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Economics of Tomato (*Solanum lycopersicum L.)* Production under Plastic Tunnel Technology in Peri-urban Areas of Kathmandu, Nepal

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Fresh vegetables, whether seasonal or off-seasonal, are seen as valuable crops in Nepal, and there is a strong push for their commercial production. Among them, tomato cultivation is widespread, with off-season tomato farming gaining traction for its greater financial returns compared to seasonal production. The main objective of this study was to examine the socio-demographic condition, economic aspects of tomato production in plastic tunnels, involving the estimation of the production function, problems and evaluation of the benefit-cost ratio. House-hold survey was conducted from May 5 to July 10, 2023, gathered data from 100 tunnel tomato growers from random sampling method from 3 wards (Chouketar Dahachok, Baad Bhanjyang and Thankot) in Chandragiri municipality, Kathmandu. We included 100 tunnel tomato growers (58 men, 42 women;

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age range 30-60 years). This study combined primary and secondary data sources. Primary data were collected from tomato farmers in Chandragiri municipality's VDCs through face-to-face interviews using a pre-tested semi-structured questionnaire. Secondary data were sourced from various publications and reports, both published and unpublished. The semi-structured interviews featured open-ended questions designed to gather detailed information on socio-economic factors, demographics, resource availability, technical aspects, economic status, farm attributes, multiple regression based on the Cobb Douglas production function and farmer's views on the advantages and challenges of tomato cultivation under plastic tunnels. Results showed that price fluctuation was the major problem in the pivotal table. Most farmers (47%) were affected by blight and 49% by leaf miners. High labor cost NRs. 133794.04 increased the cost of production which was NRs 972555.9 but still farmers were benefitted with benefit cost ratio of 1.74, gross margin NRs. 2663355 and net profit NRs. 1690819.1. The research highlights the viability of tomato production in plastic tunnels, urging action on key constraints for potential growth. The use of plastic tunnel technology for tomato cultivation has become more popular among farmers in the peri-urban areas of Kathmandu Valley, providing year-round production and substantial economic benefits. This technology enables continuous growth of tomatoes, improving income during off-seasons and enhancing rural livelihoods. Although the study found tomato farming to be profitable despite high labor costs, farmers encounter numerous challenges, including natural disasters, pest infestations, disease, poor market access, and labor demands. Market-related problems such as fluctuating prices, middleman monopolies, and a lack of adequate storage and collection facilities further complicate the sale of produce, causing significant surplus losses. However, the study identifies several opportunities to improve tomato production for farmers in Chandragiri.

Keywords: Survey; tunnel-farming; net margin; gross margin; BC ratio.

1. INTRODUCTION

Agriculture is a cornerstone of Nepal's economy, providing essential food, income, and employment for many people in rural areas. Although only 21% of the available agricultural land is farmed, agriculture contributes 24.12% to the GDP and remains the primary source of employment. The country is geographically segmented into Terai (23% of land), Hill (42%), and Mountain (35%) regions [1]. The varied climate enables the simultaneous cultivation of both warm and cool-season crops. Major cereals like rice, maize, and wheat are produced, and tomatoes, along with other vegetables such as potatoes, brinjals, carrots, and cauliflower, which are widely cultivated for commercial purposes [2]. Tomato is a key vegetable crop in Nepal, scientifically named *Solanum lycopersicum* and commonly known as tomato. Linnaeus assigned the name Solanum lycopersicum in 1753, with "Solanum" derived from the Latin "solamen," meaning "comforting," and "lycopersicum" translating to "wolf peach." In Nepal, vegetable cultivation, including tomatoes, is often more profitable than growing grains due to its lower land requirement and quicker production cycle [3].

During the fiscal year 2021/22, vegetables were cultivated on a vast expanse of 289,000 hectares of land, yielding around 4,153,000 metric tonnes of produce. Notably, there was a 4.01% increase in production compared to the preceding fiscal year, 2020/21 [4]. Talking about tomato, it ranks third most significantly cultivated vegetable in terms of both land and production volume after cauliflower. It covers an area of 22,600 hectare and production of 616 metric tonnes [5]. Tomato plants typically grow 1-3 meters in height and have a weak stem. It is perennial in its native habitat. The crop is often grown outside as a seasonal crop. Its fruits are of berry type. Fruit is red in color and commonly known as tomato plant. It has been originated in south America, its use as a food is originated in Mexico and spread throughout the world following Spanish colonization of Americas. However, since it is not as sweet as other fruit it can be taken as salad, it can also be used as pickle [6]. Most of the varieties produce red fruits but there are some varieties of tomato that produce yellow, orange, pink, purple, green and white colored fruits [7]. Tomato is the world's third-largest plant in terms of production, following potato and onion [8]. Its many varieties are now widely grown, sometimes in greenhouse in cooler climate. Sufficient sunlight and water with proper drainage is best for the tomato production. It is popular for canning due to its high acidic content [9]. Tomatoes are rich in vitamin A and C and naturally low in calorie [10]. The pigment that

makes the tomato red called lycopene [11] prevents many types of cancer [12]. The best source of lycopene is found in processed tomato products, such as ketchup and other tomato products. China is the highest tomato producing country followed by India and united states respectively [13].

