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Research Article

Analysis of profitability and resource use efficiency among banana farmers in Chitwan, Nepal

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ABSTRACT
Banana is a high value crop with immense potential to enhance production through area expansion and improved production practices. This study aimed to investigate the profitability and resource use efficiency of banana enterprises in Chitwan, Nepal. Primary data were obtained from 135 banana growers and 45 traders by using semi-structured questionnaire. Descriptive and inferential statistics, along with the Cobb Douglas production function, were used to estimate resource allocation. The study reported average gross profit of 5211.65/kattha and benefit cost ratio of 1.52, indicating that banana farming is profitable. The analysis of resource use efficiency showed the under-utilization of plantation, chemical fertilizers, and micronutrients, while farm-yard manure, labor, pesticide, and irrigation were overutilized. For the optimum allocation of resources, the cost of plantation, chemical fertilizers, and micronutrients needs to be increased by 59%, 14%, and 46%, respectively, while the cost of farmyard manure, labor, pesticide, and irrigation needs to be decreased by 209%, 250%, 194%, and 84%, respectively. Disease, insect and weed infestation were the main problem. during production, while the domination by middle men was found as the major issues for marketing. The study recommends enhancing extension services through better technologies and training in optimizing inputs.
Keywords: Banana, Efficiency, Producers share, Profit

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INTRODUCTION
Nepal is an agrarian nation, with the majority of the population involved in agricultural sector for their livelihoods. About 65% of the population are involved in agriculture, which contributes about 28.29% to the national Gross Domestic Product (GDP) (MoAD, 2018). Banana is a high value agricultural commodity, contributing about 21% of total summer fruit production, and crucial to improve the livelihood due to its high market demand and resilience in a changing climate (Pandey *et al.*, 2017; Ranjitkar *et al.*, 2016). In Nepal, banana is cultivated across 16,615 ha of land, with the production totaling 278,890 tons (FAOSTAT, 2020). However, the domestic production fails to meet national demand. Consequently, Nepal imports about 54,345 tons of banana and related products, valued at US$6836 thousand (FAOSTAT, 2020).

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Chitwan district is one of the dominant district in banana production, with production increased nearly by about 566% in the past decade (Ghimire *et al.*, 2016). The climatic condition, soil, and market had played an immense role in the growth of banana farming in Chitwan.. Prime Minister Agriculture Modernization Project (PMAMP) had declared the Chitwan district as a Banana super-zone.. PMAMP had envisioned becoming self-reliant in the banana sector within 7 years (MoAD, 2017).

Banana is a profitable enterprise in Chitwan as indicated in several prior literature (Dulal & Kattel, 2020; Ghimire *et al.*, 2019, Shrestha *et al.*, 2018). However, farmers continue to face significant challenges such as diseases and pests, low-quality planting materials, and lack of credit access. This indicated that profitability does not guarantee efficiency. With the increasing population and awareness regarding the nutritional value, the domestic demand is growing day by day. Thus, it is necessary to increase production. One of the effective approache to enhance the production level is through the efficient use of resources. Tinzaara *et al.* (2018) reported that the banana growers in developing nations were not utilize the resources efficiently. They found lack of technical knowledge to improve the productivity. All the farmers aim to maximize the profit level and minimize the cost through efficient resource use. Therefore, the concept of resource use efficiency is essential to increase agricultural production for resource-constrained farmers of developing nations (Goni *et al.*, 2013). It is possible to be self-reliant in banana production in Nepal by improving investment and advancing the production system (Joshi *et al.*, 2017).

There is limited research that quantify the efficiency of resource use in banana production system in Chitwan. Without proper understanding of resource use patterns of several key inputs, policy interventions remain ineffective and farmers may miss opportunities to reduce costs and maximize their profitability. Therefore, this study not only investigate profitability, but also provide empirical evidence into optimizing input allocation, which ultimately assist policymakers to formulate policies to address issues such as low productivity and input wastage.

METHODOLOGY

Study Area

Chitwan district, which is located centrally in Nepal, was purposively selected for study, as the district is one of the primary hubs for banana production. The Government of Nepal had prioritized banana production in Chitwan under the One Village One Product (OVOP) program. High degree of commercialization in the banana sectors, along with increasing cultivation area, make it a favorable place to conduct the study. As per MoALD (2019), banana spans over 2329 ha, with production recorded at 28,193 mt and productivity at 12.11 mt/ha in Chitwan. Ratnanagar, Khairahani, and Kalika municipalities were selected purposively as the study areas.

Sample Size and Sampling method

A sampling frame consisting of 403 producers registered in the Chitwan Banana Producer Association (CPBA) across the three municipalities was obtained. The sample size was determined using Yamane's (1967) formula with a 7% margin of error, resulting in 135 respondents. Simple random sampling was applied to select 50 respondents each from Ratnanagar and Kalika, and 35 respondents from Khairahani, which were selected

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proportionate to the population distribution (Table 1). Additionally, 45 traders were selected by using snowball sampling to analyse marketing scenarios.

$$n = \frac{N}{1+N\,e^2} \quad \ldots\ldots\ldots\ldots..(1)$$

In the Equation 1, n refers to the sample size to be obtained. N represents the population size included in the sampling frame, and e refers to the margin of error.

