PROFITABILITY AND RESOURCE USE EFFICIENCY OF TOMATO PRODUCTION UNDER PLASTIC TUNNEL IN KATHMANDU, NEPAL

Srijana Shrestha[1]*, Pratiksha Sharma[1], Shiva Chandra Dhakal[1], Samyam Pandit[1]

[1]Department of Agricultural Economics and Agribusiness Management, Agriculture and Forestry University, Nepal

ARTICLE INFO

Keywords:
Benefit-cost ratio,
Cobb-Douglas production function,
efficiency,
regression,
return to scale

[*] Corresponding author:
srijana.stha1@gmail.com
Tel: +977 9845674917

ABSTRACT

Tomato is one of the most important vegetable crops in Nepal, but its productivity and profitability are constrained by inefficient resource use and production-related challenges. A study was conducted in the Kathmandu district in 2024 to analyze the profitability and resource use efficiency of tomato production under plastic tunnels. Data from 150 farmers, selected by using simple random sampling technique, from Chandragiri, Tarakeshwar, and Kirtipur municipalities were collected through interviews using a semi-structured questionnaire. Analysis was performed using descriptive statistics, benefit-cost ratio, Cobb-Douglas production function, and multiple linear regression with SPSS and STATA software. The average production cost was NRs. 31.74 per kg of tomato, with a total production cost NRs. 1,979,921 per hectare, an average yield of 65,917 kg per hectare, a gross revenue of NRs. 3,534,467 per hectare, and a benefit-cost ratio of 1.77. Land rent, labor, seed, pest management were positively associated with gross revenue. The return to scale was nearly constant at 0.998. Resource use efficiency analysis indicated that land rent, labor, seeds, farm yard manure, pest management, and tillage costs were under-utilized, while chemical fertilizer and other associated costs were over-utilized. Key factors positively influencing revenue included education, group membership, extension advisory services, training, credit access, recommended variety use, and drip irrigation. Enhancing efficiency and profitability of tomato farming under plastic tunnel system in Nepal requires addressing inefficiencies, resource pooling, stakeholder collaboration, strong policies, and technology adoption.

1. INTRODUCTION

Agriculture contributes 24.12% to Nepal's Gross Domestic Product (GDP) (MOALD, 2025). According to the National Population and Housing Census (2021), 57.3% of the economically active population were engaged in agriculture (MOALD, 2025). Vegetables, considered high-value crops, have garnered significant attention in Nepal's development initiatives (PACT, 2014), with the potential to alleviate poverty and reduce reliance on imports (NMDP, 2015). Tomatoes, globally the second most important crop after potatoes, are worth around USD 96 billion annually (FAOSTAT, 2024), with production rising 300% over the past four decades (Costa & Heuvelink, 2007).

The growing demand for fresh tomatoes year-round, coupled with higher off-season prices, makes tomato farming a profitable option for improving farmers' livelihoods (Pokharel, 2021). In Nepal, tomato ranks third among vegetable crops, covering 26,291 ha with an annual production of 552,607 metric tons and a productivity of 20.63 mt/ha (MOALD, 2025), thereby meeting the national target of the 15th Five-Year Plan to increase vegetable yields to 20 mt/ha. However, challenges related to production efficiency and profitability still exist, particularly in terms of input use and production systems. Plastic tunnel technology is becoming a popular method for year-round tomato production especially among peri-urban farmers in Kathmandu Valley (Gautam, 2019). Tomato farmers, using plastic tunnels, can earn about NRs. 85,400 per ropani, and 2–3 times more than traditional open-field farming (Budhathoki, 2006). Tunnel farming offers a low-cost solution to stabilize temperatures and produce quality off-season yields (Pal, 2022), yet Nepal still imports large volumes of vegetables, revealing gaps in domestic production.

Despite these advances, inefficiencies in resource use, such as overuse or underuse of land, labor, seeds, and pesticides, limit profitability and productivity (Bhatta & Rijal, 2022; Tambo & Gbemu, 2010). Many studies lack comprehensive economic analyses and overlook socio-economic impacts, institutional support, and factors influencing resource allocation in tunnel farming (Pokharel, 2021; Pal, 2022). Efficiency is the measure of how effectively inputs are transformed into outputs (Otieno et al., 2012). Improving smallholder efficiency through better understanding of economics, resource use and its predisposing factors is crucial for maximizing profits and sustainability (Okello et al., 2019). This study aims to fill gaps by providing a holistic economic assessment of plastic tunnel tomato production in Kathmandu, offering insights applicable to broader regions in Nepal.