Tunnel farming is an affordable and straightforward method for managing microclimates, enabling the cultivation of vegetable crops year-round, which has proven to be a highly profitable venture. The regional agriculture research station at Lumle in Kaski developed an offseason tomato cultivation technology using plastic house 25 years ago [14]. The innovation of this plastic house technology, primarily originating from RARS (Regional Agricultural Research Station) in Lumle and HRD (Horticulture Research Division) in Khumaltar, has become increasingly favors in areas including Kaski, Syanja, Palpa, and Kathmandu valley. The plastic house is well-suited for regions situated at elevations ranging from 1000 to 1400 meters above sea level. The plastic house technology provides several advantages, namely increased crop productivity, improved soil fertility maintenance, regulated temperature and humidity, safeguarding against wildlife and pest, enhanced water conservation, and higher overall returns [15]. Continuous advancements in technology and production practices are being pursued by research institutions, emphasizing improved methods for agricultural productivity. These developments encompass enhanced cultivation practices like usage of superior varieties, optimized seed rates, spacing, sowing and transplanting schedules, as well as the adoption of plastic and poly house technologies. Recommendations also cover the optimal use of fertilizers, improved strategies for weed and pest management, efficient irrigation techniques, and refined methods for post-harvest handling and transportation. Despite these innovations, many farmers face numerous constraints that hinder their production levels. Challenges related to marketing, such as lengthy supply chains, intermediary involvement, and insufficient market information, contribute to the complexity. Price variability further exacerbates the situation, while inadequate knowledge of value chains and inefficient dissemination of market information often result in reduced profitability. In contrast to certain other nations, the Nepalese government does not support off-season tomato cultivation practices. Challenges persist in terms of inadequate training, inconsistent subsidy allocation and insurance coverage, and limited access to quality inputs and low-interest loans, with genuine farmers sometimes losing out to others who exploit available resources. Keeping its view, this study aims to consider the profitability of tomato production under plastic tunnel and its problems during production and marketing along with socio-economic condition of Chandragiri municipality, Kathmandu.

2. MATERIALS AND METHODS

The research was carried out in the hilly Central Development Region of Nepal, which is renowned for its substantial vegetable cultivation. Considering the fact that plastic tunnel farming of tomatoes is widespread among farmers in this region in recent years, the study site is selected. It becomes one of the most potent tunnel tomatoes producing area due to its fertile land, irrigation facilities, road and market accessibility and other facilities. Household survey was carried out from 5th May to 10th July, 2023. Three wards (ward 1= Chouketar Dahachok, ward 2= Baad Bhanjyang and ward 3= Thankot) were purposively selected as they were recognized as commercial tomato growers. Out of 350 tunnel tomatoes growers from 3 wards of Chandragiri municipality, 100 farmers were randomly selected for surveying and used as sampling frame who were listed in the municipality office of Chandragiri municipality. Pre- tested semi - structured questionnaire were administrated among the sampled farmers applying face to face interview technique. A pre-tested semi-structured questionnaire was employed to interview sampled farmers in person and to collected reliable data for fulfilling objectives. Interview timings were adjusted to suit the farmers' schedules.

Both primary and secondary data were employed in this study. Primary data were collected from farmers who grow tomatoes under plastic tunnels in selected VDCs of Chandragiri municipality of Kathmandu Valley. The data collection process utilized a pre-tested semi-structured questionnaire administered through face-to-face interviews. Secondary data were gathered from various published and unpublished sources such as journals, books, reports, and unpublished documents. The semi-structured interview schedule was developed with open-ended questions intended to gather information on socio-economic factors, demographics, resource availability, technical aspects, economic status,