Table 1: Estimation of sample size for the study

Municipality	Population size in sampling frame	Required samples size
Ratnanagar	151	50
Kalika	148	50
Khairahani	104	35
Total	403	135

Data Collection and Analysis

Two semi-structured questionnaires were prepared separately in the water portal system for banana growers and traders, and it was deployed by using enumerators for the data collection. Prior to the deployment of these questionnaires, pretesting was performed with five respondents from each municipality and five traders to assess the efficacy. The limitations were assessed and rectified. After successful pretesting, the questionnaires were deployed in the field for the data collection. Focus group discussion was performed in each municipality with 8 progressive farmers and stakeholders to obtain qualitative information on banana farming. After the data collection, the data were refined, coded, and analyzed using both MS Excel 2016 and STATA. The accuracy of data was checked by employing both the cross-tabulation method as well as logical check. Both the descriptive and inferential statistical tests were carried out in the study.

Cost and benefit analysis

Total production costs included both the fixed and variable costs. The fixed cost was computed using the rental value of land and insurance premium cost, while the variable costs included costs incurred by growers during plantation (involving costs incurred during land preparation, buying suckers, and planting suckers), human labor, farmyard manure, chemical fertilizer, micronutrients, pesticides, and irrigation.

Total cost = Total fixed cost + Total variable cost ……………………………….(2)

The gross return was obtained by multiplying the volume with the farm gate price. The gross return was computed using the following formula.

Gross return (NRs.) = Farm gate price (NRs.) × Volume of banana sold (kg) …….……………………….(3)

Gross profit was calculated by subtracting the total costs from the gross return, which is represented in the formula below.

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Gross profit (NRs.) = Gross return (NRs.) - Total cost (NRs.) ……………………………………..…. (4)

Benefit-cost ratio was calculated for profitability assessment. We employed the following formulae to calculate the benefit-cost ratio.
Benefit-cost (BC) ratio = Gross return (NRs.)/ Total cost (NRs.) ………..(5)

Marketing Analysis
Marketing margin refers to the difference between the farm gate price received by farmers and the price paid by the consumers. The formula for calculating the marketing margin is presented below.

Marketing margin = Retailer price (NRs.)–Farm gate price(NRs.) …………….(6)

Producer share refers to the price received by the farmer, which is expressed as the percentage of the retail price paid by the consumer. The producer's share was estimated by using following formula.
$Ps = (Pf / Pr) \times 100$ ……………………………….(7)

Where, Pf represents the farm gate price, Pr represents the retail price paid by consumer, and Ps represents the Producers share in percentage.

Estimation of resource use efficiency
Cobb-Douglas production function was used to estimate the relationship between inputs and output. For the estimation of the Cobb-Douglas production function (CDPF) model, the gross return was as the dependent variable, while the variable costs, such as expenses incurred in plantation, labor, farmyard manure, chemical fertilizer, micronutrients, pesticides, and irrigation, were used as independent variables. The CDPF model can be expressed mathematically as in the equation below.
$Y= \alpha X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6 b^6 X_7 b^7 e^u$ …………………….(8)
In the Equation 8, Y refers to the gross return obtained from banana production in NRs/ha. X1= Cost of plantation, which includes expenses incurred during land preparation, buying suckers, and planting suckers (NRs/ha), X2 = Cost of human labor (NRs/ha), X3 = Cost of chemical fertilizers (NRs/ha), X4 = Cost of farmyard manure (NRs/ha), X5 = Cost of micronutrients (NRs/ha), X6 = Cost of pesticides (NRs/ha), and X7 = Cost of irrigation (NRs/ha). b1, b2…., b7 represent the coefficients of the respective independent variables included in the model. e refers to the base of the natural logarithm, and u represents the stochastic error term.
As the CDPF model is non-linear, the above equation is transformed into a linear form by employing a logarithmic transformation, which is expressed as below.
$\text{Log } Y = \alpha + b_1 \text{Log}X_1 + b_2 \text{Log}X_2 + b_3 \text{Log}X_3 + b_4 \text{Log}X_4 + b5\text{Log}X5 + b_6 \text{Log}X_6 + b_7 \text{Log}X_7$ …………………..(9)
The CDPF model offers the advantage of beta coefficients, which represent the partial elasticity of the inputs employed. The summation of all the partial elasticities is referred to as the return to scale, which is represented below.