2. METHODOLOGY

2.1 Study area

The study was conducted in Kathmandu district of Bagmati Province, Nepal, covering 413.69 sq. km with a population of 2,041,587 (NSO, 2024), the highest density in the country. It lies between 27°27′–27°49′N latitude and 85°10′–85°32′E longitude and is well known for plastic tunnel tomato farming as one of the agricultural production enterprise.

2.2 Sampling procedure and data collection

Purposive sampling method was used to select tomato growing areas under plastic tunnels in Chandragiri, Tarakeshwar, and Kirtipur Municipalities. From 255 growers registered in the Agriculture Knowledge Center (AKC), Lalitpur, and the Project Implementation Unit (PIU), Kathmandu, 150 households, 50 from each municipality, were chosen using simple random sampling. The sample size was determined using Yamane's (1967) formula;

$$n = \frac{N}{1 + N * e2}$$

Where, N is the population size, n is the sample size and e is the margin of error (maintained at 5% in this study).

Both primary and secondary data were used while following standard research ethical procedures. Primary data were collected through face-to-face interviews with a questionnaire, supplemented by key informant interviews and focus group discussions with farmers and agricultural staff. The study was based on cross-sectional data collected from farmers during 2024 tomato production season. However, information on all major inputs, costs, and outputs incurred throughout the complete production cycle, from planting to final harvest, was collected and used for the analysis. Secondary data were obtained from government and non-government reports, annual agricultural statistical books, relevant journal articles, and official websites.

2.3 Data analysis

The collected data were coded and managed in Microsoft Excel and analyzed using SPSS and STATA. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize the respondents' socio-demographic and farm characteristics. Profitability was assessed through benefit-cost ratio (BCR). The Cobb-Douglas production function was used to estimate resource-use efficiency and return to scale, while multiple linear regression was employed to identify factors affecting gross revenue from tomato production under plastic tunnel. Multicollinearity was assessed using the Variance Inflation Factor (VIF).

2.3.1 Descriptive analysis

The socio-demographic and farm characteristics of the respondents were summarized using descriptive statistics, including frequency, percentage, mean, and standard deviation.

2.3.2 Analysis of cost of production

Tomato production costs under plastic tunnel were estimated using the standard cost approach;

$$Total\ cost = Fixed\ cost\ (FC) + Variable\ cost\ (VC)$$

Here, fixed costs included land rent, depreciation of tunnel construction and drip installation, and annual loan interest. Tunnel construction and drip pipe installation costs were depreciated over the expected lifespan of tomato cultivation. Similar approaches were used by Mwangi (2012); Ali et al. (2017); Paudel and Adhikari (2018); and Paudel (2022).

Similarly, total variable costs encompass all ongoing expenses associated with production as calculated by Paudel and Adhikari (2018); Pokharel (2021) and can be expressed as;

$TVC = C_{seed} + C_{media} + C_{tillage} + C_{FYM} + C_{fertilizer} + C_{pest\ management} + C_{intercultural\ operations} + C_{labor} + C_{other}$

Where,

TVC = Total variable cost of tomato production under plastic tunnel (NRs./ha)

C_{seed} = Cost of seed/seedlings (NRs./ha)

C_{media} = Cost of media used for seed sowing (NRs./ha)

$C_{tillage}$ = Cost on tillage by mini-tiller (NRs./ha)

C_{FYM} = Cost of farm yard manure (NRs./ha)

$C_{Fertilizer}$ = Cost of chemical fertilizers (NRs./ha)

$C_{pest\ management}$ = Cost of pesticides, micronutrients, and lure and trap installed (NRs./ha)

$C_{intercultural\ operations}$ = Cost of irrigation, and mulching (NRs./ha)

C_{labor} = Cost of human labor used (NRs./ha)

C_{other} = Other cost of cultivation (repair and maintenance, transportation, etc.) (NRs./ha)

2.4.3 Return and margin analysis

Gross and net margin were calculated following Ali et al. (2017) and Usman (2013).

Gross Margin (NRs.) = Gross return (NRs.) – Total variable cost (NRs.)

Where, Gross return (NRs.) = Total quantity marketed (kg) × Price (NRs./kg)

And, Net margin (NRs.) = Gross return (NRs.) – Total cost (NRs.)

