and sustainability of maize seed production in the region.

Keywords: Cost Estimation, Efficiency, Gross return, Geometric Mean, MVP, Regression Coefficient

1. Introduction

Agricultural production must be more profitable as it directly contributes to economic growth. The necessary framework to strengthen the agricultural value chain must be created to realize profitable

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production. *Zea mays*, also known as maize, is one of the world's most widely grown cereal crops and has a wide range of adaptability to different agro-climatic conditions. Non-waterlogged soil, like sandy loam or loamy soil, is the best soil for growing maize. 28 to 34 degrees Celsius is the ideal temperature range for maize cultivation. Higher yields depend on timely sowing (Biswas, et al., 2022). Among cereal crops, maize has emerged as one of the most significant modern staple food crops, and with the highest genetic yield potential (ALABUJA et al. 2022; Adesina and Omonona 2019). Regarding global importance, maize came in third place behind wheat and rice. However, maize is known as the world's top source of calories, providing 19.5% more than either wheat (16.5%) or rice (15.0%) (World Atlas 2017; Adesina and Omonona 2019). It serves as a crucial raw material for the industrial production of fuel, starch, medications, and food sweeteners. Levulinic acid, a chemical derived from maize, replace of hazardous petroleum-based ingredients in anti-freeze products. Maize-derived ethanol is used as a biomass fuel. In order to heat furnaces in homes, maize straw is used as a cheap energy source. A common primary ingredient in fish and poultry feed is maize. Additionally, maize is used for direct human consumption (Adesina and Omonona 2019; Biswas et al. 2022).

Maize (*Zea Mays*) is the world's second most cultivated crop with 197 million ha of land cultivation (Erenstein et al. 2022). In Nepal, it is the second most important crop with a production area of 979,776 ha and production of 2,997,733 Mt indicating a productivity of 3.06 Mt/ha (MoALD, 2021). Maize is grown in various agro-regions of Nepal and contributes to over 26% of food requirements in the hills and mountains (Sapkota and Pokhrel 2013). Mid-hill region of Nepal which covers 43% of the land has a significant variation in maize production and productivity (Dhakal et. al. 2022). The yield shown by different research in hills is about 1.98 MT/ ha in Sindhuli (Dahal and Rijal 2019) and 2.30 tons/ ha in Rolpa (Agriculture Knowledge Center, Rolpa 2020). Maize food and feed demand grow~~s~~ by 5% and 11% respectively per annum (Sapkota and Pokhrel 2013). However, Nepalese production has not meet this increasing demand, thus a large amount of Maize is imported from India. The yield and profit of a crop rely on the inputs and their efficient use. Low-quality seeds, low soil fertility and lack of an appropriate crop management system (Karki et al. 2015), disease infestation, and labor shortage cause lower yield of maize in Nepal. Overusing or underusing of any input resource can thus lead to a waste of money and time, leading to an economic loss for the farmers (Băşa et al. 2016). Thus, generating an idea of resource use efficiency can directly impact the farmers. Rolpa, the mid-hill district of Nepal, in the Lumbini Province, mainly relies on agriculture (Pokhrel 2019). Among 31496 hectares of Rolpa's cultivable land, Maize alone covers 12660 ha with an annual production of about 29150 metric tons (DADO 2016). Most of the Maize Production area of Rolpo is concentrated in the Uplands, where the plant is grown from April to October in rain-fed conditions (Pokhrel et al. 2018). After the establishment of the PMAMP Maize Zone in Rolpa, government sector is encouraging farmers towards Maize Seed Production (Ghimire et al. 2019). Even then, the economic status of Maize Seed Farmers in Rolpo has not improved significantly (Sapkota et al. 2018). Hence, evaluating the social features and the cost/ profit of Maize Seed Production in Rolpa is important.