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Return to scale (RTS) = $\sum_{i=1}^{7} \beta_i$ …………………(10)

In the Equation 10, βi represents the beta coefficients derived from CDPF modelling. The interpretation of RTS can be performed as follows: an RTS value exceeding the value of 1 implies increasing return to scale, an RTS value equal to 1 suggests constant return to scale, and an RTS value below 1 indicates decreasing return to scale. The value of RTS can also be interpreted pertaining to the zone of production. RTS value greater than 1 corresponds to Zone I of the production function, which indicates potential for more efficient utilization of inputs. The value of RTS equal to 1 signifies Zone II (rational zone) of the production function, which suggests that resources are optimally utilized, and an RTS value below 1 indicates Zone III of the production function, which implies that the resources are not efficiently utilized, i.e., characterized by excessive use of inputs while the increment in output is minimal.

The estimation of the resource use efficiency was done utilizing the efficiency ratio, which represents the ratio of Marginal Value Product (MVP) and Marginal Factor cost. The efficiency ratio can be expressed as below.

Efficiency ratio (r) = MVP/MFC ……………………..(11)

Marginal Value Product (MVP) refers to the value derived from employing an additional unit of input that leads to an increase in output. Marginal Factor Cost (MFC) can be defined as the additional costs resulting from the acquisition of an additional unit of inputs. As both the dependent and independent variables are estimated in monetary values, marginal factor cost was set to 1. This ensures the standardization of marginal factor cost, which ensures consistency and comparability in analysis, facilitating more lucid interpretation of resource use efficiency. The marginal value product (MVP) can be calculated using the following formula.

$$\text{MVP} = (\text{bi} * \overline{\text{Yi}}) / \overline{\text{Xi}}$$ ………………………..(12)

In the Equation 12, b_i refers to the beta coefficient of corresponding inputs X. $\overline{Yi}$ denotes the geometric mean value of gross return, and $\overline{Xi}$ denotes the geometric mean of ith input. At last, the estimation of relative percentage change in marginal value product of each employed resource can be computed as below.

D = (1 – MFC/MVP) x 100 ……………………..(13)

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

The decision rule for resource use efficiency can be interpreted using the value obtained from the efficiency ratio. If the value of the efficiency ratio is 1, then the resources are optimally utilized. The value of an efficiency ratio greater than or less than 1 indicates that the resources are underutilized and overutilized, respectively.

Index of importance

The index was primarily concerned with qualitative data. On the basis of frequencies of responses, the weighted index was calculated. The perceptions of farmers regarding the issues related to production and marketing were analyzed using a five-point scale, which categorized the problems as most serious, serious, moderately serious, slightly serious, and no problem. Weightage value was provided based on priority, with a score value of 5 for most

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serious, 4 for serious, 3 for moderately serious, 2 for slightly serious, and 1 for no problem. The index of importance for the problem was computed to draw the conclusion and make reasonable decisions. The index of importance was calculated using the following formula.

$$I_{imp} = \sum \frac{S_i f_i}{N} \quad \text{.................................(14)}$$

Where, I_{imp} denotes Index of importance, S_i refers to the ith scale value (1,2,3,4,5), f_i refers to frequency of i^{th} importance perceived by the respondents, and N refers to the total number of respondents.

RESULTS AND DISCUSSION

Analysis of cost, return and profitability based on farm size

To provide a more detailed investigation of profitability relative to farm size, we classified the farms according to their cultivated area. The farms were classified into three categories: small farm, medium farm, and large farm. A small farm category (<10 kattha) constitutes 34 percent of the total surveyed farms, which amounts to 46 farms. Medium-sized farms (10-40 kattha) constitute about 48% of the total surveyed farms, totaling 65 farms, whereas large farms (>40 kattha) account for 18%, i.e., 24 farms. Figure 2 illustrates the distribution of banana farms based on farm size in the study area.

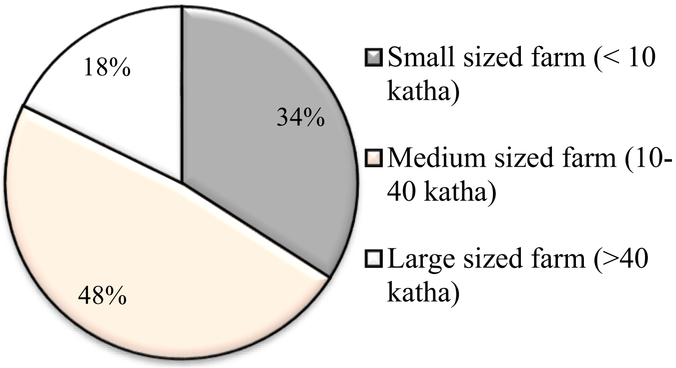

Figure 1: Distribution of farm based on farm size

Cost involved in banana cultivation

Table 2 represents the cost incurred by farmers in banana production. The overall expenses incurred in banana production amounted to NRs. 10,263.4 per kattha. The total fixed cost and variable cost in banana production were NRs. 2393.35 and NRs. 7,870.04 per kattha, respectively. Fixed cost accounts for approximately 23.32% of total cost, whereas the variable cost constitutes 76.68%. Rental value covers the largest share of total cost at 22.17%, which is followed by chemical fertilizer at 19.04%, plantation at 18.76%, human labor at 15.24%, farmyard manure at 10.18%, pesticides at 8.01%, irrigation at 1.33%, and insurance premium at 1.15%.