2.4.4 Benefit-cost analysis

The BCR is a quick measure of business profitability, comparing benefits gained per unit of cost. Following Ali et al. (2017); Usman (2013), BCR was calculated as;

$$BCR = \frac{Gross\ return}{Total\ cost}$$

2.4.5 Production function analysis and estimation of efficiency ratios

The Cobb-Douglas production function was used to assess resource use efficiency in tomato production under plastic tunnels. Efficiency was measured as the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC). The state of resource use (i.e., underutilization, optimum utilization, and overutilization) was estimated by following Ali et al. (2017); Dhakal et al. (2015);

The Cobb-Douglas production function is;

$Y = aX_1^{b1}X_2^{b2}X_3^{b3}\ X_4^{b4}\ X_5^{b5}\ X_6^{b6}X_7^{b7}\ X_8^{b8}e^u$

By taking natural logarithm on both side,

$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + u$

Where,

Y = Gross revenue from tomato production under plastic tunnel (NRs./ha)

X_1 = Land rent for tomato production under plastic tunnel (NRs./ha)

X_2 = Human labor cost (NRs./ha)

X_3 = Seed cost (NRs./ha)

X_4 = FYM cost (NRs./ha)

X_5 = Chemical fertilizer cost (NRs./ha)

X_6 = Pest management cost (pesticides, micronutrients, and lure/trap) (NRs./ha)

X_7 = Tillage cost by mini-tiller (NRs./ha)

X_8 = Other associated cost (media, irrigation, mulching, transportation, repair and maintenance, etc.) (NRs./ha)

a = intercept

ln = Natural logarithm

e = Base of natural logarithm

u = Error term

Following Goni et al. (2013) as cited in Dhakal et al. (2015), efficiency can be expressed as;

$$r = \frac{MVP}{MFC}$$

Where,
r = efficiency ratio
MVP = Marginal Value Product
MFC = Marginal Factor Cost
The MVP was estimated by using the formula:

$$MVP_i = b_i * \frac{Y}{X_i}$$

Where,
b_i = Estimated regression coefficients
Y = Geometric mean of total income from tomato production under plastic tunnel
X_i = Geometric mean of i^{th} inputs
Decision rule:
r = 1 or MVP = MFC indicates the efficient utilization of the resources
r > 1 or MVP > MFC indicates the under-utilization of the resources
r < 1 or MVP < MFC indicates the over utilization of the resources
The relative percentage change in MVP of each resource was estimated as follows:

$$D = \left(1 - \frac{MFC}{MVP}\right) * 100 = \left(1 - \frac{1}{r}\right) * 100$$

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

2.4.6 Return to scale (RTS) analysis
Return to scale (RTS) was calculated using the Cobb-Douglas production function:

$$\text{RTS} = \sum bi$$

Where,
b_i = coefficient of i^{th} explanatory variables obtained from OLS regression of Cobb-Douglas production function.
Decision rule:
RTS = 1 indicates the constant return to scale
RTS > 1 indicates the increasing return to scale
RTS < 1 indicates the decreasing return to scale

2.4.7 Factors affecting the revenue from tomato production under plastic tunnel
Gross revenue per hectare from tomato production under plastic tunnels was regressed with socioeconomic, demographic, and social capital factors using multiple linear regression. The effects of independent variables were estimated via the Ordinary Least Squares (OLS) method. Following the Paudel (2022), the regression function used in the model was;

$$\ln(Y) = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + e$$

Where,
Y = Gross revenue from tomato production under plastic tunnel (NRs./ha)
X_1 = Schooling of the household head (years)
X_2 = Economically active members (No.)
X_3 = Membership in farmers group (Yes = 1)
X_4 = Extension advisory service from government (Yes = 1)
X_5 = Training received about plastic tunnel tomato farming (Yes = 1)
X_6 = Access to agricultural credit (Yes = 1)
X_7 = Variety used (Srijana = 1)
X_8 = Irrigation type (Drip = 1)
ln = Natural logarithm
b_0 = constant
e = error term
Variance Inflation Factor (VIF) was used to assess multicollinearity among predictors within the regression model, check homoscedasticity, and validate regression assumptions (Gujarati & Porter, 2009).

3. RESULTS AND DISCUSSION

3.1 Socio-economic and demographic information

Table 1 presents the socio-economic profile of 150 randomly selected tomato farmers cultivating under plastic tunnels. The findings indicate that household heads had an average of 7.7 years of schooling, reflecting a moderately educated farming population. On average, households had 3.25 economically active members (aged 15–59 years), accounting for 68.3% of the total household population. Regarding institutional participation, 56.7% of farmers were members of groups such as farmer organizations, women's groups, or cooperatives, with 42% specifically engaged in farmer groups. Access to agricultural credit was reported by 42.7% of farmers, while only 36% had participated in agricultural training programs. In terms of varietal adoption, four tomato varieties were cultivated, with 'Srijana' being the dominant choice, adopted exclusively by 72.7% of farmers. This highlights its strong adaptability and preference among growers. With respectto irrigation practices, 45.4% of farmers employed drip irrigation, while others relied on sprinkler systems and wells.The results suggest high adoption of improved tomato varieties under tunnel farming. However, the relatively low participation in agricultural training, limited access to credit, and partial adoption of modern irrigation systems point to gaps in the uptake of complementary practices that could further enhance productivity.

