Economic Affairs, Vol. **70**(03), pp. 203-211, September 2025
DOI: 10.46852/0424-2513.3.2025.5

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RESEARCH PAPER

Assessing Resource Use Efficiency and Addressing Production and Marketing Problems of Tomato in Solan District, Himachal Pradesh: A Case Study

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Received: 20-05-2025 **Revised:** 19-08-2025 **Accepted:** 01-09-2025

ABSTRACT

The present study has been designed to investigate the resource use efficiency and identify the issues and challenges of tomato growers. A sample of 400 farmers cultivating tomato was selected using multistage random sampling. The CAGR for area, production and productivity during period (1995-96 to 2019-20) increased at rate of 4.96 per cent, 6.85 per cent and 1.85 percent in Solan district respectively, indicated that the tomato has been major cash crop sown in this area. The Coefficient of determination was 0.82 which indicated that 82 per cent variation in tomato production. The ratio of MVP/MFC was greater than unity that indicated increasing return to scale and the resources were underutilized which signifies that there is need to enhance usage of inputs and package of practices for the maximization of profits. The major issues and challenges related to tomato production and marketing were shortage of skilled labor, high wages rates, high price of fertilizers, high price of plant protection chemical, non-availability of quality seed, lack of cold storage and agro processing units along with post-harvest losses. There is need to reduce the number of intermediaries to increase producers share in consumer's rupee and better marketing facilities for cold storage and value addition. The study suggested that proper mitigation strategies for production and marketing system by giving adequate supply of quality seed, good package of practices, quality plant protection chemicals, fertilizers and agriculture inputs along with subsidies and welfare scheme by the government that help the farmers to increase their production and yield.

HIGHLIGHTS

- In the mid-hills of Solan, Himachal Pradesh, the MVP/MFC ratio above unity indicated increasing returns to scale, suggesting underutilization of resources and scope for improved input use and practices to maximize tomato production profits.
- Major challenges included high labor and input costs, poor seed quality, post-harvest losses, and lack of storage/processing facilities; the study emphasized reducing intermediaries and strengthening marketing and value-addition infrastructure for better farmer returns.

Keywords: CAGR, MVP, MFC, Marketing, Efficiency

How to cite this article: Sharma, P., Divyanshu, Kathuria, K., Barwal, P. and Sharma, S. (2025). Assessing Resource Use Efficiency and Addressing Production and Marketing Problems of Tomato in Solan District, Himachal Pradesh: A Case Study. *Econ. Aff.*, **70**(03): 203-211.

Source of Support: None; **Conflict of Interest:** None

India is an agricultural country where 68.84 per cent population lives in rural areas. Most of Indian people busy in agricultural and related sector. Agriculture is the stronghold and the backbone of Indian economy. 54.60 per cent of the total workforce is engaged in agricultural and allied sector activities (Census 2011) and accounts for 18.80 per cent of the country's Gross Value Added (GVA) for the year 2021-22 (at current prices). (Ministry of Statistics & Programme Implementation (MoSPI 2021-22). Agriculture is one of the largest sectors in the country, which provides employment opportunity to nearly 42.38 per cent population of the country in 2019 (World Bank, 2020). Horticultural sector has been recognized as a vibrant sector in agriculture, which provides avenue for crop diversification, enhanced farm income per unit area, better land and water used with opportunities for employment generation (Kumari *et al*. 2018; Singh *et al*. 2020). Horticultural crops are integral component for achieving the goal of doubling farmers' income (Jha *et al*. 2019). The wide range of horticultural crops provides ample opportunities by farmers to adopting multilayer cropping for minimizing risk of crop failure and maximizing their farm income (Shende and Meshram, 2015). Fruits and vegetables account for nearly 90 per cent horticultural production in the country (Neeraj *et al*. 2017).

Tomato (*Solanum lycopersicum*) cultivation plays a vital role in the agricultural landscape of Solan district, Himachal Pradesh. The region's favorable climatic conditions and fertile soil have made it conducive for tomato production (Singh et al., 2018). However, like many agricultural sectors, tomato farming in Solan district faces resource use inefficiencies and various challenges in production and marketing. Addressing these issues is crucial for enhancing resource utilization, improving production outcomes, and ensuring sustainable growth in the tomato value chain.