Aligning with our results, Dulal and Kattel (2020) reported a total cost of NRs. 9.765.76/kattha in banana farming. Ghimire *et al.* (2019) found the average production cost of NRs. 455,857.60/ha, with the highest proportion constituted by rent, followed by labor,

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machines, and planting materials in banana cultivation. The average total cost of banana cultivation was found to be NRs. 358,546.5, with human labor contributing 19.88% of the total cost, animal/machine (19.23%), and land lease (14.8%) (Shrestha *et al.*, 2018). Singh *et al.* (2017) reported a total cost of Rs. 246130.83/ha in the cultivation of bananas in UP, India.

Table 2: Total cost involved in banana production

Particulars	Cost (NRs)	Share (%)
Plantation	1925.64	18.76
Human labor	1564.34	15.24
Farm-yard manure	1045.32	10.18
Chemical fertilizer	1954.63	19.04
Micronutrient	422.03	4.11
Pesticides	821.62	8.01
Irrigation	136.46	1.33
Total Variable cost	7870.04	76.68
Rental value	2275.67	22.17
Insurance premium	117.68	1.15
Total fixed cost	2393.35	23.32
Total cost	10263.4	100

The largest farm category incurred the highest average production costs at NRs. 12,244.00/kattha, which is followed by the medium farm category at NRs. 10,058.00/kattha. The minimum expense was attributed to the small farm category, amounting to NRs. 9,900.40/kattha (Table 3). The reason for incurring low cost may be due to the subsistence nature of farming among the small farm category utilizing minimal inputs. The small farmer attempted to lower costs to secure high profitability by employing the resources below the recommended levels. The highest cost incurred by the large farm category can be attributed to commercial and intensive-type farming among large-scale farmers. Shrestha *et al.* (2018) and Dulal and Kattel (2020) also reported similar findings in Nepal. They found that the highest production expense was incurred by large farms, which is followed by moderate and small farms. Also, Kumari *et al.* (2021) revealed that the average production cost was incurred highest by large farms (NRs. 142114), followed by medium farms (NRs. 135937) and small farms (NRs. 126103) in the Vaishali district of Bihar, India.

Table 3: Average production cost incurred per kattha based on farm category

Farm category	Mean	Std. Deviation	Maximum	Minimum	Range
Small (<10 kattha)	9900.4	2587.21	17425	5362.86	12100
Medium (10-40 kattha)	10058	2327.091	15561.62	4335	11200
Large (>40 kattha)	12244	1345.873	14053.25	9065	4988.25
Total	10263.4	2458.024	17425	4335	13100

Table 4 showed that the largest farm category achieved the highest average return per kattha (NRs 19239.68), followed by the medium farm (NRs 15341.05) and small farm category (NRs 14537.94). The average return from banana cultivation was NRs. 15475.05 per kattha. The superior return observed in large farms may result from better input management along with greater bargaining power in large-scale cultivation. In alignment with our findings,

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Shrestha *et al.* (2018) also reported the lowest return per bigha for small banana farms (NRs. 349428.57) and the highest for large-sized banana farms (NRs. 381085.72).

Table 4: Average return obtained through sales of banana per kattha

Farm category	Mean	Std. Deviation	Minimum	Maximum	Range
Small (<10 kattha)	14537.94	3920.13	7142.86	28750	21607.14
Medium (10-40 kattha)	15341.05	3454.28	7692.31	25000	17307.69
Large (>40 kattha)	19239.68	2545.80	13571.43	22625	9053.57
Total	15475.05	3848.98	7142.86	28750	21607.14

The findings of average gross profit per kattha are provided in Table 5. The findings showed that average gross profit was achieved highest by large farms, i.e., 6,996.69/kattha, which is followed by medium farms (NRs. 5,282.69/kattha) and small farms (NRs. 4637.49/kattha). The average gross profit for all the farms in the study area was found to be NRs. 5211.65/kattha. Table 6 presented the benefit-cost ratio (BC) based on the farm category. The study revealed a B:C ratio of 1.52 in the study area. This indicates that banana farming was a profitable enterprise. The BC ratio of 1.52 states that with each rupee invested, a total return of 1.52 rupees is achieved. Likewise, the result revealed that banana farming was profitable in all farm size categories. The highest BC ratio was found among large farms (1.57), which was followed by medium farms (1.53) and small farms (1.47).

Similar with our results, Shrestha *et al.* (2018) also reported the lowest gross margin among the small farm and the highest gross margin among the large farm. They reported the average gross margin among all farm categories to be NRs. 131,262.33/bigha. In addition, they also found the highest BC ratio among large farms (1.56), which is then followed by medium farms (1.54) and small farms (1.53). Dulal and Kattel (2020) also reported similar findings with an average benefit-cost ratio of 2.18. As per the report of DoAD (2076), the benefit-cost ratio was reported as 1.42 in banana production. Ghimire *et al.* (2019) found a benefit-cost ratio of 1.50 in their study. Rama Krishna *et al.* (2017) reported a benefit-cost ratio of 1.53 in India.

