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# Socio-Economic Impact Assessment of Protected Cultivation: Income, Employment and Livelihood Advancements for Farmers

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**Abstract**

*This study was conducted using primary data collected from 240 households in the state of Himachal Pradesh. The results of the study revealed that in protected cultivation, respondents aged 43 to 56 were more prevalent, with a higher literacy rate and diverse experience levels, while open field cultivation had a wider age range, lower literacy rates, and a majority of farmers with over 13 years of experience. The economic evaluation revealed that protected cultivation yields significantly higher output but necessitates higher initial investment. The output-input ratio of 2.81 in open cultivation as compared to 3.24 in protected cultivation underscored the efficiency of protected cultivation. The adoption of protected cultivation in tomatoes led to a substantial increase in income (Rs.72658.84) and employment (11.45 mandays). Multiple regression analysis elucidated that income, experience, polyhouse area and extension contacts exerted a positive influence on entrepreneurial behavior. These findings reflected the potential of protected cultivation in bolstering income, employment, and entrepreneurial endeavors among vegetable growers.*

**Keywords:** Impact, Livelihood, Regression analysis Model, Income, Employment, Protected cultivation.

**JEL Classification:** D13, Q10, N3, O33

## Introduction

The impact of climate change has led to a rise in average temperatures, prolonged drought, excessive rainfall and the emergence of new pests and diseases leading to an adverse impact on agricultural production in Southeast and South Asia (Rosenzweig *et al*., 2001; Chhogyel and Kumar, 2018; Aryal *et al.*, 2020). These adverse changes have put open field farming on bumpy roads while sustaining agricultural production. Therefore, to provide a favorable microclimate to crops, protected cultivation is a feasible alternative, mitigating climate risk (Prabhakar *et al*., 2017). The protected cultivation is a hi- tech method of growing crops under a controlled environment and protection from adverse climatic conditions using innovative structures (polyhouses, net houses, tunnels) or protections (windbreaks, irrigation, mulches). Protected cultivation is more sustainable as the effect of climate is minimized by controlled environment and the inputs such as fertilizers, pesticides and water are utilized more efficiently (Jensen, 2002; Stanghellini and Montero, 2012; Mehta *et al.*, 2020) and improved productivity with better quality ensures higher returns for the produce (Spehia, 2015; Chaoudhary, 2016; Kumar *et al*., 2016). Protected cultivation lets farmers to produce crops off season and fetch higher prices (Sabir and Singh, 2013). The protected cultivation can help in the reduction of greenhouse gas emissions and the overall environmental impact of food production (Gruda *et al*., 2019). Although heating, artificial lighting, post-harvest transport, packaging and use of fertilizers under hi-tech greenhouses are a major environmental concern (Gruda *et al*., 2019, Anton *et al.,* 2012; Theurl *et al*., 2017) the productivity obtained under protected cultivation is three to five times higher than open methods of cultivation depending on the crops (Jethi *et al*., 2012; Negi *et al.*, 2013). Further, in horticultural crops, the protected cultivation is a very lucrative venture (Sabir and Singh, 2013; Punera *et al*., 2017). Yet, protected cultivation in India is at a very nascent stage with only 0.2 percent penetration, which is very low as compared to other courtiers like The Netherlands, Turkey and Israel. The liberalization of industrial and trade policy paved the way for the development of export-oriented cut flowers.

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Subsequently, the programmes and incentives of the central and state governments have led to a substantial increase in the area under protected cultivation in India.

In North India, where agriculture serves as the backbone of the economy, the adoption of protected cultivation presents a promising opportunity to enhance agricultural productivity and livelihoods. Deriving a livelihood through protected agriculture entails relying primarily on farming activities conducted within controlled and sheltered environments. The farmers engaged in protected agriculture invest in technology, infrastructure and knowledge to create optimal growing conditions, leading to higher productivity, extended growing seasons and improved crop quality. Protected cultivation offers a more stable income, sustainability benefits, year-round production, and increased food security. However, it demands expertise, investment, and crop-specific knowledge.