The total production of tomato in India was 201.47 lakh tonnes with average yield was 25.10 MT (NHB, 2021). Madhya Pradesh had higher production and largest area under tomato cultivation followed by Karnataka and Andhra Pradesh and the state of Himachal Pradesh was stood at 14th position (NHB, 2021). The total production for tomato in Himachal Pradesh was 5.77 lakh tonnes and area was 13.79 thousand ha (Directorate of Economics and Statistics, 2021). It was found that Solan was major tomato producing district of Himachal Pradesh. Solan ranks first in production followed by Sirmaur and Shimla. The total area and production for tomato crops in solan district was 5183 ha and 256559 MT followed by Sirmaur and Shimla were 3833 ha, 48297 MT and 932, 48297 respectively. Whereas the district like Kullu, Mandi, Bilaspur are also the major producer of tomato with production share was 6.45 per cent, 4.45per cent and 5.77 per cent respectively.

Resource use efficiency is a critical aspect of sustainable agriculture. The efficient utilization of key resources such as water, seed, fertilizers, and energy is essential for maximizing yields while minimizing environmental impact (Kumar *et al.* 2019). Evaluating the current state of resource use efficiency in tomato cultivation in Solan district is necessary to identify potential areas for improvement. By understanding the resource management practices, irrigation methods, and technological interventions employed by tomato farmers, we can develop strategies to optimize resource utilization in the context of Solan district's unique agro ecological conditions.

Furthermore, production and marketing problems pose significant challenges to tomato farmers in Solan district. Pests, diseases, and soil health issues are common obstacles that affect production outcomes (Thakur *et al.* 2017). Limited access to quality seeds and agrochemicals further compounds these challenges (Gupta *et al.* 2016). Inefficient marketing systems, transportation constraints, inadequate storage facilities, and price fluctuations hamper market access and profitability for tomato farmers (Yadav *et al.* 2020). Understanding and addressing these production and marketing problems are crucial for improving the livelihoods of tomato farmers and fostering agricultural sustainability in Solan district.

METHODS

Solan district of Himachal Pradesh was purposively selected for the present study because of its major contribution in area and production of tomato in Himachal Pradesh. The area under tomato in Solan district was 5183 hectares which was 37.57 per cent of total area under tomato cultivation

in H.P. The area and production under tomato cultivation was 5183 hectares and 256559 metric tonnes. (Department of Agriculture, Himachal Pradesh, 2021).

Multistage random sampling technique was used to select the ultimate respondents. In first stage, 3 blocks i.e. Kandaghat, Dharmpur and Solan out of 5 blocks which were major growing area of tomato cultivation was selected. At the second stage, 10 panchayats from each selected block were selected. A total of 30 panchayats were selected from 3 identified block. At third stage, a list of farmers doing vegetable cultivation of the selected panchayat was prepared with the help of the officials from the Revenue, Agriculture department, SAU KVK's and Horticulture department, 10 tomato growers in each selected panchayats were selected for collection of primary data. Thus, a sample of 300 tomato growers were selected for the study trader's/commission agents in which 10 trader's/ commission agents each from three blocks APMC and sub market yard were selected for the study.

Compound growth rate (CGR)

The compound growth rates were computed by fitting the exponential function to area, production and productivity of tomato of Himachal Pradesh for the period 1965-66 to 2015-16. The ordinary least square method was used to fit the exponential function of the following form and it was converted into log linear function with the help of logarithmic transformation as under:

$$Y = ae^{bt}$$

$$Ln\ Y = Ln\ a + bt.$$

where,

Y = Dependent variable (area, production and productivity)

t = Independent variable (time in year).

Compound growth rate (CGR) was calculated by using the following formula:

$$CGR = b*100$$

Standard error (SE) of CGR was calculated by using the following formula:

$$SE \text{ of } CGR = 100*SE\ (b)$$

Cobb- Douglas production function

The Cobb-Douglas production function was estimated for studying the relationship between output of tomato and the various input variables for the estimation of resource use efficiency.