Table 5: Average gross profit obtained per kattha

Farm category	Mean	Std. Deviation	Minimum	Maximum	Range
Small (<10 kattha)	4637.49	2137.66	457.50	11325	10867.50
Medium (10-40 kattha)	5282.70	1544.30	2115.39	9644	7528.62
Large (>40 kattha)	6996.69	1745.96	1372.86	8571.75	7198.89
Total	5211.65	1985.96	457.50	11325	10867.50

Table 6: Benefit cost ratio analysis

Farm category	Average cost	Average return	Average B:C ratio
Small (<10 kattha)	9900.4	14537.94	1.47
Medium (10-40 kattha)	10058	15341.05	1.53
Large (>40 kattha)	12244	19239.68	1.57
Total	10263.40	15475.05	1.52

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Marketing analysis

Marketing margin and producer share

Table 7 presented the price spread and producer share categorized by farm size. The result presented in Table 7 showed that the average farm gate price was NRs. 35.28/dozen for small farms, NRs. 36.15 for medium farms, and NRs. 38.61 for large farms. The overall average farm gate price was NRs. 36.68. The average retail price was NRs. 77.09/dozen. The average marketing margin for small, medium, and large farms was NRs. 41.81, NRs. 40.94, and NRs. 38.48, respectively. The average marketing margin for all farms was NRs. 40.41. The producer shares for small, medium, and large farms were 46%, 47%, and 50%, respectively. The average producer share was 48% in the overall farm. In alignment with our findings, Shrestha *et al.* (2018) reported an average marketing margin of NRs. 3.61/finger (43.42/dozen) and a producer share of 44.46% in banana production. Ghimire *et al.* (2019) also found an average marketing margin of 43.59/dozen and a producer share of 44.90%.

Table 7: Marketing margin and producer share based on the farm category

Farm category	Producer price	Retailer price	Marketing margin	Producer share
Small (<10 kattha)	35.28	77.09	41.81	46%
Medium (10-40 kattha)	36.15	77.09	40.94	47%
Large (>40 kattha)	38.61	77.09	38.48	50%
Total	36.68	77.09	40.41	48%

Identified marketing channel of banana from farm to consumer

Marketing channels play a crucial role in the distribution of products from producer to end consumers. Due to the short shelf life of bananas, it is essential to expedite the safe disposal of bananas in the market following harvesting. Producers, wholesalers, retailers, and consumers are the key players involved in the production, marketing, and consumption chain. The study found the four channels being prevalent within the study areas for the marketing. The identified marketing channels are presented below:

Channel 1: Producer – Supplier – Wholesaler – Retailer – Consumer
Channel 2: Producer – Local collector – Wholesaler – Retailer – Consumer
Channel 3: Producer – Wholesaler – Retailer – Consumer
Channel 4: Producer – Retailer – Consumer

Selling practice preferred in the study area

Two types of selling practice were observed in the study area, i.e., contract selling and non-contract selling. Figure 3 illustrated the prevalent selling practice within the study areas. The majority of the respondents, i.e., 67%, followed non-contract selling practices, while only 33% of the respondents reported contract-type selling practices where they sell their farm produce to a pre-harvest contractor. Traders were found to prefer the non-contract system due to market volatility and storage issues.

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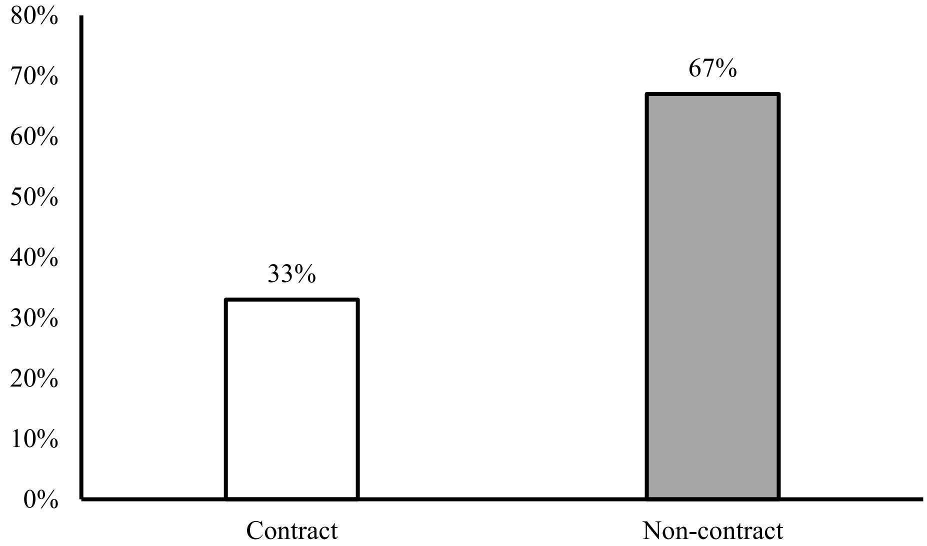