2. Materials and Methods

2.1 Study Area

The study was carried out in the Rolpa district of Lumbini province with its headquarters at Libang, situated in the Western Development Region of Nepal, at 28.8° to 28.38° N latitude and 83.10° E to 83.90° longitude. It is at a height of 701 m to 3669 m from the sea level. The population of this district is 224506. In Ropla, Maize Seed Production has been a major focus of PMAMP (Prime Minister Agriculture Modernization Project). Rolpa municipality is the only Municipality of the district that is declared as a Maize zone area under PMAMP.

2.2 Sampling Procedure and Data Collection

Wards 4, 7, 9, and 10 were selected purposively as survey zones as major seed-producing cooperatives and Farmer's groups are located in these wards. There were about 80 farmers from 4 cooperatives and 1 farmer group involved in maize seed production under the study area. The sample size was determined from the Raosoft software (Raosoft 2014). The required sample size at a 95% confidence level and a 5% margin of error using Raosoft is 67. Hence, a random sampling of altogether 67 farmers was done.

The questionnaire was Pre-tested with 10 respondents (5.5 percent of the sample size) from different wards. A pre-tested questionnaire was used for the data collection between March to July 2023. Key Informant Interview was done with 4 cooperative members at the PMAMP zone office. Chairpersons of cooperatives and farmer groups; and progressive farmers were selected for Key Informant Interviews. Also, Focus group discussions (FGD) among cooperative members and farmers' group was done to verify the responses obtained. Furthermore, different data collected from the government and non-governmental organizations over a period of time was considered secondary data.

2.3 Methods and Techniques of Data Analysis

Statistical Package for Social Science (SPSS) and Microsoft Excel (MS Excel) were used for data entry and analysis.

2.4 Socio-Demographic and Economic Variables

Calculation of socio-demographic variables such as the education of the sample, population distribution, family size, income level, and land holding will be done with the use of descriptive statistics. Model as percentage, frequencies, means, and standard deviation shall be used.

2.5 Gross Margin

The gross margin was calculated by deducting the total variable cost from the gross return. Gross margin calculation was done to estimate of the difference between the gross return and variable costs.

$Gross\ Margin\ (NRs/ha) = Gross\ return\left(\frac{NRs}{ha}\right) - Total\ Variable\ Cost(\frac{NRs}{ha})$ Olukosi et al. (2006)

2.6 Resource use efficiency

Cobb-Douglas production function together with SPSS25 and Excel shall be used to analyze the Resource use efficiency. Cobb-Douglas production indicates the formula below.

$Y=aX1^{b1}\ X2^{b2}\ X3^{b3}\ X4^{b4}\ X5^{b5}\ e^{u}$ (Sapkota et al. 2018)

Where Y=income of maize production in ha (Nrs),

X1=cost of maize seed per ha

X2=cost of labor per ha,

X3=cost of FYM per ha,

X4=Cost of chemical fertilizer per ha,

X5=Management cost per ha.

e is error term and b1 to b5 is coefficient to be estimated.

The above mentioned equation is linearized in logarithmic function.

lnY= lna+ b1lnX1+ b2lnX2+ b3lnX3+b4lnX4+b5lnX5+u

Where, ln= natural logarithm, a= constant and u is random disturbance.

The efficiency ratio (r) was computed using the formula

$r = \frac{MVP}{MFC}$ (Sapkota et al. 2018)

where, MFC= Marginal factor cost

MVP= Marginal value product,

The marginal value product was computed by using formula:

MVPi = bi× Y/XI

Where, bi = Estimated regression coefficients

Y and Xi are the values from geometric mean.

Efficiency estimation r = 1 indicate the efficient use of resource r < 1 indicate overused of resource r > 1 indicate underuse of resource

Again, the MVP relative % change of indivisual resource was calculated by the use of following formula,

D= (1- MFC/MVP) ×100 Or, D= (1-1/r) ×100 (Sapkota, et al., 2018)

Where, D= Absolute value of percentage change in MVP of each resource

2.7 Economic Analysis

Cost-benefit analysis was done after the calculation of total cost and gross return. Cost of production included all variables cost items as the investment done for Seed, Labor, FYM, fertilizer, and Management practices such as sowing, weeding, harvesting and marketing. Similarly, the income was obtained from the sales of maize seed and maize grain.