The following types of equations were used:

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^u$$

The above function is linearized double log form as below:

$$In\ Y = In\beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + u$$

Where,

Y = Returns

X_1 = Expenditure on Human labour (₹)

X_2 = Expenditure on Planting material (₹)

X_3 =Expenditure on FYM (₹)

X_4 =Expenditure on Fertilizers (₹)

X_5 = Expenditure on Plant protection chemicals (₹)

β_0 = Intercept

e^u = The error term

β_1 to β_5 = The elasticity coefficient

Adjusted coefficient of multiple determination

Adjusted R^2 is a modified version of $\overline{R}^2$ that has been adjusted for the number of predictors in the model. Adjusted R^2 adjusts the statistic based on the number of independent variables in the model. That is the desired property of a goodness-of-fit statistic. The adjusted value of $\overline{R}^2$ is calculated as follows:

$$\overline{R}^2 = 1 - \left(1 - R^2\right)\frac{n-1}{n-k}$$

where,

R^2 = Coefficient of multiple correlation

n = Number of sample observations

k = Number of parameters estimated

$\overline{R}^2$ = Adjusted R^2

Test for overall significance of regression

'F' test has been used to test the overall significance of explanatory variables whether they affect the dependent variable or not. The expression for the test is as under:

$$F(k-1, n-k)df. = \frac{R^2}{1-R^2}\frac{n-k-1}{k}$$

where,

k = Number of parameters

n = Number of observations in the sample

R^2 = Coefficient of multiple correlation

Marginal value products (MVP_s)

In order to evaluate the economic rationale of resource use on different categories of farms, the marginal value productivities (MVPs) of different resources were calculated by multiplying regression coefficient of given resources with the ratio of geometric mean of gross return to the geometric mean of given resources. The marginal value product of a particular resource represents the expected addition to the gross returns caused by an addition of one unit of that resource while other inputs are held constant. For estimation of MVP_{xi} the computational steps followed are as under:

$$MVP_{xi} = \left\{ b_i \frac{\overline{y}}{\overline{x}_i}\left(P_y\right)\right\}$$

where,

$\overline{y}$ = Geometric mean of output

$\overline{x}_i$ = Geometric mean of input

b_i = Regression coefficients

i = 1, 2, 3, ……n

P_y = Price of tomato per unit (₹/qtl)

The relative percentage change in MVP of each resource was required to obtain optimal resource allocation estimated:

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

where, D is the absolute value of percentage change in MVP of each resource (Mijindadi, 1980).

Garrett Ranking Method

In this method the constraints were focused on the response of all sample farmers. The respondents were asked to rank the problems related to production, processing and marketing. It was used to study the growers' problems towards the climate change with the following:

$$\text{Percent Position} = \frac{100\left(R_{ij} - 0.5\right)}{N_j}$$

Where,

R_{ij} = Rank given for i^{th} item j^{th} individual

N_j = Number of items ranked by j^{th} individual

From Garrett's Table, the estimated percentage positions were converted into scores. Thus for each constraint, the scores of the various respondents were added and the mean values were computed. The resultant mean values for each of the attributes were arranged in descending order. The attributes with the highest mean value was considered as the most important one and the others followed in that order till the least one.

RESULTS AND DISCUSSION

Status of tomato production in India and Himachal Pradesh

The results are prescribed in the table 1 and 2. It can be seen from the tables that maximum area under tomato cultivation had been 13185 hectares during the crop year 2019-20 in HP and 4839 hectares in Solan during the same crop year 2019-20. The production of tomato had been found minimum during the crop year 1995-96 in Himachal Pradesh i.e., 79057MT and in Solan i.e. 42146 MT. The area, production and productivity with respect to tomato crop in Himachal Pradesh is increasing at a rate of 4.96, 6.85 and 1.83 per cent per annum. They were significant at 1 per cent level. The area under tomato crop in Solan district was increasing with a significant rate of 4.70 per cent per annum, production had shown increasing significant rate of 7.5 per cent per annum and productivity was increasing with a significant rate of 1.95 per cent per annum.