Figure 2: Selling practice prevalent in the study areas

Production function analysis

The CDPF model was employed to evaluate the factors affecting the gross return in banana production. The dependent variable included in the model was gross revenue per kattha, whereas the independent variables were variable cost components. The findings from the CDPF model are presented in Table 8. The result showed the significant F value at 1%, indicating that the model has good explanatory power. The explanatory variables included in the model explained the variation in the output. The R-squared value was 0.509, which inferred that 50.9% of the variation in the dependent variable is explained by the independent variable, while the remaining 49.1% of the variation is accounted for by unknown factors. Several assumptions of ordinary least squares regression were tested for the validity of the model. The model assumes the normality of residuals, which is assessed using the Shapiro-Wilk test. The test reported a z-value of 0.653, and the p-value (0.257) was reported higher than the significance level of 5%, indicating the normal distribution of residuals.

The normal QQ plot in Figure 4 also positively favors the assumptions regarding the normality of residual terms. In a normal QQ plot, if the points lie exactly on the line, it is a perfect normal distribution; however, we can expect some deviations, particularly near the tail ends. In Figure 4, the points in the normal QQ plot fall exactly on the diagonal line, with some deviation observed at the tail ends. Hence, we can conclude that the residuals are normally distributed. The assumption of linearity of the relationship between dependent and independent variables was assessed using the residual to the fitted line in Figure 4. The residual to the fitted line showed that there exists a linear relationship, as the residuals form an equal spread around the horizontal line without any distinct pattern.

Another important assumption is constant variance of the error term, or homoskedasticity, which is assessed by employing the Breusch-Pagan test. The chi-square value of the Breusch-Pagan test was found to be 1.61, with a p-value of 0.205. This indicated the failure to reject the null hypothesis of homoskedasticity. Hence, the assumptions of constant variance or absence of heteroskedasticity in the model hold. The model assumes the absence of a high degree of correlation or multicollinearity among the independent variables. The existence of

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multicollinearity among the explanatory variables results in spurious outcomes.

For testing the existence of multicollinearity among the independent variables, we used the Variance Inflation Factor (VIF). The mean VIF was calculated as 1.16, indicating the absence of multicollinearity. The Ramsey Reset test, also known as the Ovtest, was utilized for assessing the omitted variable bias. The null hypothesis for Ovtest assumes the absence of omitted variable bias or that the model is correctly specified. The F value of Ovtest was calculated to be 0.35, with the p-value of 0.257. We cannot reject the null hypothesis at a significance level of 5%, indicating that the model does not have omitted variable bias or is correctly specified. The Durbin-Watson test (DW) was employed to test whether the residuals are autocorrelated or not. The DW statistic was calculated at 2.118, i.e., near the value of 2, which indicates that the residuals are not autocorrelated.