Himachal Pradesh is an agrarian economy and the majority of the population depends on the agriculture sector for their income and livelihood security. A small proportion of geographical area of the state is available for cultivation due to the hilly terrains. The majority of land holdings are marginal and due to the demand of an expanding population on scarce arable land, the land available for cultivation is continuously declining. Cash crops are one of the catalysts for improving livelihood and agripreneurship opportunities in the state. Here, farmers grow a variety of seasonal and off-season vegetables in an open environment, which yield higher returns than conventional crops. In the rural areas of Himachal Pradesh, various socioeconomic factors significantly shape the livelihood choices of its inhabitants. Notably, protected cultivation emerges as the predominant source of livelihood for a majority of households, reflecting the area's agrarian focus (Chahal *et al*., 2020). Therefore, the present study was undertaken to assess the livelihood opportunity through protected cultivation of vegetable crops in Himachal Pradesh.

## Data Sources and Methodology

The present study was conducted in the mid zone of Himachal Pradesh during 2022-23. The mid hill zone was chosen to conduct the study as maximum extent of protected cultivation is seen in this zone. From this zone, Mandi and Solan districts were purposively chosen because there is comparatively more focus on protected cultivation of vegetable crops and people there are more involved in this. The data from 240 households were collected with the aid of structured and comprehensive questionnaire exclusively prepared for the study. Both primary and secondary data were collected. Primary data were collected on a pretested schedule by personal interview method from the selected respondents on different aspects of vegetable growers. The schedule was then modified and finalized for the main survey.

**Analytical framework:** It includes computation of averages, ratios and indices.

$$\text{Literacy index} = \frac{\sum w_i x_i}{\sum x_i}$$

Where $W_i$ = weights (0, 1, 2, 3, 4and 5) for illiterate, primary, middle, matric, senior secondary and graduate respectively. $X_i$ = Number of persons in respective category.

$$\text{Literacy rate} = \frac{\text{Total number of literate persons}}{\text{Total Population}} \times 100$$

$$\text{Dependency ratio} = \frac{\text{Number of dependents in a family}}{\text{Total workers}}$$

**Singh's cube root method**: In 1975, Singh gave a method to categorize group data into various categories known as Singh's cube root method and gave a formula:

$$S_1 = \frac{L_1 + \frac{n_i}{3} - C_{i-1}}{C_f} \times h$$

Where,

I = Indicate category number (I=1, 2, 3, n)

$S_1$= Segment (e.g. I, II, III)

$L_1$ = Lower limit of the quartile class

$C_{i-1}$=Cumulative frequency of the class preceding to the quartile class

f = Frequency

h= Width of the quartile class

N= Total cumulative cube root of frequencies

**Cost analysis:** The CACP cost concepts were used as follows:

**Cost $A_1$:** input costs, depreciation, interest on working capital etc.

**Cost $A_2$:** Cost $A_1$ + rent paid for leased in land

**Cost $B_1$:** Cost $A_1$+ interest on the fixed capital

**Cost $B_2$:** Cost $B_1$ + rental value of owned land

**Cost $C_1$:** Cost $B_1$ + imputed value of family labour

**Cost $C_2$:** Cost $B_2$ + imputed value of family labour

**Cost $C_3$:** Cost $C_2$ + value of management input (10% of Cost $C_2$)

**Income measures:** Farm business income, family labour income (FLI), farm investment income (FII) and net income (NI) were worked out.

**Protected cultivation as a livelihood opportunity**: Difference in income and employment generated in open versus protected cultivation was worked out using regression adjustment model (RAM). In RAM, we employ two separate regression equations for protected cultivation and open cultivation group.

$Y_i = \alpha + \beta_j X_{ij} + U_i$ - For protected cultivation

$Y_i = \upsilon + \tau_j X_{ij} + e_i$ - For open cultivation

Finally, we fit separate outcome equations for both groups.

POM (protected cultivation) = E (outcome | coefficient of regression on treated units)

POM (open cultivation) = E (outcome | coefficient of regression on control units)

Impact is measured as the difference between POM protected cultivation and POM open cultivation.