Then, benefit-cost analysis was done with the following formula: (Dhakal et al. 2015; Subedi et al. 2019).

$$Benefit\ Cost\ Ratio = {}^{Gross\ Return}/_{Total\ Variable\ Cost}$$

$$Gross\ return = Total\ quantity\ of\ seed\ sold\ (kg) * Price\ per\ unit\ of\ maize\ seed (NRs) + Total\ quantity\ of\ grain\ produced\ (kg) * Price\ per\ unit\ of\ maize\ grain\ (NRs)$$

Total variable cost = seed cost + Bullock cost + Labor cost + seed cost of mixed crop

2.6 Problem ranking

With the use of qualitative data, the index values were calculated. The rank received by each problem given by the individual respondent, we get the final index value to show the severity of each of the farmer's problems.

Five major problems of the study site were ranked according to the severity that farmers have experienced. The problems included the incidence of disease and pests, lack of irrigation, Natural Hazards, Lack of technical services, and labor shortage.

3. Results

3.1 Socio-economic Characters

The majority of farmers from Rolpa municipality were from medium-size families with 4 to 7 family members. Most of those farmers were female i.e. 62.7% and few were male. The number of female farmers in agriculture sector of Rolpo has increased after male members of family started out-migrating to larger cities or foreign countries in search of better economic conditions (Tamang et al. 2014). 41.8% of the family head were in the age group 30 to 40 years. Engagement of young adults in agriculture was seen significantly less in Rolpa. As per a research, the lower number of young adults i.e. 20 to 30 years old is due to parental pressure for alternative job and problems in agriculture like crop loss, lack of resources and less access to technical and financial support (Pelzom and Katel 2017). Agriculture Extension programs and engagement of, the government as well as private sector, beholds great importance in the increase of Maize seed production and higher resource use efficiency in Rolpa. 67% of farmers are engaged in farmers group and cooperative. Facts indicates that these cooperatives help farmers with better accessibility of Farm Inputs and subsidy, thus improving the overall farming practices.The engagement of farmers' cooperative also increased their exposure to different agriculture training (Neupane et al. 2018). 46.3% of the farmers in the area received training about appropriate management practices. However, another 53.7% of farmers who do not have excess to such training program lack knowledge of modern agriculture practices and resource use efficiency. The role of cooperative in Rolpa is not limited to extension and training, but also play a vital role in accessing credit facility to the farmers have been remarkable. However, only 25.4% of farmers have accesss to credit facilities. This explains the lack of capital for large-scale farming and technology adoption in Rolpa municipality.

Table 1: Socio-economic characteristics of the respondents

S.N.	**Socio-economic characters**	**Frequency**	**Percent**
	Family Size		
1	Large	6	9.0
	Medium	36	53.7
	Small	25	37.3
	Gender		
2	Male	25	37.3
	Female	42	62.7
	Other	0	0.0
	Age of household head		
3	Young adults	6	9
	Adults in thirties	13	19.3
	Adults in forties	28	41.8
	Middle-aged adults	14	20.9
	Other adults	6	9.0
	Training Received		
4	Received	31	46.3
	Not received	36	53.7
	Access to credit		
5	Yes	17	25.4
	No	50	74.6
	Seed Variety		
6	Manakamana	27	40.3
	Deuti	40	59.7
	Membership in farmers group		
7	Member	67	100.0

Source: Field survey (2023)

3.2 Cost of Maize Production

The overall expense of maize production was determined to be NRs 134062.6. The largest portion of the total cost was attributed to labor expenses, accounting for 45.61% of the total cost, followed by FYM at 39.27% and tillage at 7.03%. The labor force is employed in various tasks related to maize production, including nursery bed preparation, sowing, weeding, applying weedicides, insecticides, and pesticides, as well as harvesting.