Table 1. Socio-economic and demographic characteristics of the respondents in the study area

Continuous Variables	Unit	Mean	SD
Schooling of the HHH	Year	7.70	5.62
Economically active members	Number	3.25	1.30
Categorical Variables	Unit	Frequency	%
Membership	Involved in farmers group, Yes=1	63	42
Training received	Yes=1	54	36
Access to agri. credit	Yes=1	64	42.7
Variety used	Srijana=1	109	72.7
Irrigation type	Drip irrigation, Yes=1	68	45.4

Source: Field Survey, 2024

3.2 Production economics

3.2.1 Cost of production of tomato using plastic tunnel

The average cost of constructing a 28×5 m² bamboo-based plastic tunnel was NRs. 23,647.64, with three tunnels typically accommodated per ropani of land. This finding is consistent with previous studies (Kafle & Shrestha, 2017; Ghimire et al., 2023).

Table 2 summarizes the production costs of tomatoes under plastic tunnels. The mean production cost per hectare was NRs. 1,979,921.33, comprising fixed costs of NRs. 766,466.45 and variable costs of NRs. 1,213,454.88. The total cost was lower than Pokharel (2021); Ghimire et al. (2023), but higher than Kafle and Shrestha (2017); Gautam (2019). Production costs varied significantly across the three municipalities. The total cost was significantly higher in Tarakeshwar and Chandragiri than in Kirtipur.

Table 2. Cost per hectare of tomato production under plastic tunnel

Cost items	Cost (NRs./ha)			Overall	F-value	p-value
	Chandragiri	Tarakeshwar	Kirtipur			
Land rent	367356.74	395565.44	254197.15	339039.78	64.763***	0.000
Depreciated tunnel construction cost	354797.39	354321.99	283615.43	330911.60	3.905**	0.022
Depreciated drip pipe installment cost	76135.60	78040.55	78834.63	77146.52	0.303	0.739
Annual interest on loan	82732.35	180822.46	157715.97	148891.90	9.614***	0.000
Total fixed cost	806359.60	859028.39	634011.38	766466.45	18.420***	0.000
Seed	39472.14	41943.25	27145.04	36186.81	4.404**	0.014
Media	10737.94	12647.11	9121.31	10659.62	1.987	0.142
Tillage	29214.20	26663.44	26596.37	27503.43	2.355*	0.099
FYM	121115.72	125865.01	104884.49	117288.41	5.463***	0.005
Chemical Fertilizer	42903.91	30845.26	32755.81	35871.69	5.897***	0.004
Pest management	320782.62	325215.61	289741.75	311913.33	0.298	0.743

Labor	290316.44	301416.34	252112.39	281281.72	1.910	0.152
Intercultural operation	81981.80	126245.94	107326.02	104910.74	2.297	0.104
Other cost (Repair, management and transportation)	370547.33	309152.79	246521.66	308311.50	3.638**	0.029
Total variable cost	1286747.78	1266358.37	1087258.48	1213454.88	2.857*	0.061
Total cost	2093107.38	2125386.76	1721269.85	1979921.33		

Note: *, **, and *** indicate level of significance at 10%, 5%, and 1%, respectively.
Source: Field survey, 2024

3.2.2 Benefit-cost ratio

The average cost of production was NRs. 31.74 per kg of tomato produced. The average production of tomato under plastic tunnel was 16895.23 kg with an average yield of 65916.94 kg per hectare. This was higher than Gautam (2019); but lower than Khan and Khan (2020). The average revenue from tomato production under plastic tunnel in the study area was NRs. 3534466.52 per hectare. This is higher than the findings of Kafle and Shrestha (2017); Khadka and Adhikari (2021), but lower than Pokharel (2021). The BCR was 1.77, indicating good profitability. This ratio was higher than BCR of 1.5, reported by NARC (2016) for poly-house farming in mid hills, and BCR of 1.34 found by Subedi et al. (2020) for tomato production under open field conditions. Though this was comparable with findings from Kafle and Shrestha (2017); Paudel and Adhikari (2018). Among the municipalities, Tarakeshwar had the highest BCR, followed by Chandragiri and Kirtipur, with no significant differences observed (Table 3).