Table 1: Trends in area, production and productivity of tomato in Himachal Pradesh (Production/MT, Area/ha)

Year	Area(ha)	Production (MT)	Productivity (MT/ha)
1995-1996	2570	79057	30.76
1996-1997	4000	121400	30.35
1997-1998	4300	132700	30.86
1998-1999	4500	144900	32.20
1999-2000	5000	163615	32.72
2000-2001	6000	207870	34.65
2001-2002	7035	243950	34.68
2002-2003	9000	231700	25.74
2003-2004	9813	246033	25.07
2004-2005	8973	300976	33.54
2005-2006	9211	301183	32.70
2006-2007	9388	316800	33.75
2007-2008	9499	319217	33.61
2008-2009	9555	336287	35.19
2009-2010	10124	383824	37.91
2010-2011	9944	388426	39.06
2011-2012	9870	392061	39.72
2012-2013	9930	413709	41.66
2013-2014	10373	430789	41.53
2014-2015	10800	475965	44.07
2015-2016	11037	485536	43.99
2016-17	11064	473284	42.78
2017-18	11240	481936	42.88
2018-2019	11750	502422	42.76
2019-2020	13185	539540	40.92
CAGR	4.96*	6.85*	1.83*
	(0.005)	(0.004)	(0.002)

Figure in parentheses is Standard error; Significant at 1 % and 5% level.

It was observed that over the period of time the farmers of Himachal Pradesh and Solan are growing tomato in larger area due to good returns and hybrid varieties of tomatoes are giving 12-14 pickings from single tomato plant during the crop season that led down to increase production and yield of tomato crop.

Table 2: Trends in area, production and productivity of tomato in Solan (Production/MT, Area/ha)

Year	Area(ha)	Production (MT)	Productivity (MT/ha)
1995-1996	1250	42146	33.72
1996-1997	1750	56680	32.39
1997-1998	1850	63085	34.1
1998-1999	1890	67200	35.56
1999-2000	2000	70500	32.25
2000-2001	2500	91220	36.49
2001-2002	3100	115380	37.22
2002-2003	3200	89600	28
2003-2004	3655	124103	33.95
2004-2005	3735	130695	34.99
2005-2006	3800	125400	33
2006-2007	3935	137725	35
2007-2008	3950	138250	35
2008-2009	4020	147000	36.57
2009-2010	4275	175375	41.02
2010-2011	4280	175480	41
2011-2012	4292	175975	41
2012-2013	4298	193500	45.02
2013-2014	4451	200295	45
2014-2015	4593	229650	47.5
2015-2016	4608	230400	46.25
2016-17	4621	245600	48.25
2017-18	4735	265432	48.95
2018-2019	4786	284523	49.26
2019-2020	4839	299853	49.28
CAGR	4.7*	7.5*	1.95*
	(0.005)	(0.003)	(0.002)

Significant at 1% and 5% level of significance; Figures in parentheses are standard errors.

Hence it was concluded that production and yield of solan district is increasing as there are large number of farmers that are doing tomato cultivation as it is a seasonal crop along with good climatic conditions of Solan gives favorable condition with good drained fertile soil and temperature requirement that increase yield and production per unit area.

Production function analysis and resource use efficiency in tomato crop

In tomato cultivation, the estimated Cobb-Douglas production function was statistically significant and explained 82 per cent of variation in tomato production. The sum of the elasticity coefficients ($\Sigma\ b_i$ = 1.05) at overall farm level was greater than unity, indicating a increasing return to scale. The result of increasing return to scale is in line with the findings of Uchegbu (2001) and Barwal *et al.* (2022) but disagreed with the finding of Obasi (2007). Seed (0.37), Fertilizers (-0.38), FYM (0.14), Irrigation (0.36), Plant protection (0.04) and Labour

(0.29) were the significant factors in tomato. The finding is consistent with studies by Dipeolu and Akinbode (2008) and Alboghdady (2014) in which number of labor, and costs of land, fertilizer, seed, and labor were significant factors of production to explain production efficiency and economics efficiency of pepper and tomato production. It is also consistent with studies by Murthy *et al.* (2009), Belén *et al.* (2003), Adenuga *et al.* (2013), and Cyprian (2014) in which labor and seed were significant inputs to explain the level of technical efficiency of smallholder tomato producer. It means that tomato is gives good return and income to farmers of Solan area.