Table 2: Summary of resource use and production metrics in maize seed production

Metrics	**Minimum**	**Maximum**	**Mean**
Total Area (ha)	0.153	1.224	0.592
Cultivated Area (ha)	0.051	0.714	0.244
Seed Quantity (kg)	19.607	39.215	34.829
Seed Quantity Produced (100 kg)	9.803	19.607	15.460

Source: Field survey (2023)

Table 3: Average cost of Maize production

Variables	Minimum cost	Maximum cost	Mean	Percentage
Labor cost	549.01	117647.10	61154.73	45.62
FYM Cost	39215.69	58823.53	52648.52	39.27
Tillage cost	5392.15	11764.71	9426.05	7.04
Management cost	1426.02	21568.63	4186.73	3.12
Seed cost	1960.78	3921.56	3482.95	2.59
Fertilizer cost	0	7843.13	2575.35	1.92
Other costs	588.23	588.23	588.23	0.44
Total variable cost	49131.88	222156.89	134062.60	100.00

Source: Field survey (2023)

3.3 Returns from Maize Production

A total of NRs. 134062.60 was determined as the cost of producing maize. The main cost component with the highest percentage of the total cost was labor costs (45.62%), followed by farm yard manure (39.27%) and tillage operation (7.04%).

Table 4: Average returns from maize production

Return items	Mean (NRs/ha)	Percentage
Seed of maize	92995.30	61.25
Grains of maize		38.75
Total returns	151832.92	100

Source: Field survey (2023)

It was determined that the average total returns from maize production were NRs 151832.92. While grains make up 38.75% of the total, maize seeds account for 61.25%.

3.4 Financial Indicators

Table 5: Financial indicators of maize seed production in the study area

Indicators	Average value (NRs/ha)
a. Total fixed cost	609.74
b. Total variable cost	134062.58
c. Total cost (a+b)	134672.32
d. Gross returns	151832.92
e. Gross margin (d-c)	17160.60
f. Benefit-cost ratio (d/c)	1.127

Source: Field survey (2023)

The gross margin of maize production in the study area was calculated NRs. 17160.60. The benefit- cost ratio was estimated 1.127 which means if 1 rupee is invested it will give 1.127 rupees returns. The positive value of BC Ratio being greater than 1 indicates the financial viability. The calculations mentioned above revealed that maize production is profitable in the research area.

Table 6: Estimated value of coefficients and related statistics of Cobb-Douglas production function of maize seed production

Variables	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.
	B	Std. Error	Beta		
(Constant)	5.055	4.740		1.066	0.291
Seed cost	0.485	0.122	0.442	3.967	0.000
Labor cost	-0.010	0.026	-0.045	-0.401	0.690
FYM cost	0.182	0.444	0.248	0.410	0.684
Fertilizer cost	0.023	0.019	0.711	1.218	0.228
Tillage cost	0.031	0.059	0.068	0.528	0.599
Management cost	0.084	0.058	0.155	1.447	0.153

Model summary statistics	
Number of sample (N)	67
R	0.593
R square	0.352
Adjusted R square	0.287
Std. error of estimate	0.115
R square change	0.352
F change	5.423
Sig. f change	0.000
Durbin-Watson	2.021

Source: Field survey (2023)

The value of the coefficient of multiple determination R square (R^2) was estimated 0.35 which indicated that 35% of the variation in the total maize income was explained by the explanatory variables in the model. Six independent variables are included in the model, one variable have statistically significant i.e. seed cost (1% level of significance). With an increase in the seed cost, the income from maize production increases by 48%. Increase in the cost of seed was in accordance with the findings of Dhakal et al. (2015); Ghimire and Dhakal (2014); Sharma (2009); Gani and Omomona (2009); Ojo, Salami and Mohammed (2008).

3.5 Input Use Efficiency in Maize Production

The resource use efficiency (r) was calculated as the ratio of the marginal value products (MVP) to the corresponding marginal factor costs (MFC). The marginal value products (MVP) of the maize farmers were calculated using the estimated coefficients of the exogenous variables, and the marginal factor cost (MFC) was determined using the current inputs unit market price (Adesina & Omonona, 2019).