Table 3. Benefit cost analysis of tomato under plastic tunnel

Variable	Chandragiri	Tarakeshwar	Kirtipur	Overall	F-value	p-value
Production in household (kg)	24938.11	13085.31	12662.28	16895.23	5.265***	0.006
Yield (kg/ha)	69982.85	72623.25	55144.73	65916.94	8.044***	0.000
Gross revenue (NRs./ha)	3752480.42	3894058.86	2956860.27	3534466.52	8.044***	0.000
Gross margin (NRs./ha)	2465732.64	2627700.48	1869601.80	2321011.64	7.988***	0.001
Net margin (NRs./ha)	1659373.04	1768672.09	1235590.42	1554545.18	5.135***	0.007
Cost of production (NRs./kg)	31.36	30.68	33.19	31.74	2.286	0.105
BCR	1.79	1.82	1.70	1.77	0.989	0.374

Note: *, and *** indicate level of significance at 10%, and 1% respectively.
Source: Field survey, 2024

3.3 Production function analysis

Table 4 shows the Cobb–Douglas production function for tomato farming under plastic tunnels. The model was highly significant (p=0.000) and explained 42.18% of variation in gross revenue (R^2 = 0.4218; adj. R^2 = 0.3890). Land rent, labor, seed, pest management, and other costs had a positive and significant effect, indicating that a 1% increase in these inputs raises returns by 0.487%, 0.176%, 0.096%, 0.140%, and 0.033%, respectively. Similar results were reported by Subedi et al. (2020); Khadka and Adhikari (2021); Pal (2022), highlighting the importance of efficient input use.

The sum of the estimated coefficients (0.998) indicates near-constant returns to scale in tomato production, suggesting that a proportional increase in all inputs leads to a nearly proportional increase in output. This finding shows slight variation compared to Kunwar and Maharjan (2019), who reported decreasing returns to scale, and Subedi et al. (2020), who found increasing returns to scale.

Table 4. Production function analysis of tomato production under plastic tunnel

Variables	Coef.	SE	t	P>t
Land rent	0.487***	0.092	5.32	0.000
Labor cost	0.176**	0.068	2.58	0.011
Seed cost	0.096*	0.057	1.69	0.093
FYM cost	0.059	0.093	0.64	0.526
Chemical fertilizer	-0.002	0.003	-0.50	0.620
Pest management cost	0.140***	0.035	4.07	0.000
Tillage cost	0.008	0.022	0.37	0.710
Other associated cost	0.033**	0.014	2.39	0.018
Constant	2.723	1.512	1.80	0.074
Number of observations	150			
F (8,141)	12.86			
Prob>F	0.000			
R-squared	0.422			
Adjusted R-squared	0.389			
Root MSE	0.307			
Return to scale	0.998			
Mean VIF	1.13			

Note: *, **, and *** indicate level of significance at 10%, 5%, and 1%, respectively.
Source: Field survey, 20243.4 Resource use efficiency

3.4 Resource use efficiency

Table 5 showed that several inputs are underutilized, indicating scope for improving input use efficiency under the current production system. The resource use efficiency ratio was highest for seed cost (10.07), followed by land rent (4.91) and labor (2.25). However, land rent in this context represents the cost of land use rather than a policy variable, and its higher value may also reflect farm size differences rather than a direct recommendation for increased land use. Overall, the results suggest that efficiency gains are possible through better allocation and optimization of existing resources rather than simply increasing input use. The results were consistent with findings by Tambo and Gbemu (2010); Subedi et al. (2020); Anthony et al. (2022).

Conversely, chemical fertilizer (-4.18), and other associated costs (0.39), such as irrigation, mulching, media, transportation, repair and maintenance, and miscellaneous were over utilized. The negative marginal value product of chemical fertilizer indicates that its application has exceeded the economically optimal level, implying that additional fertilizer use reduces gross revenue. This aligns with Ibitoye et al. (2015), but in contrast with Tambo and Gbemu (2010); Subedi et al. (2020); Anthony et al. (2022). These results suggest that, under the current input use pattern, efficiency could potentially be improved through better allocation of resources, particularly by addressing over-utilized inputs such as fertilizer and other associated expenditures, while increasing the use of underutilized inputs that show higher marginal returns.