**Multiple Linear Regression Model (MLRM):** The relationship of independent variables with the entrepreneurial behavior of respondents was assessed. The regression function 'Y' dependent on n explanatory (predictor) variables $x_1$, $x_2$, ….. $x_n$ is given as:

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Where, Y = dependent variables; $X_i$ = independent variables (i= 1,2,3,……n); $\beta_1, \beta_2, \ldots, \beta_n$ = unknown parameters (coefficients) and $\beta_0$ = constant

**Table 1. Factors affecting EBI along with their measurement**

The Table 1 shows the measurement of different factors affecting EBI along with their measurement:

| Independent variables | Measurement |
|---|---|
| Age | Chronological age of the respondents in years |
| Farm income | The net income from protected cultivation of vegetable crops |
| Experience | In years |
| Area | Under polyhouse cultivation of vegetable crops in hectares |
| Education level | Number of years of formal schooling years completed |
| Family Size | Total number of members in a family |
| Extension Contact | 1 for contact, 0 for no contact |
| Gender | 1 for male, 0 for female |

## Results and Discussion

The results of the present study have been given under four sub-sections viz., Socio-economic profile of vegetable growers under protected and open field conditions, Economics and profitability analysis of open and protected cultivation of tomato, Impact of protected cultivation on income and employment and Contribution of significant socioeconomic factors to the entrepreneurial behaviour of tomato growers.

## Socio-economic Profile of Sample Vegetable Growers

### Age

The vegetable growers of the study area were divided into two categories viz. open condition growers and polyhouse growers. The age of the respondents varied from less than 43 years to above 56 years. Under protected conditions category, on an average, 37.50 per cent of the respondents belonged to the age group of 43 to 56 years, 26.67 per cent belonged to the above 56 years age group and the remaining 35.83 per cent respondents were in the age group of 43 to 56 years. Whereas, under open field conditions, on an average, 22.50 per cent of the respondents belonged to the age group of 56 years and above, 38.33 per cent belonged to the age group of 43 to 56 years and the remaining 39.17 per cent respondents were less than 43 years in age. It was concluded that in case of protected cultivation, maximum proportion was for the age group of 43 to 56 years of age, except for small farmers where maximum percentage was for the less than 43 years age category. However, in case of open field conditions, maximum proportion was seen in less than 43 years of age group except for the medium farmers, where maximum farmers were in the age group of more than 56 years.

### Education Status

The literacy rate is an indicator of a nation's human resources. Increased knowledge is influenced by increased literacy rates, which implies the adoption of new innovations and technologies. At overall level, literacy rate was found to be similar (about 90%) in both protected growers and open filed growers. In case of protected cultivation, literacy rate was highest for the marginal farmers (92.26%), whereas, in case of the open field growers, highest literacy was observed in medium farmer category (96.59%). For the protected farmers, the literacy indices were found to vary between 2.63 to 2.76, whereas, it varied from 1.95 to 2.86 for the open field growers. At an overall level, literacy index was more in the protected farmers (2.75) highlighting high equality of education among them as compared to the open field growers (2.39)

### Experience in Vegetable Cultivation

The years of experience were grouped in three categories viz. less than 10 years, 10 to 13 years and more than 13 years, using Singh cube root method. At an overall level, in case of protected cultivation, equal number of respondents was having an experience of less than 10 and more than 13 years of experience. While in case of open cultivation of vegetable crops, maximum farmers were having more than 13 years of experience (58.33%), followed by respondents with 10 to 13 years of experience (30%) and least with respondents with less than 10 years of experience (11.67%).

## Extension Contacts

The extension contacts are needed to make people aware about any new technology. In case of protected cultivation about 56.50 per cent respondents had good extension contacts, whereas, remaining 43.50 per cent were with no extension contact. In case of the respondents practicing open cultivation, maximum respondents were not having extension contacts (84.17%) while, rest of the respondents had extension contact in the study area.

## Economics and Profitability Analysis of Open and Protected Cultivation of Tomato

The comparison between open cultivation and protected cultivation revealed striking differences in various cost and return aspects. Protected cultivation demonstrated a remarkable advantage in yield, producing 84.50 quintals compared to the 25.29 quintals of open cultivation. However, it demanded a higher initial investment, as evidenced by the substantially elevated costs in categories $A_1$, $B_2$, and $C_3$, indicating greater expenses in inputs etc. Despite this, protected cultivation reaped significantly higher gross returns of approximately Rs. 160,550.00 in contrast to the Rs. 37,940.52 generated in open cultivation. This translated into a substantially greater farm business income, highlighting the superior profitability of protected cultivation, which reaches Rs. 120,110.64 compared to the Rs. 30,321.25 of