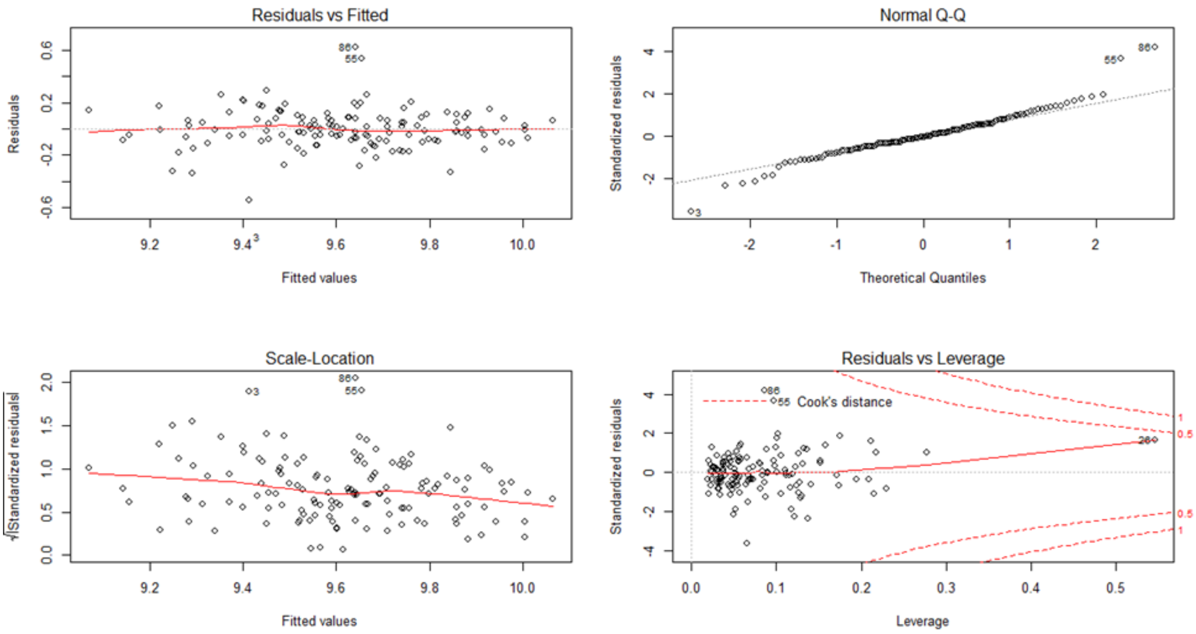

Figure 3: Residual vs fitted and Normal Q-Q plots

Among the variable cost components, plantation cost, farmyard manure, chemical fertilizer, micronutrients, and human labor were positively and significantly influence the gross revenue from banana production. The findings revealed that a 1% increase in the cost of plantation, farmyard manure, chemical fertilizer, micronutrients, and human labor led to increases in gross revenue by 0.324%, 0.015%, 0.165%, 0.029%, and 0.039%, respectively. Similarly, the result found the positive coefficients for irrigation and pesticides. The coefficient of irrigation and pesticides indicates that a 1% increase in these expenses leads to a 0.017% and 0.004% increase in gross revenue, respectively. However, the coefficients of irrigation and pesticides were non-significant. Consistent with our findings, Phularaa *et al.* (2020) reported that expenses incurred in planting material, manures, fertilizers, and micronutrients had a significant positive relation with yield in their study on banana production in Kailali, Nepal. Dulal and Kattel (2020) found a significant positive association between expenses incurred in land preparation, suckers, labor, and fertilizer with gross return, while they reported a significant negative relationship between manure cost and gross return. Similarly, Ghimire *et al.* (2019) also reported a significant positive impact of costs incurred in fertilizer, manure,

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and labor on gross return in banana production. The return to scale was calculated at 0.611, indicating diminishing return to scale. It is the summation of all the coefficients of independent variables included in CDPF analysis. This suggests that a 1% increment in all the expenses of variable inputs results in a 0.611% increase in gross revenue. The return to scale lower than 1 also indicates that the farmers involved in banana production were operating at Zone III of the production function. It infers that the inputs utilized in banana production were not optimally utilized. The decreasing return to scale was consistent with findings reported by Dulal and Kattel (2020) and Mahalakshmi *et al.* (2016).

Table 8: Production function analysis

Return	Coefficient	Std.Err	t-value	p-value	95% confidence interval		Sig
Plantation	0.342	0.052	6.56	0.000	0.239	0.445	***
Farm-yard manure	0.015	0.008	1.79	0.077	-0.002	0.031	*
Chemical fertilizer	0.165	0.040	4.14	0.000	0.086	0.244	***
Micronutrient	0.029	0.011	2.71	0.008	0.008	0.049	***
Human labor	0.039	0.006	6.05	0.000	0.026	0.052	***
Pesticides	0.017	0.020	0.91	0.367	-0.021	0.056	
Irrigation	0.004	0.008	0.12	0.907	-0.015	0.022	
Constant	5.116	0.463	11.06	0.000	4.201	6.032	***
Mean dependent variable			9.616	SD dependent variable			0.254
R-squared			0.509	Number of observations			135
Adjusted R-squared			0.482	F-test			55.286
Akaike crit. (AIC)			-68.426	Prob > F			0.000
Bayesian crit. (BIC)			-45.185	Durbin-Watson test			2.118
Variance Inflation Factor (VIF)			1.16	Shapiro Wilk test			z = 0.653 Prob>z = 0.25699
Breusch Pagan Test	$chi^2(1) = 1.61$, Prob $>Chi^2$ = 0.205			Ramsey RESET test (Ovtest)	F (3, 124) = 0.35, Prob>F = 0.786		

****, **, and * indicate significant at 1%, 5%, and 10%.*

Estimation of resource use efficiency

The study found that resources employed in banana production were not optimally utilized (Table 9). The efficiency ratios of plantation cost, chemical fertilizer, and micronutrients were found to be greater than one, which indicates that these resources were underutilized. However, farmyard manure, labor, pesticides, and irrigation were found to be less than one, suggesting that these resources were overutilized. The study reported the requirement of necessary adjustment in resource use to achieve optimum allocation of resources. The result showed that the cost of plantation, chemical fertilizer, and micronutrients should be increased by 59%, 14%, and 46%, respectively. In contrast, the cost of farmyard manure, labor, pesticides, and irrigation needs to be decreased by 209%, 250%, 194%, and 84%, respectively. A study by Dulal and Kattel (2020) found that the resources were not optimally utilized in banana production. They found that the allocative efficiency of land preparation cost, sucker cost, fertilizer cost, and labor cost was less than one and positive, indicating that these resources were underused, while the manure cost, irrigation cost, pesticide cost, and micronutrient cost were negative, inferring overuse. Sakamma *et al.* (2018) found that the sucker, FYM, irrigation, and chemical fertilizer were underutilized, while the human labor, bullock labor, and pesticides were overutilized in banana cultivation in the hilly region of Karnataka, India. Dhakal *et al.* (2015) reported underutilization of resources such as seed, fertilizer, and irrigation cum insecticides, while they found overutilization of tractor power and human labor in mustard production in Chitwan. Similarly, Sapkota *et al.* (2018) revealed excessive use of FYM, human labor, and tractor power, while they noted an underuse of seed and chemical fertilizer in maize production.