Table 5. Resource use efficiency of tomato production under plastic tunnel

Cost (NRs. ha^{-1})	GM	Coefficient	MVP	MFC	r	Efficiency
Land rent	325947.45	0.487	4.91	1	4.91	Underutilized
Labor	257945.40	0.176	2.25	1	2.25	Underutilized
Seed	31206.00	0.096	10.07	1	10.07	Underutilized
FYM	112698.85	0.059	1.72	1	1.72	Underutilized
Chemical fertilizer	1181.90	-0.002	-4.18	1	-4.18	Over-utilized
Pest management	234215.70	0.140	1.97	1	1.97	Underutilized
Tillage	23235.22	0.008	1.13	1	1.13	Underutilized
Other associated	283174.02	0.033	0.39	1	0.39	Over-utilized

Source: Field survey, 2024

3.5 Factors affecting revenue

Multiple linear regression identified factors affecting revenue from tomato farming under plastic tunnel (Table 6). The model explained 54% of revenue variation, and the F-test was significant at 1%, confirming predictor relevance. Multicollinearity was not an issue, with a mean VIF of 1.99.

a. *Education*

The schooling years of the household head are positively associated with tomato farm revenue at the 10% significance level, indicating that better-educated farmers tend to achieve higher revenue, likely due to improved decision-making and adoption of better practices. This aligns with Adejoh et al (2010), and Ibitoye et al. (2015).

b. Membership

Membership in farmers' groups positively associated with revenue at the 10% level, suggesting that members tend to achieve higher revenue, possibly due to better access to information and collective benefits. This is consistent with the findings of Mwaura (2014).

c. Extension advisory service

Extension services from the government positively influence revenue, indicating that farmers receiving extension support tend to perform better in terms of revenue. This was in accordance with Ibitoye et al. (2015); Shrestha et al. (2016).

d. Training

Training on plastic tunnel tomato farming is positively and significantly associated with revenue at the 1% level, reflecting better practices and technology adoption among trained farmers. The findings supported the conclusions of Shrestha et al. (2016).

e. Access to agricultural credit

Access to agricultural credit positively and significantly affects revenue at a 5% level. This implies that credit users tend to have higher investment capacity and better farm performance. Shrestha et al. (2016) also reported that easy access to agricultural credit in the eastern high hills of Nepal significantly increase revenue from vegetable farming.

f. Variety

Use of the Srijana variety is positively associated with higher revenue at the 5% level. The higher adoption rate of this variety may be due to its higher yield potential (NARC, 2016), market preference, and suitability for local production conditions, while other varieties are adopted based on seasonal needs and farmer preferences.

g. Irrigation type

Drip irrigation is positively associated with revenue at the 10% significance level, indicating relatively better performance among users. This may be attributed to its efficiency in water use and improved nutrient management through fertigation, as reported by Zhai et al. (2010), and Holmer and Schnitzler (1997).

Table 6. Factors affecting revenue from tomato production under plastic tunnel

Variables	Coefficient	S.E.	t	p-value
Schooling of HHH (Year)	0.008*	0.004	1.83	0.070
Economically active members (No.)	0.026	0.018	1.47	0.144
Membership in farmers group (1=Yes)	0.155*	0.093	1.67	0.096
Extension service from government (1=Yes)	0.142*	0.083	1.72	0.087
Training received (1=Yes)	0.202***	0.076	2.66	0.009
Access to agri. credit (1=Yes)	0.130**	0.052	2.52	0.013
Variety used (1=Srijana)	0.129**	0.051	2.50	0.013
Irrigation type (1=Drip)	0.091*	0.047	1.93	0.056
Constant	14.481***	0.089	163.62	0.000
Number of observation	150			
F(8,141)	21.32			
Prob>F	0.000			
R-squared	0.5474			
Adjusted R-squared	0.5217			
Root MSE	0.2711			
Mean VIF	1.99			

Note: *, **, and *** indicate level of significance at 10%, 5%, and 1% respectively.
Source: Field survey, 20224.

4. CONCLUSION

The study concludes that tomato production under plastic tunnel in Kathmandu district is profitable. Results show scope for improving efficiency through better allocation of inputs, with evidence of both underutilization and overutilization of resources. Inputs such as land rent, labor, seed, pest management, and other costs significantly influenced revenue, highlighting the importance of efficient input management. The production system exhibits nearly constant returns to scale. Socioeconomic factors such as education, group membership, extension advisory services, training, access to agricultural credit, improved varieties, and drip irrigation are also positively associated with higher revenue. Overall, the findings suggest that enhancing input use efficiency along with strengthening institutional support and technology adoption can improve profitability of tomato production under plastic tunnel systems in Nepal.

ACKNOWLEDGMENTS

The authors sincerely thank the Department of Agricultural Economics and Agribusiness Management, Agriculture and Forestry University, Nepal for their research support.