Table 3: Estimated Cobb-Douglas production function in the sampled households

Particulars	Marginal	Small	Medium	Overall
Intercept	3.11	4.56	1.61	3.48
	(0.75)	(0.58)	(0.46)	(0.64)
Seed (g)	0.22**	0.34**	0.32*	0.37**
	(0.12)	(0.08)	(0.08)	(0.10)
Fertilizer (kg/ha)	-0.10	-0.24	-0.32	-0.38
	(0.08)	(0.08)	(0.12)	(0.09)
FYM (kg/ha)	0.25**	0.11**	0.26*	0.14**
	(0.09)	(0.07)	(0.07)	(0.08)
Irrigation (l/ha)	0.30*	0.27*	0.12**	0.36*
	(0.15)	(0.04)	(0.15)	(0.10)
Plant Protection Chemical (ml/ha)	0.10*	0.06*	0.08**	0.04*
	(0.02)	(0.01)	(0.06)	(0.02)
Labour (mandays)	0.30**	0.29**	0.13**	0.29**
	(0.06)	(0.01)	(0.20)	(0.06)
R-square	0.86	0.83	0.78	0.82
F	28.76	18.23	19.40	16.23
Σb_i	1.07	0.95	0.91	1.05

*Significant at *1% and **5% level of significance; Figures in parentheses are standard errors.*

Marginal value product (MVP) and Price ratio of Tomato crop

Resource use efficiency determines the efficiency with a resource is used as mandated by its economically optimal level. When efficiency ratio is less than one, the resource is over utilized. When the ratio is greater than one, the resource is underutilized. The MVP to MFC ratio is greater than one except for fertilizers which indicates that the farmers are underutilizing the resource (Table 4). The efficiency ratio for FYM was (4.65) followed by irrigation (5.95), plant protection (2.64) and labour (1.54) being was positive and greater than unity which means under utilization of resources and in usage would lead to profit maximization. Fertilizers however had a negative coefficient (-6.15) was less than unity which indicates that these inputs were over utilized and there was need to reduce the use of fertilizers to get optimum level of output. In study of Ibitoye et.al (2015) the efficiency ratio result showed that quantity of fertilizers was over utilized while labour, irrigation and farm size were underutilized. The adjustment in the MVPs for optimal resource use indicates that for optimum allocation of resources more than 47. 65 per cent increase in Seed was required, while approximately 78.49 per cent increase in FYM, 83.20 per cent in irrigation, 62.15 per cent in plant protection and 34.86 percent in labour was needed. Fertilizers were over utilized and required approximately 83.75 per cent reduction for optimal use in tomato production.

Garrett ranking for the production constraints

The Garrett's ranking technique was used to rank the constraints in production. The results have been discussed below in table 5. It can be seen from the table 7 that pest infestation and diseases attack was

Table 4: Marginal value products (MVP_s) and factor price ratio in the sampled households of overall farm category

Particulars	Coefficient	APP	MPP	MVP	MFC	r	D Value
Seed	0.37	51.65	19.11	11467.14	600.00	19.11	47.65
Fertilizers	-0.38	38.44	-6.15	-7380.03	1200.00	-6.15	-83.74
FYM	0.14	33.22	4.65	697.61	150.00	4.65	78.49
Irrigation	0.36	28.35	5.95	1190.70	200.00	5.95	83.20
Plant Protection	0.04	22.02	2.64	2378.43	900.00	2.64	62.15
Labour	0.29	7.31	1.54	767.62	500.00	1.54	34.86

Py = 1, MFC = 1.

the first ranked production constraint followed by high price of fertilizers and plant protection chemicals and non-availability of quality seed and planting material. The least ranking was given to the production constraints of inadequate facilities for agriculture inputs and agriculture insurance and non-availability of desired brands of fertilizers and plant protection chemicals The ranks were given from 1-10.