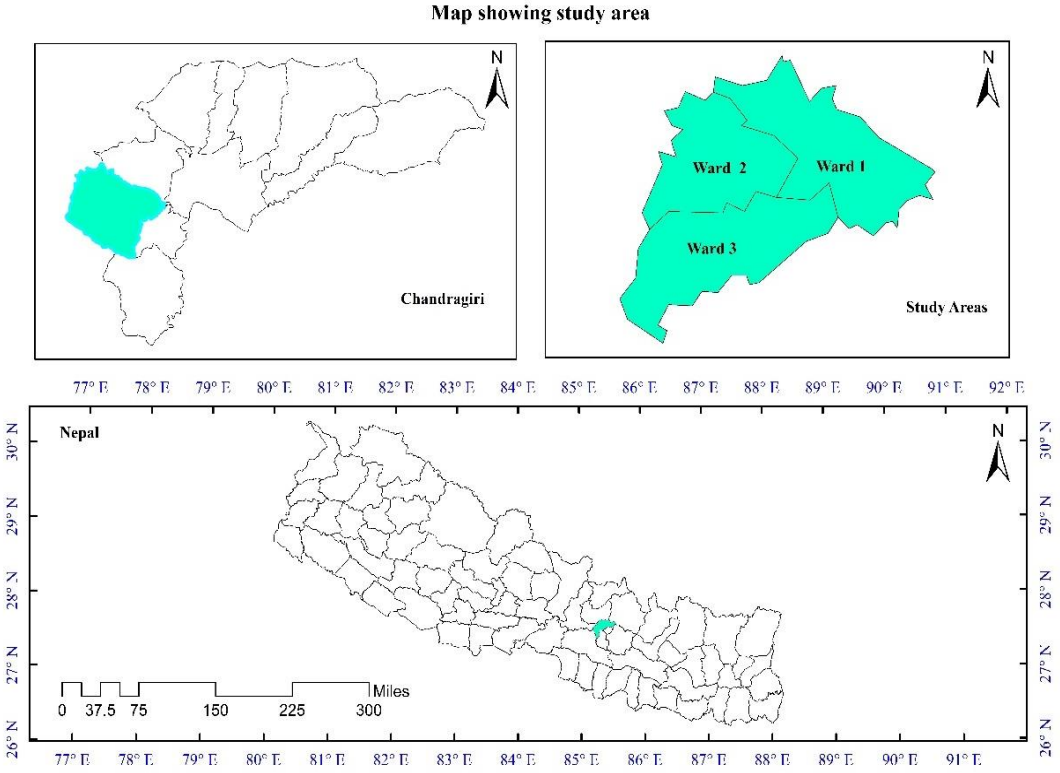

Fig. 1. Map showing study area

farm characteristics, farmers' perceptions, and knowledge regarding tomato cultivation under plastic tunnel technology, including the advantages and challenges associated with it. The data gathered from interviews were first recorded using Computer software Package "MS Excel" and analysis was done through SPSS. Descriptive statistics, such as mean, percentage, and frequency distributions, were employed to describe economic conditions and farm attributes. Analyzed data were then presented in tables, graphs and pie-chart.

2.1 Methods and Techniques of Data Analysis

2.1.1 Socio-demographic variables

Socio demographic variables like age, gender, education level, land holdings and category of farmers were analyzed by using descriptive statistics like frequency, percentage, mean, standard deviation, etc.

2.1.2 Marketing channel

Based on the information obtained from producers, traders and consumers marketing channel were drawn that show the linkages between input suppliers, producers, local collectors/traders, wholesalers, retailers, and consumers. Marketing channel was drawn to identify the effectiveness of the existing marketing channel and to realize and solve the problems during marketing.

2.1.3 Problem ranking

It was done by using forced ranking technique to know the rank of different constraints faced by farmers during tomato production and marketing. The index was prepared on the basis of responded frequencies. The frequency of response for each problem was tabulated in a table for each problem, then scaled value for each rank was calculated. Problem faced by the farmers were ranked by scaling techniques. The formula used for indexing is as below [16],

$$I_{imp} = \sum Si\ fi\ /N$$

Where:

I_{imp} = index of importance
S_i = i^{th} scale value (i= 1,2, 3, 4 and 5),
f_i = frequency of i^{th} importance given by the respondents
N= total number of respondents.

2.1.4 Economic variables

Different economic variables such as gross revenue, gross margin, net margin, BC ratio etc were analyzed to the profitability of tomato farming. The cost of production was analyzed by considering all variable and fixed costs. The variable costs include those for seeds, fertilizers, manure and other costs like chemical, preparation, human resource, bagging and harvesting. The fixed cost includes the cost incurred by land tax, construction materials, depreciation costs, interest and rental value. Total cost of production was calculated by summing up all the expenditure of variable and fixed inputs.

Total cost of production = ∑ of cost incurred in all variable inputs + ∑ of cost incurred in all fixed inputs.

2.1.4.1 Depreciation

It is calculated by using salvage value (10%) of purchase price of equipment and entire depreciation is considered as fixed cost [17]. Mathematically,

Depreciation = (Purchase price – Salvage Value) / Number of Years of Life

Where:

Purchase price includes construction costs (NRs. 318000)
Salvage value = 10 % purchase price
Number of Years of Life = 5 years

2.1.4.2 Benefit-cost ratio

B:C ratio is the ratio of net profit and total cost of production. It can be calculated as,

B:C ratio= Net income / Total cost of production

Where:

Net profit = Gross revenue - Total cost of production

2.1.4.3 Gross revenue

Gross revenue is obtained by multiplying the selling price of tomato with its quantity.

2.1.4.4 Gross margin and net margin

Gross margin is the difference between the gross return and the variable cost incurred during production. The gross margin tells us about whether the cost incurred during production is covered by the value of the product or not. It can be calculated as,

Gross margin = Gross return - Total variable cost incurred.

Where:

Gross return = Per kg price of tomato × Quantity of tomato market
Net margin = Gross return - Total cost of production
Total cost of production = Total variable cost + Total fixed cost.