REFERENCES

Adejoh, S. O., Onuche, U., & Edoka, M. H. (2010). Evaluating the factors influencing the adoption of selected soil management technology by yam farmers Olamaboro LGA of Kogi State, North Central Nigeria. *International Journal of Agricultural Economics Management & Development, 1*(1), 1-5. Retrieved from www.daeeksu/journal.com

Ali, Q., Ashfaq, M., & Khan, M. T. (2017). An economic analysis of off-season tomato production in Punjab. *The Journal of Animal & Plant Sciences, 27*(1), 294-301.

Anthony, L., Ajibare, D. B., Alabi, O. O., Njoku, V. O., Ukaoha, C. A., & Oluleye, O. D. (2022, October). Resource Use Efficiency and Profitability Analysis of Tomato Production (Lycopersicum Esculetum Species) in Federal Capital Territory, Nigeria. *European Journal of Agriculture and Food Sciences, 4*(5). https://doi.org/10.24018/ejfood.2022.4.5.539

Bhatta, S., & Rijal, U. K. (2022, July). An Analysis of Resource Use Efficiency of Vegetable Growers in Chitwan district of Nepal. *Nepalese Journal of Agricultural Sciences, 23*. Retrieved from https://www.cabidigitallibrary.org/doi/pdf/10.5555/20230329825

Budhathoki, K. (2006). *Bajarmukhi, organic ra bemausami tarkari kheti prabidhi [Market oriented organic and off-season vegetable production technology].* Lalitpur, Nepal: Shrimati Basanti Budhathoki.

Costa, M., & Heuvelink, E. (2007). Today's worldwide tomato production. *Fruit &Veg tech*, 14-16. Retrieved from http://refhub.elsevier.com/S2667-0100(21)00108-6/sbref0016

Dhakal, S. C., Regmi, P. P., Thapa, R. B., Sah, S. K., & Khatri-Chhetri, D. B. (2015, December). Resource Use Efficiency of Mustard Production in Chitwan District of Nepal. *International Journal of Applied Sciences and Biotechnology, 3*(4), 604-608. https://doi.org/10.3126/ijasbt.v3i4.13525

FAOSTAT. (2024). *Statistical Database.* Food and Agriculture Organization of the United Nations. Retrieved from www.fao.org

Gautam, P. (2019). Economics of tomato production under plastic tunnel technology in peri-urban areas of Kathmandu valley. *Nepalese Journal of Agricultural Sciences, 18*, 149-156.

Ghimire, A., Aryal, D., Karki, R., Dhital, D., Dahal, M., & Poudel, A. (2023, September). Navigating the Economics of Production and Marketing of Tomatoes in Lalitpur, Nepal. *Global Scientific Journals, 11*(9), 160-168. Retrieved from http://www.globalscientificjournal.com/

Goni, M., Umar, M., & Sman, M. (2013). Analysis of resource-use efficiency in dry season vegetable production in Jere Borno State, Nigeria. *J. Bio. and Agri. Health, 3*(19), 18-23.

Gujarati, D. N., & Porter, D. C. (2009). *Basic Econometrics* (5th ed.). McGraw-Hill. Retrieved from https://www.cbpbu.ac.in/userfiles/file/2020/STUDY_MAT/ECO/1.pdf

Holmer, R., & Schnitzler, W. H. (1997). Drip Irrigation for Small Scale Tomato Production in the Tropics. *Kasetsart Journal - Natural Science, 32*(5), 54-55.

Ibitoye, S. J., Shaibu, U. M., & Omole, B. (2015, January). Analysis of Resource Use Efficiency in Tomato (Solanum lycopersicum) Production in Kogi State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology, 6*(4), 220-229. https://doi.org/10.9734/AJAEES/2015/18112

Kafle, A., & Shrestha, L. K. (2017). Economics of Tomato Cultivation using Plastic House: A Case of Hemja VDC, Kaski, Nepal. *International Journal of Agriculture, Environment and Biotechnology, 2*(01). Retrieved from www.ijaeb.org

Khadka, S., & Adhikari, R. K. (2021, January). Comparative economics of tomato production under polyhouse and open field condition in Dhading district of Nepal. *Nepalese Journal of Agricultural Sciences, 20*, 100-107.