**Table 2. Socio-economic profile of sampled vegetable growers under protected and open conditions in the study area (No.)**

| Socio - Economic parameter | Protected Cultivation | | | | Open Cultivation | | | |
|---|---|---|---|---|---|---|---|---|
| | Marginal | Small | Medium | Overall | Marginal | Small | Medium | Overall |
| A. Age of the Respondents (Categories based on Singh Cube root method) | | | | | | | | |
| <43 years | 18 (34.62) | 18 (37.50) | 7 (35.00) | 43 (35.83) | 24 (40.00) | 21 (46.67) | 2 (13.33) | 47 (39.17) |
| 43-56 years | 19 (36.54) | 17 (35.42) | 9 (45.00) | 45 (37.50) | 23 (38.33) | 18 (40.00) | 5 (33.33) | 46 (38.33) |
| >56 years | 15 (28.85) | 13 (27.08) | 4 (20.00) | 32 (26.67) | 13 (21.67) | 6 (13.33) | 8 (53.33) | 27 (22.50) |
| Total | 52 (100.00) | 48 (100.00) | 20 (100.00) | 120 (100.00) | 60 (100.00) | 45 (100.00) | 15 (100.00) | 120 (100.00) |
| B. Education of the Respondents | | | | | | | | |
| Literacy rate | 92.26 | 87.45 | 88.71 | 89.74 | 92.44 | 84.26 | 96.59 | 89.89 |
| Literacy Index | 2.63 | 2.90 | 2.73 | 2.75 | 2.60 | 1.95 | 2.86 | 2.39 |
| C. Experience in Vegetable Cultivation (Categories based on Singh Cube root method) | | | | | | | | |
| <10 years | 16 (30.77) | 23 (47.92) | 8 (40.00) | 47 (39.17) | 10 (16.67) | 4 (8.89) | 0 (0.00) | 14 (11.67) |
| 10-13 years | 14 (26.92) | 7 (14.58) | 5 (25.00) | 26 (21.2) | 14 (23.33) | 20 (44.44) | 2 (13.33) | 36 (30.00) |
| >13 years | 22 (42.31) | 18 (37.50) | 7 (35.00) | 47 (39.17) | 36 (60.00) | 21 (46.67) | 13 (86.67) | 70 (58.33) |
| Total | 52 (100.00) | 48 (100.00) | 20 (100.00) | 120 (100.00) | 60 (100.00) | 45 (100.00) | 15 (100.00) | 120 (100.00) |
| D. Extension Contacts | | | | | | | | |
| Extension contact | 30 (57.69) | 25 (52.08) | 13 (65.00) | 68 (56.50) | 11 (18.33) | 5 (11.11) | 3 (20.00) | 19 (15.83) |
| No extension contact | 22 (42.31) | 23 (47.92) | 7 (35.00) | 52 (43.50) | 49 (81.67) | 40 (88.89) | 12 (80.00) | 101 (84.17) |
| Total | 52 (100.00) | 48 (100.00) | 20 (100.00) | 120 (100.00) | 60 (100.00) | 45 (100.00) | 15 (100.00) | 120 (100.00) |

*Figures in parenthesis represent the percentage to the total.*

**Table 3. Cost and return estimates of open and protected cultivation of tomato**

**(Rs. per 1000 m$^2$)**

| Particulars | Open Cultivation | Protected Cultivation |
|---|---|---|
| Yield (qtls) | 25.29 | 84.50 |
| Cost $A_1$ | 7619.27 | 40439.36 |
| Cost $B_2$ | 8927.97 | 41579.17 |
| Cost $C_3$ | 13588.64 | 49595.76 |
| Gross Return | 37940.52 | 160550.00 |
| Farm Business Income | 30321.25 | 120110.64 |
| Family Labour income | 29012.55 | 118970.83 |
| Farm Income (net income) | 24351.87 | 110954.24 |
| Farm Investment Income | 26895.91 | 112585.10 |
| Output-Input Ratio | 2.81 | 3.24 |

open cultivation. Additionally, both family labor income and net farm income were substantially higher in protected cultivation, underscoring its economic viability. The output-input ratio further reinforced the efficiency of protected cultivation, with a ratio of 3.24, in contrast to the 2.81 ratio of open cultivation, indicating that protected cultivation produced more output per unit of input. Ultimately, these comparisons demonstrated that while protected cultivation might require higher upfront investments, it yielded significantly greater returns and proved to be a more efficient and lucrative cultivation method.