2.1.4.5 Regression analysis (Estimation of production function)

The Cobb-Douglas production function was utilized to analyse the factors influencing tomato production.

Mathematically, the Cobb-Douglas production function is represented as follows:

$$Y=\beta_0+X_1\beta_1+X_2\beta_2+X_3\beta_3+X_4\beta_{4+}+X_5\beta_5+X_6\beta_6+X_7\beta_7+X_8\beta_8+X_9\beta_9+X_{10}\beta_{10}+X_{11}\beta_{11}+X_{12}\beta_{12}+X_{13}\beta_{13}+X_{14}\beta_{14}+u_i$$

Where:

Y = Tomato production in kg
β_0 = Constant (Intercept)
X_1 = Capital cost (NRs.)
X_2 = Land preparation cost (NRs.)
X_3 = Seed cost (NRs.)
X_4 = Nursery preparation cost (NRs.)
X_5 = Transplantation cost (NRs.)
X_6 = Farm Yard Manure (FYM) cost (NRs.)
X_7 = Urea cost (NRs.)
X_8 = Diammonium phosphate cost (NRs.)
X_9 = Muriate of potash cost (NRs.)
X_{10} = Micronutrient cost (NRs.)
X_{11} = Poultry manure cost (NRs.)
X_{12} = Pesticide cost (NRs.)
X_{13} = Intercultural operation cost (NRs.)
X_{14} = Harvesting cost (NRs.)
$\beta_1 \ldots \beta_{14}$ = Coefficients of estimates in the model.
u_i = Error term which included the effect of unexplained factors on yield

3. RESULTS AND DISCUSSION

3.1 Socio-demographic Condition

The socio-economic makeup of the respondents includes aspects like how the population is spread out, gender ratios, marital status, family sizes, levels of education, primary jobs, land ownership status, sources to get agriculture inputs and availability of labor. The majority of

respondents accounting for 100 in number were aged between 31 and 59 years old. Males outnumbered females, with 58 respondents compared to 42. Educational attainment ranged from illiteracy to bachelor's degrees and higher. Respondents lived in nuclear families (65) and joint families (35) with married (80) and unmarried (20). Labor availability was considered easy by 57 respondents with foreign employment noted as a primary factor contributing to labor shortages. 43 respondents had more than ten years of experience. Additionally, 19 respondents claim that they themselves substituted agricultural labor and 55 respondents got sources of agriculture inputs from agro-vets while 8 respondents got from governments.

3.2 Whom to Sell the Product

It was found that majority of the producers sell their products to middlemen (51%), followed by wholesalers (23%), retailers (15%) and consumers (11%). More than half of the farmers of this study area sells their produce to the wholesale market via middlemen to ensure that their produce are marketed whereas the rest of the farmers closer to the market sell their

Table 1. Socio-demographic condition

Age group	Frequency	Gender	Frequency
<31	15	Male	58
31-59	74	Female	42
>59	11	Total	100
Total	100		
Marital status	**Frequency**	**Family type**	
Married	80	Nuclear	65
Unmarried	20	Joint	35
Total	100	Total	100
Education level	**Frequency**	**Availability of Labor**	**Frequency**
Illiterate	14	Easily	57
Primary Level	31	Difficulty	18
Secondary Level	38	Very difficulty	6
Bachelor and above	17	Managed by family labor	19
Total	100	Total	100
Year of experience	**Frequency**	**Sources to get agriculture inputs**	**Frequency**
<10 years	17	Agro-vets	55
5-10 years	40	Cooperatives	26
>10 years	43	Governments	8
Total	100	Others	11
		Total	100

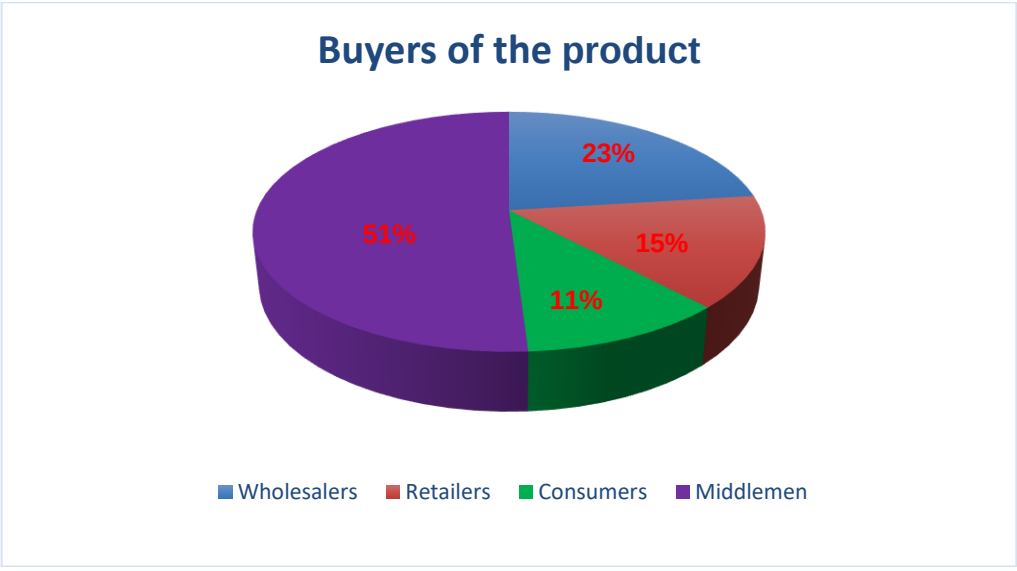

Fig. 2. Buyers of the product

produce directly to the retailers and very few of the farmers sell the produce to consumers directly from their farms.