Khan, M. B., & Khan, J. (2020, February). An Economic Analysis of Tunnel Farming in Enhancing Productivity of Off-Season Vegetables in District Peshawar. *Sarhad Journal of Agriculture, 35*(1), 153-160. https://doi.org/10.17582/journal.sja/2020/36.1.153.160

Kunwar, B., & Maharjan, B. (2019). Economic analysis of off-season tomato production under poly-house in Okhaldhunga, Nepal. *The Journal of Agriculture and Environment, 20*, 67-77. https://doi.org/10.3126/aej.v20i0.25012

MOALD. (2025). *Statistical Information on Nepalese Agriculture 2080/81 (2023/24).* Singhdurbar, Kathmandu: Government of Nepal. Retrieved from https://moald.gov.np/content/307/statistics-information-on-nepalese-agriculture-2080-81/

Mwangi, W. J. (2012). *Comparative analysis of greenhouse versus open-field small scale tomatoproduction in Nakuru-North District, Kenya.* Egerton University, Deptt.of Agri. Econ. and Agribusiness Management, Kenya.

Mwaura, F. (2014). Effect of farmer group membership on agricultural technology adoption and crop productivity in Uganda. *African Crop Science Journal, 22*(s4), 917-927.

NARC. (2016). *Srijana Hybrid Tomato: A Potential Technology for Enterprise Development in Nepal.* Socioeconomics & Agricultural Research Policy Division. Khumaltar, Lalitpur, Nepal: Nepal Agricultural Research Council (NARC). Retrieved from http:// www.narc.gov.np

NMDP. (2015). *Vegetable sector in Nepal: Rapid Post Earthquake Market Analysis.* Kathmandu, Nepal: SAMARTH-NMDP.

NSO. (2024). *National Population and Housing Census 2021, Population Composition of Nepal.* Thapathali, Kathmandu: Government of Nepal, National Statistics Office. Retrieved from https://censusresults.nsonepal.gov.np

Okello, D. M., Wabbi, J. B., & Mugonola, B. (2019). Farm level allocative efficiency of rice production in Gulu and Amuru districts, Northern Uganda. *Agricultural and Food Economics*, 19. https://doi.org/10.1186/s40100-019-0140-x

Otieno, D. J., Hubbard, L., & Ruto, E. (2012). Determinants of Technical Efficiency in Beef Cattle Production in Kenya. *Paper presented at the International Association of Agricultural Economist (IAAE) Triennial Conference.* Foz do Iguacu, Brazil.

PACT. (2014). *Value Chain Development Plan for Tomato.* Kathmandu, Nepal: Government of Nepal, Ministry of Agricultural Development, Project for Agriculture Commercialization and Trade (PACT).

Pal, S. K. (2022, June). *An Economic Analysis of Tunnel Tomato Farming in Chandragiri Municipality, Kathmandu.* Master's thesis, Tribhuvan University. Retrieved from https://elibrary.tucl.edu.np

Paudel, A. (2022). *Economic Analysis of Honeybee Production and Marketing in Myagdi District, Nepal.* Unpublished Master's Thesis, Agriculture and Forestry University, Department of Agricultural Economics and Agribusiness Management, Rampur, Chitwan, Nepal.

Paudel, P., & Adhikari, R. K. (2018). Economic analysis of tomato farming under different production system in Dhading district of Nepal. *Nepalese Journal of Agricultural Sciences, 16*.

Pokharel, A. (2021). Economic Analysis of Offseason Tomato Production in Kathmandu, Nepal: A study of Nepalese tomato growers. [Bachelor degree thesis]. Centria University of Applied Sciences.

Shrestha, R. B., Huang, W. C., Gautam, S., & Johnson, T. G. (2016, April). Efficiency of small scale vegetable farms: Policy implications for the rural poverty reduction in Nepal. *Agricultural Economics (AGRICECON), 62*(4), 181-195. https://doi.org/10.17221/81/2015-AGRICECON

Subedi, M., Pandey, M., Ojha, R. K., & Acharya, B. (2020). Production economics and resource use efficiency of tomato under open field condition in Kapilvastu, Nepal. *Journal of Agriculture and Natural Resources, 3*(1), 282-289. https://doi.org/10.3126/janr.v3i1.27181

Tambo, J. A., & Gbemu, T. (2010). Resource-use Efficiency in Tomato Production in the Dangme West District, Ghana. *Paper presented at the Conference on International Research on Food Security, Natural Resource Management and Rural Development.* ETH Zurich: Tropentag.

Usman, M., Ashfaq, M., & Ali, I. (2013). An economic analysis of staticecut-flower production in Punjab, Pakistan. *J. Agri. Sci., 50*(2), 311-315.

Yamane, T. (1967). *Statistics, An Introductory Analysis* (2nd ed.). New York: Harper and Row.

Zhai, Y. M., Shao, X. H., Xing, W. G., Wang, Y., Hung, T. T., & Xu, H. L. (2010). Effects of drip irrigation regimes on tomato fruit yield and water use efficiency. *Journal of Food, Agriculture & Environment, 8*(3), 709-713. Retrieved from www.world-food.ne