Table 9: Estimation of resources use efficiency in banana production

Variables	Coefficient	Geometric mean	MVP	MFC	r	Efficiency	D = (1-1/r)
Plantation	0.342	2101.361	2.441	1	2.441	Underused	59%
Farm-yard manure	0.015	694.7305	0.323	1	0.323	Overused	-209%
Chemical fertilizer	0.165	2140.023	1.157	1	1.157	Underused	14%
Micronutrient	0.029	236.814	1.837	1	1.837	Underused	46%
Human labor	0.039	2046.041	0.286	1	0.286	Overused	-250%
Pesticide	0.017	749.901	0.340	1	0.340	Overused	-194%
Irrigation	0.004	110.350	0.544	1	0.544	Overused	-84%
Gross return		15001.045					

Problems during the prodcution and marketing of banana

Indexing was employed to investigate the major problem perceived by banana growers during the production and marketing. Table 10 showed the constraints faced by farmers during the cultivation of bananas along with their relative ranking. Disease, insects, and weed infestation were perceived by farmers as the most important issue, with an index value of 0.921. It was followed by unavailability of chemical fertilizer (0.759), lack of human labor (0.504), non-availability of agricultural loans (0.495), and lack of access to technical services (0.351). Shrestha *et al.* (2018) also reported disease and pests as the most severe problem perceived by farmers during banana production. Infestation with diseases and pests results in huge economic losses due to low production along with deterioration of fruit quality. Shah and Yadav (2018) reported mainly four diseases in bananas, i.e., Panama wilt, Sigatoka disease, bacterial diseases, or 'moko disease,' and bunchy top of bananas in Nepal.

Table 11 showed the problem perceived by the banana grower during the marketing phase along with their relative ranking. The result showed that middlemen domination is the major issue perceived by banana growers during the marketing phase, with an index value of 0.85. It was followed by fluctuating market prices of bananas (0.76), imports of Indian bananas in the market (0.75), a lack of market information (0.51), and a lack of collection centers (0.49). Middlemen facilitate the movement of produce from the farmhouse to the consumer table; however, the dominating demeanor of middlemen negatively impacted the farmer's ability to receive the justified price for their produce. The middlemen's exploitation poses a significant threat to the profit of farmers.

Table 10: Problem perceived by growers during the production phase

Problems	Relative index	Rank
Diseases, insects, and weed infestation	0.921	I
Unavailability of chemical fertilizer	0.759	II

Problems	Relative index	Rank
Non-availability of agricultural loan	0.495	IV
Lack of access to technical services	0.351	V
Lack of human labour	0.504	III

Table 11: Problem perceived by the growers during the marketing phase

Problems	Relative index	Rank
Middle men domination	0.85	I
Fluctuating market price of the produce	0.76	II
Import of Indian banana in the market	0.75	III
Lack of market information	0.51	IV
Lack of collection centre	0.49	V

CONCLUSION

The study found that banana cultivation is a profitable agri-enterprises in Chitwan, however inputs in the study siteswere not utilized optimally. Therefore, it is crucial to increase investment in plantation, chemical fertilizers, and micronutrients, while it is necessary to reduce the excessive use of labor, manure, pesticides, and irrigation to to increase efficiency and profitability. Major production constraints perceived by farmers were disease, insect, and weed infestation, while marketing issues arise from the higher margin received by middlemen.

To address these key issues and enhance the potential of banana sector, efforts needs to be provide training farmers on orchard management, Integrated Pest Manageemnt (IPM) strategies, and facilitate for the adoption of disease-free planting materials. In addition, support should be strengthened through improved credit access, effective insurance policies, and promotion of mechanization. Finally, it is important to assist producer by establishing producer led collection center and improve market information for a fairer return. It is possible to make Nepal self-sufficient in bananas, and all the sectors involved in banana production and marketing need to work collaboratively to address these issues.

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Authors' contributions

S. Shrestha, R. Thakali, and S. Kandel designed the research plan. S. Shrestha, R. Thakali, and S. Kandel collected the data from the field survey. S. Shrestha analyzed the data, and S. Shrestha, R. Thakali, and S. Kandel prepared the manuscript. R. Subedi provided guidance during the field survey and provided valuable suggestions to finalize this manuscript. The final form of the manuscript was approved by all authors.

Conflicts of Interest

The author declares no conflict of interest.

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Ethics Approval Statement

This study involved human participants who provided informed consent. All procedures were conducted in accordance with institutional ethical guidelines, and necessary approvals were obtained from the relevant ethics committee.

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