3.3 Access to Agricultural Services and Facilities

Farmer's access to training, membership in farmer's group/cooperatives, subsidy and credit facilities are important to build and strengthen the capacity of the farmers. These services also contribute to agricultural sustainability, livelihood improvement and well-being of populations in the study areas. In the study area, only 41.7% of respondents had received training related to tomato production but majority of the respondents i.e., 58.3%, had not received any training related to tomato production. Similarly, 34.5% respondents were members of farmers group or cooperatives whereas remaining 65.5% did not hold any membership of farmers group or cooperatives.

3.4 Information Source on Market Price of Tomato

Access to market price data empowers producers to negotiate more effectively with traders, potentially securing better prices. It is evident that the main source of information regarding market price of tomato in this study area was social media (39%) and friends and relatives (32%) and other sources like middleman (18%), co-operatives (11%) as well.

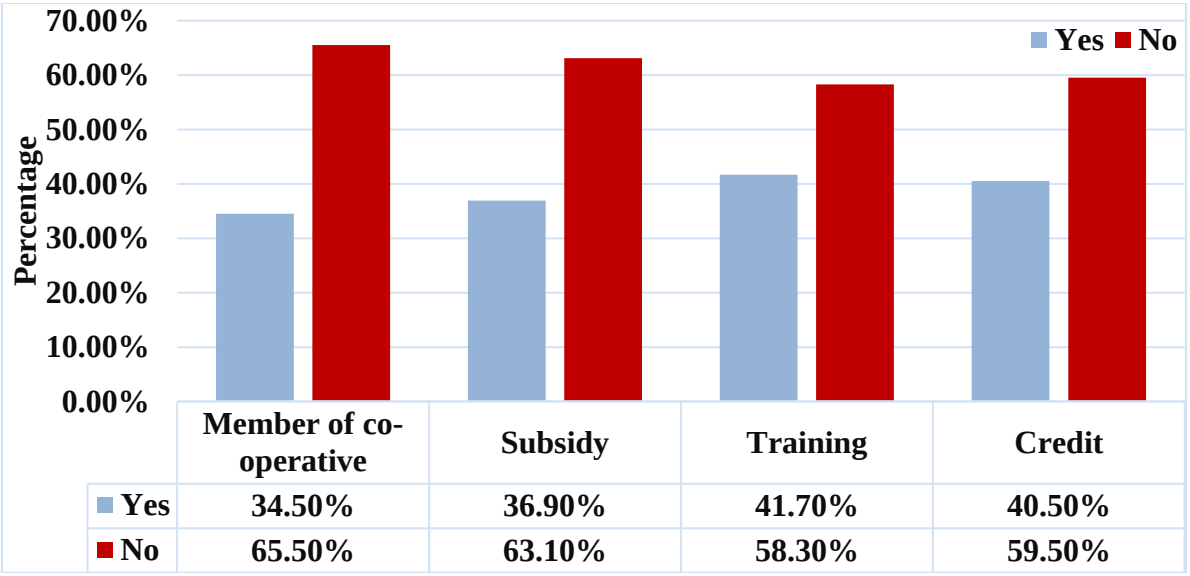

Fig. 3. Bar diagram showing farmers access to agricultural services and facilities

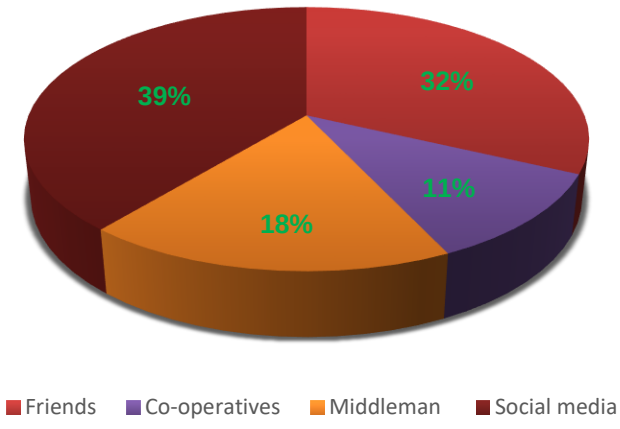

Fig. 4. Information source on market price of tomato

3.5 Reasons to Adopt Plastic Tunnel

The major reason for adopting plastic tunnel was protection from extreme weather conditions as observed from the responses of 42 farmers whereas 19 farmers grew their tomatoes in plastic tunnel for the protection from biotic factors like insect pest and diseases. Likewise, number of farmers adopting tunnel farming for the protection from rain, hailstone and as a hobby were 22, 12 and 5 respectively.