Table 5: Garrett ranking for the production constraints of the sampled households

Factors	Total Score	Average mean	Rank
Higher wages and shortage of skilled labour	13848	46.16	7
High price of fertilizers and plant protection chemicals	17967	59.89	2
Irrigation facilities not available	15968	53.23	4
Lack of technical knowledge about package of practices	15607	52.02	5
Pest infestation and diseases attack	18801	62.67	1
Climatic conditions	13676	45.59	8
Non availability of quality seed and planting material	16965	56.55	3
Desire brand of fertilizers and plant protection chemicals not available	11507	38.36	10
Inadequate facilities for agriculture inputs and agriculture insurance	12162	40.54	9
Lack of extension programmes and training	14638	48.79	6

Marketing constraints of the sample households

Table 6: Garrett ranking for the marketing constraints of the sample households

Factors	Total Score	Average mean	Rank
Non availability of grading and packaging machines	13212	44.04	9
Shortage of crates and packaging material	13243	46.94	8
Inadequate storage and cold storage facilities	17193	60.71	2
Post-harvest losses due to perishability	16358	58.68	3
No value addition and non-availability of processing units	18707	65.34	1
High transport charges during marketing	15403	54.85	5
Late information of market demand for seasonal Vegetables	15068	52.39	7
Not getting good prices for crop/ wide price fluctuations	15534	54.06	6
High commission charges and delay of payment by wholesaler	11019	37.87	10
Competition from other states	16374	57.28	4

It can be seen from the table 6 that no value addition and non-availability of processing units was the first ranked marketing constraint followed by inadequate storage and cold storage facilities and post-harvest losses due to perishability. The least ranking was given to the marketing constraints of non-availability of grading and packaging machines and high commission charges and delay of payment by wholesaler. The ranks were given from 1-10.

Constraints of the traders

It can be seen from the table 7 that lack of procurement and cold storage facilities was the first ranked marketing constraint followed by high post-harvest of produce during transportation. The least ranking was given to the labour scarcity and high wages rates. The rank was given from 1-5.

Table 7: Garrett Ranking for the constraints of the traders in the study area

Particulars	Total Score	Average mean	Rank
Lack of procurement and cold storage facilities	485	69.52	1
Road blockage during marketing season	365	55.45	4
Lack of grading standards and no premium price for graded produce	384	58.21	3
High postharvest losses of produce during transportation	425	62.23	2
Labour scarcity and high wage rates	320	51.41	5

CONCLUSION

The resource use efficiency of tomato cultivation has been estimated by Cobb-Douglas function. The study has shown that FYM, seed, Irrigation, plant protection chemicals were significantly contributed to the production and marketing of tomato. Whereas the resources like fertilizers and cold storage resources were underutilized thus

there is need for proper under-utilized thus there is need for proper utilization of the resources for optimum value of output. The balanced utilization of these inputs by the tomato farmers can boost the productivity of tomato crop. Hence in case of production the major constraints and problems were pest infestation and diseases, high price of fertilizers and plant protection chemicals, non-availability of quality seed and material, Irrigation facilities and lack of technical knowledge. Whereas constraint and problems related to marketing in study area were no value addition and non-availability of processing unit's Inadequate storage facilities, post-harvest losses due to Perish ability, Competition from other states and High transport charges during marketing. In case of traders the marketing constraints and problems were Lack of procurement and storage facilities, High postharvest losses of produce during transportation, Lack of graded standards and no premium price for graded produce, Road Blockage during marketing season, labour scarcity and high wages rate. Therefore, it is suggested that govt and researcher's and SAU's should provide proper mitigation strategies for production by giving adequate supply of quality seed, good package of practices, quality plant protection chemicals, fertilizers and agriculture inputs along with subsidies and welfare scheme by the government that help the farmers to increase their production and yield. The marketing channel plays an important role for farmers and traders. Hence, there is need to cut down the intermediaries to increase producer share in rupee and more over better marketing facilities cold storage at market yard and direct selling of produce to consumers by giving good profits to farmers. Hence the major issues and challenges of tomato growers will be overcome by working on farmer's welfare schemes and research to provide strategies to reduce the post-harvest losses of farmers, traditional cultivation practices and sustainable use of agriculture inputs to doubling farmer income. Tomato production is a profitable enterprise in Solan Himachal Pradesh and is in its mature state as depicted positive and increasing return's to scale.

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