## Impact of Protected Cultivation on Income and Employment

The adoption of protected cultivation in tomato crops significantly impacted income as well as employment of tomato growers. The regression adjustment model depicted that those farmers who adopted protected cultivation received significantly higher income compared to open cultivators. The farmers who adopted the protected cultivation received Rs. 72658.84 which was found to be 70.59 per cent higher than the income of open cultivators of tomato. Furthermore, similar results were obtained for employment generated upon adoption of the protected cultivation. The employment generated in case of protected cultivation of tomato crop was higher as compared to the open cultivators. The protected cultivation of vegetable crops generated 11.45 man days of employment, which was 85.45 per cent higher than the employment (mandays) generated in case of open cultivators of tomato. Therefore, the protected cultivation of tomato crop could be taken as a way to uplift the farmers and assist them increasing income as well as employment of the farmers.

## Contribution of Significant Socioeconomic Factors to the Entrepreneurial Behaviour of Tomato Growers

Multiple regression analysis was carried out to estimate the contribution of significant socioeconomic factors to the entrepreneurial behavior. The R square value of the fitted model revealed that 73.6 per cent variation in the entrepreneurial behavior of the respondent has been explained by the explanatory variables taken in the model. It was found that income (0.40), experience in vegetable cultivation (0.78), area under polyhouse cultivation (4.87) and extension contacts (1.93) were significant and positively related to the

**Table 4. Impact of protected cultivation technology on farmers' income and employment: Regression adjustment estimates**

| Particulars | Difference (protected v/s open) | Robust SE | % higher than PO mean | Z - value |
|---|---|---|---|---|
| *Income (Rs.)* | | | | |
| Treatment (PC vs OC) | 72658.84 | 2914.21 | 70.59 | 24.93 |
| POM income OC | 102924.21 | 9548.64 | | 10.78 |
| *Employment (mandays)* | | | | |
| Treatment (PC vs OC) | 11.45 | 0.35 | 85.45 | 32.71 |
| POM employment OC | 13.40 | 0.48 | | 27.92 |

*PC: protected cultivation and OC: open cultivation*

**Table 5. Multiple regression analysis of the predictor variables with the entrepreneurial behaviour of the growers**

| Variables | Regression coefficients (b) | SE (b) | t value |
|---|---|---|---|
| Income | 0.40 | 0.01 | 5.67* |
| Experience in protected cultivation | 0.78 | 0.18 | 4.26* |
| Area under polyhouse cultivation | 4.87 | 1.29 | 0.78* |
| Extension contacts | 1.93 | 0.78 | 2.40** |

*a= 48.094**, F= 16.02**, $R^2$= 0.736*

*** and * indicates significance at 1% and 5% level of significance, respectively.*

entrepreneurial behavior of the tomato growers. Further, it can be interpreted that keeping other factors constant, a unit change in income led to increase in entrepreneurial behavior of grower by a factor of 0.4. Similarly, the entrepreneurial behavior increases by a factor of 0.78, 4.87 and 1.93 for a unit increase in experience, area under polyhouse and extension contacts, respectively.

## Conclusion and Policy Implications

Protected cultivation technology revolutionizes global agriculture, offering a controlled environment for crops, ensuring year-round production despite climate challenges and limited land. It also generates employment opportunities, boosts farm incomes, contributing to economic growth in both rural and urban areas. Overall, protected cultivation exemplifies how agricultural innovation can address global challenges while supporting local economies and livelihoods. From the present study, it can be concluded that the tomato yield was higher in protected cultivation (84.50 qtls). Nevertheless, all costs and returns were higher in protected cultivation as compared to open cultivation, even then, the output-input ratio was more for protected cultivation (3.24) as compared to open cultivation (2.81). The protected cultivation resulted in higher income (Rs. 72658.84) and employment (11.45 mandays) than open cultivation. A unit change in income, experience, area under polyhouse and extension contacts led to increase in entrepreneurial behavior of grower by a factor of 0.4, 0.78, 4.87 and 1.93 respectively. So, it can be concluded that promoting protected cultivation requires targeted policies. Government should offer financial incentives like grants and tax breaks to support farmers in setting up greenhouse systems. Research funding should be allocated for developing efficient cultivation technologies. Training programs and market linkages can enhance farmers' skills and help them connect with buyers. Streamlining regulations on land use and environmental considerations is crucial. Additionally, a focus on resource efficiency, sustainability, and crop diversity will bolster the long-term success of protected cultivation. Monitoring progress and making adjustments as needed ensures that these policies yield the desired benefits.

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