3.6 Impact on Household Income from Tomato Cultivation

Among the households in the study area, 66% noted a slight rise in income due to tomato cultivation in plastic tunnels. Meanwhile, 10% had a considerable income increase, 17% saw no change, 5% experienced a slight decline and 2% recorded a significant decrease.

3.7 Marketing Channel

Effective marketing channel is the most important during tomato marketing. The involvement of the middle persons increased the price to be paid by the consumers and reduced the farm gate prices. Majority of the farmers i.e., 48% respondents in the study area were found to adopt Channel IV where producers sold their produce to middlemen who in turn sold tomatoes to the wholesalers and then to retailers and finally to consumers. 23% respondents sold their produce to the wholesalers who in turn sold tomatoes to the retailers and then to consumers. 17% of respondents sold their produce to retailers and then to consumers. 12% of respondents in the study area were found adopting Channel I where producers directly sold their produce to the consumers.

3.8 Major Diseases of Tomato

Incidence of disease was one of the major problems faced by the farmers in the area. Majority of the farmers (47%) said that Late blight/early blight was the major disease occurring in the farm. It was followed by viral disease (24%) and damping off (17%). Similarly, 12% farmer said wilt was the major disease in the farm.

3.9 Major Insect and Pest

Insects and pest are the major factors which cause heavy loss of production. Majority of the farmers (49%) said that leaf miner was the major insect of tomato in their farm. Similarly, 33% farmers said Fruit borer causes heavy loss in their farm. Whiteflies were major problem for 17% respondents. Aphid was main problem for 1% respondent.

3.10 Problems Associated with Tomato Cultivation

3.10.1 Ranking of the problems faced by farmers during tomato production

A simple indexing technique was used to analyse the major production problem using five-point Likert scale [18]. Natural hazards such as erratic rain, hailstone, extreme temperature etc were the major problems faced by farmers during production which led to flower fall and hindrance in pollination process, consequently resulting in loss of production. The second most significant problem was incidence of diseases-pest. Also, poor market access and high cost of input and unavailability of quality seeds were also reported as problems by many farmers. Poor irrigation is least significant problem for tomato production by the farmers of the study areas.

3.10.2 Ranking of the problem faced by farmers during marketing

Every business, including farming, revolves around two core functions: production and marketing. Even with excellent production capabilities, insufficient attention to marketing can lead to minimal income. Therefore, it is crucial for tomato farmers to be well-informed about marketing challenges. In the study area, farmers faced several significant issues, with fluctuating market prices being the most severe (index value: 0.874) as there is unstable government policies and seasonal variations, while lack of technical knowledge relatively posed the least severe challenge (index value: 0.584). The second most critical issues included poor bargaining power and the monopoly of middlemen (index value: 0.746), followed by inadequate storage and collection facilities. Furthermore, farmers struggled with limited access to crucial market information.

3.11 Economic Analysis

An economic assessment of tomato farming involved determining land allocation, production levels, production costs, income generated from sales, and benefit-cost ratios using a simplified method. All data was systematically analyzed per hectare or annually.

Table 2. Information on reason to adopt, impact on household, major diseases, insect and pest of tomato

Reason to adopt plastic tunnel	Frequency	Impact on household income	Frequency	Marketing channel	Frequency	Major diseases of tomato	Frequency	Major insect and pest	Frequency
Protection from extreme weather conditions	42	significant increase	10	Channel I (Producer- consumer)	12	Late blight/early blight	47	Tomato leaf miner	49
Protection from hailstone	12	slight increase	66	Channel II (Producer- Retailer- Consumer)	17	Viral diseases	24	Fruit borer	33
Protection from rain	22	no change	17	Channel III (Producer- Wholesaler- Retailer- consumer)	23	Damping off	17	Whitefly	17
Protection from insect and disease	19	Slight decrease	5	Channel IV (Producer- middleman- wholesaler-retailer- consumer)	48	wilt	12	Aphid	1
Hobby	5	Significant decrease	2						

Table 3. Ranking of the problem faced by farmers during tomato production

Problems	Priorities given by respondents					Total score =$\Sigma S_i f_i$	Imp= $\Sigma S_i f_i/N$	Rank
	1	2	3	4	5			
Poor market access and high cost of input	59	11	18	7	5	82.4	0.824	III
Incidence of disease pest	54	33	6	4	3	86.2	0.862	II
Poor irrigation facility	16	10	11	24	39	48	0.48	V
Unavailability of quality seeds	33	37	4	9	17	72	0.72	IV
Natural hazard	83	6	3	4	4	92	0.92	I

Table 4. Ranking of the problem faced by farmers during marketing

PROBLEMS	Priorities given by the respondents					Total score = $\Sigma S_i f_i$	Imp = $\Sigma S_i f_i/N$	Rank
	1	2	3	4	5			
Lack of market information	14	25	26	20	15	60.6	0.606	IV
Fluctuation in market price	61	25	7	4	3	87.4	0.874	I
Poor bargaining power and monopoly of middleman	38	27	13	14	8	74.6	0.746	II
Lack of technical knowledge	12	19	37	13	19	58.4	0.584	V
Lack of storage and collection centers	30	28	13	11	18	68.2	0.682	III

3.11.1 Cost of production

The cost of producing tomatoes under plastic tunnel conditions was analyzed by dividing it into variable costs and fixed costs. All fixed expenses were calculated per hectare.