Table 7. Resource use efficiency analysis of maize seed production in the study area

Input	G.M (Geometric Mean)	Coefficient	MVP	MFC	r (MVP/MFC)	Efficiency (Decision rule)	%Adjustment req.
Seed cost	3457.95	0.485	16.77	1	16.77	Under-utilized	94.03
Labor cost	57471.6	-0.01	-0.020	1	-0.020	Over-utilized	4905.29
FYM cost	51803.4	0.182	0.420	1	0.420	Over-utilized	-137.98
Fertilizer cost	19	0.023	144.77	1	144.77	Under-utilized	99.30
Tillage cost	9048.48	0.031	0.409	1	0.409	Over-utilized	-144.05
Management cost	3992.67	0.084	2.516	1	2.516	Under-utilized	60.25

Source: Field survey (2023)

The ratio of MVP and MFC of Farm Yard Manure and tillage for maize production was positive and less than one, which indicated that in the study area farm yard manure and tillage for maize cultivation was over-utilized. Therefore, farmers should decrease the use of farm yard manure and tillage to attain an efficiency level.

The ratio of MVP and MFC of seed, fertilizer, and management was found to be 16.77,144.77 and 2.516 for maize cultivation, positive and more than one which indicated that in the study area, the use of seed, fertilizer, and management for maize production was under-utilized. Therefore, the farmers should increase the use of seed, fertilizer, and management to attain efficiency in maize cultivation.

The ratio of MVP and MFC of labor was found to be (-0.020) for maize cultivation was negative and less than one, which indicated that in the study area, the use of labor for maize production is over-utilized. Therefore, farmers should decrease the use of labor to attain efficiency considerably

3.6 Constraints Faced by Farmers

Table 8. Problems associated with maize seed production in the study area

Problems	**Most serious**	**Serious**	**Moderate**	**Less serious**	**Least serious**	**Index value**	**Score**
Disease/Insect incidence	40	16	5	4	2	0.86	I
Lack of Irrigation Facility	15	30	10	7	5	0.70	II
Natural Hazards	7	18	20	16	6	0.61	III
Lack of technical services	1	15	22	10	19	0.50	IV
Labor Shortage	4	20	11	18	14	0.33	V

Source: Field survey (2023)

The information provided highlights the difficulties faced by producers of maize seeds. To examine the issues facing farmers from each perspective, five key issues were identified. Infestations with insects and the spread of diseases are the main, serious issues with maize seed production. Lack of irrigation resources is a second major issue. Learning how to manage insect pest incidents is crucial for farmers.

4. Conclusions

The findings of this study demonstrate that maize seed production exhibits financial viability and represents a profitable enterprise. Moreover, the Rolpa district has been identified as a highly productive and promising area for maize seed production. However, the research reveals that maize seed production is used inefficiently. In light of the data obtained, it is predicted that in order to ensure optimal allocation of resources in the research area, reducing the costs of human labor, farmyard manure (FYM), and tillage, and increasing expenditures on seeds, chemical fertilizers, and management costs will provide a more effective production. However, the study reveals that the inputs employed in maize seed production are being inefficiently utilized. To achieve optimal allocation of resources, it is recommended to increase expenditure on seed, chemical fertilizers, and management costs, while reducing costs associated with human labor, farmyard manure (FYM), and tillage. By ensuring rational utilization of resources, maize seed production can evolve into a commercially more viable venture with enhanced profitability and improved food availability. Further research and implementation of efficient resource management strategies are warranted to fully realize the economic potential of maize seed production in the study area.

Annex

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.433	6	.072	5.423	.000[b]
	Residual	.798	60	.013		
	Total	1.231	66			

a. Dependent Variable: ln Total return

b. Predictors: (Constant), ln Management cost, ln labor cost, ln seed cost, ln Tillage cost, ln Fertilizer cost, ln FYM cost

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	11.734075546264648	12.119148254394531	11.921361756345663	.080980951008126	67
Residual	-.200426161289215	.354093074798584	.000000000000002	.109964822661660	67
Std. Predicted Value	-2.313	2.442	.000	1.000	67
Std. Residual	-1.738	3.070	.000	.953	67

a. Dependent Variable: ln Total return

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