3.11.1.1 Fixed cost

Every cost associated with fixed inputs utilized in tomato production under the plastic tunnel method was carefully computed. Rent on land, land tax, constructing materials, interest and depreciation cost on fixed assets were considered on fixed cost for one hectare of land and obtained NRs 477,305.18/ha per year.

3.11.1.2 Variable cost

The variable costs of tomato farming per hectare were calculated by totaling the financial outlay for all variable inputs, which encompass seeds, fertilizers, manures, pesticides, labor, intercultural operation and harvesting and obtained NRs 495,250.72.

3.11.2 Total cost of production

The overall expenses for cultivating tomatoes per hectare within a plastic tunnel include both the variable and fixed costs of all inputs utilized. Research findings indicate that the yearly total cost of tomato production per hectare was NRs. 972,555.9 with total production of 42614kg/ha. The cost of production per kg of tomato was NRs 22.82.

3.11.3 Price of tomato

Tomatoes, being perishable, face daily price variations due to unpredictable production and demand cycles. Those grown in greenhouses are mainly available off-season, with peak production occurs over six months from August/September to January/February. The highest average farm gate and retail prices are seen from September to November when field-grown tomatoes are scarce, festivals, consumers favor their quality and size. Conversely, price is lowest in January/February. Field-grown tomatoes from various parts of the country which are kept for sowing in June are cheaper and more readily available from March to July.

3.11.4 Economics of production

3.11.4.1 Returns from tomato production

The study computed the gross return from tomato production, which represents the total monetary worth of the harvested yield. It was found that the gross return per hectare per year for tomatoes grown under a plastic tunnel was NRs. 2,663,375.

3.11.4.2 Profit from tomato production

Profit in tomato production under a plastic tunnel is calculated as the difference between total revenue and total costs, which include both fixed and variable costs. Fixed costs encompass land tax, construction costs, depreciation, interest and land rent. The study revealed a net return of NRs. 1690819.1 per hectare per year.

3.11.4.3 Benefit cost ratio of tomato production

The benefit-cost ratio assesses the efficiency of recovering production costs through product earnings and provides a straightforward measure of return on investment. It also serves to evaluate the overall value of a project or business. Based on the study, the average benefit-cost ratio for tomato production using plastic tunnel technology per hectare was 1.74. It was also found that BC ratio of tomato cultivation using plastic house was also 1.65 in kaski, Nepal [19].

In regard to farmer's experience, 4 out of 14 explanatory variables were found to be statistically significant including: FYM, Mop, Micronutrient and Pesticide. The rest like Land preparation, seed, Nursery preparation, Transplantation, Urea, Di-ammonium phosphate, Poultry manure, Intercultural operation, Harvesting were insignificant.

The coefficient of independent variable capital cost is -0.11 meaning 1 percent increase in land preparation costs leads to 11% decrease in total output of tomato, whereas 0.009 means1 percent increase in seed costs leads to 0.9% increase in total output of tomato. A multiple linear regression model with an R-value of 0.932 indicates strong correlation between dependent and independent variable. R-Square value of 0.868 suggests that approximately 86.8% of the variability in tomato output can be accounted for by factors such as Farm yard manure, Muriate of potash, Micronutrient, Pesticide. Furthermore, the adjusted R^2 =0.847 which implies that the regression

model accounted for about 84.7% of non-zero variations in the study model and F-value is 40.018, indicating statistical significance at a confidence level of 0.05, affirming the validity of the model.

Table 5. Cost of production

Inputs	Cost (NRs/hectare)	% Share in cost of production
Variable cost		
Land Preparation	124390.1	12.8
Seed	15072.54	1.55
Nursery Preparation	10079.8	1.04
Transplantation	10579.5	1.09
Fertilizers		
Farm Yard Manure (FYM)	110079.8	11.32
Urea	4867.08	0.50
Di-ammonium Phosphate (DAP)	18320.87	1.88
Muriate of Potash (MOP)	4642.55	0.48
Micronutrient	11558.95	1.19
Poultry manure	16654.69	1.71
Pesticide	35210.8	3.62
Labor cost		
Intercultural operation	110079.8	11.32
Harvesting	23714.24	2.44
Total variable cost	**495250.72**	**50.94**
Fixed cost		
Land tax	24	0.0025
Land rent	30000	3.08
Construction costs (including pipe, plastic, fitting materials etc)	318000	32.69
Depreciation	57240	5.89
Interest (10% on initial investments and variable costs)	72041.18	7.40
Total fixed cost	**477305.18**	**49.06**
Total cost	**972555.9**	**100**
Cost of production per Kg (NRs)	**22.82**	
Total production	**42614 kg/ha**	

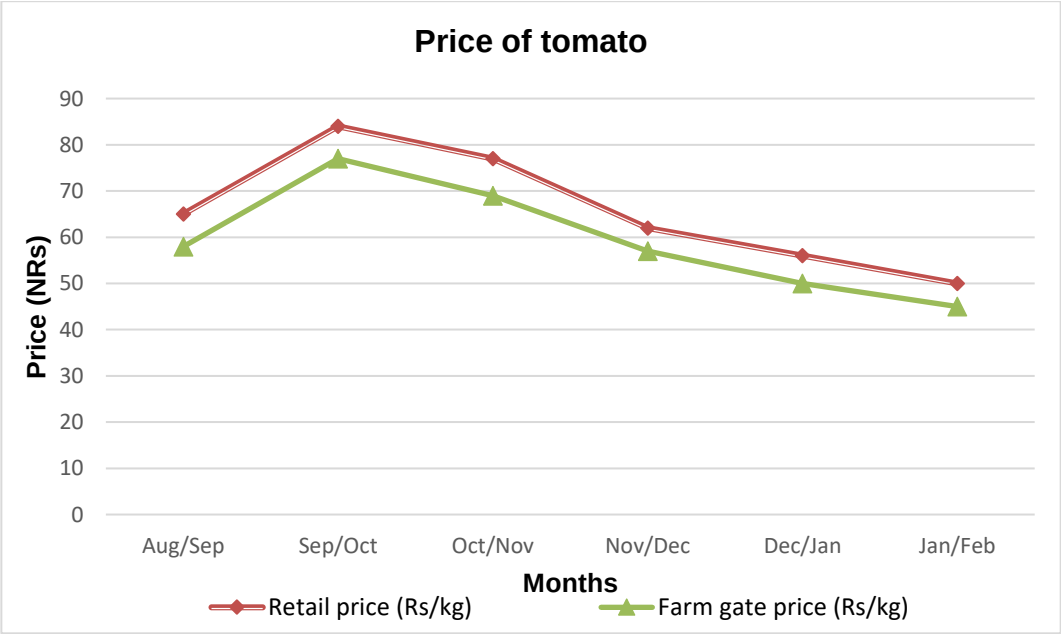

Fig. 5. Market Price of tomato

Table 6. Economics of production

Particulars	Amount
Total cost of production (NRs/ha)	972555.9
Average production (kg/ha)	42614
Average Sold Price (NRs/kg)	62.5
Gross revenue (NRs/ha)	2663375
Net profit (NRs/ha)	1690819.1
Benefit cost ratio	1.74

Table 7. Regression analysis of tomato production in the study area

Variables	Coefficient	Std. Error	T value	P value
Constant	16915.091	10229.553	1.654	.102
Capital cost	-.011	.020	-.565	.574
Land Preparation	-.001	.002	-.319	.751
Seed	.009	.049	.183	.855
Nursery Preparation	.034	.063	.544	.588
Transplantation	.011	.061	.182	.856
Farm yard manure	.012	.003	4.079	.000***
Urea	-.002	.011	-.152	.880
Diammonium phosphate	-.035	.034	-1.006	.317
Muriate of potash	-.057	.017	-3.404	.001**
Micronutrient	.176	.069	2.558	.012*
Poultry manure	.022	.037	.583	.562
Pesticide	.780	.067	11.713	.000***
Intercultural operation	-.003	.002	-1.255	.213
Harvesting	.027	.018	1.484	.142
F-value		40.018		
R		0.932		
R^2		0.868		
Adjusted R^2		0.847		

, **, * represents 0.1%, 1% and 5% significant level at respectively*

4. CONCLUSION

Tomato cultivation using plastic tunnel technology has become increasingly popular among farmers in peri-urban areas around Kathmandu valley, offering year-round production opportunities and significant economic benefits for households. The technology not only supports continuous tomato and vegetable growth but also enhances income generation during off-seasons, thereby improving rural livelihoods. Despite the high costs associated with labor, the study revealed tomato farming to be a profitable enterprise in the area under review. Farmers frequently encounter challenges such as natural hazards, disease and pest infestations, poor markets access, and labor-intensive production processes. Market-related issues, including fluctuation in market price, monopoly of middleman, lack of storage and collection centers and lack of technical knowledge, further complicate tomato sales. The absence of adequate storage facilities results in significant losses of surplus produce after harvest. However, the study identifies many opportunities such as rising year-round demand for tomatoes, engagement of both private and public sectors in input supply, processing and marketing, government subsidy etc for enhancing tomato production that could benefit farmers in Chandragiri.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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