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Impact of protected vegetable cultivation on growers

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Abstract
The present investigation entitled "Impact of Protected Vegetable Cultivation on Growers" was conducted in Badnapur, Jalna, Bhokardan, and Jafrabad tehsils of Jalna district in the Marathwada region of Maharashtra state. An ex-post facto research design was adopted for the study. From the four selected tehsils, a total of 20 villages (five from each tehsil) were chosen purposively on the basis of maximum protected cultivation structures. From each village, six vegetable cultivators (three Protected Vegetable Cultivation Growers [PVCG] and three Non-Protected Vegetable Cultivation Growers [NPVCG]) were selected, constituting a total sample size of 120 respondents (60 PVCG and 60 NPVCG). Data were collected through personal interview method using a comprehensive, pre-tested, structured interview schedule.
The primary data were analyzed using frequency, percentage, mean, standard deviation, and large-sample 'Z' test. The assessment of technological impact revealed an overall composite mean impact of 102.89 per cent for PVCG over NPVCG across five core dimensions: change in employment generation recorded the highest increase of 287.14 per cent (mean of 885.92 man-days/year for PVCG vs. 228.50 man-days/year for NPVCG, $Z = 11.92$**), followed by change in annual income with a 109.93 per cent gain (mean of Rs. 9,08,666.67 vs. Rs. 4,32,833.33, $Z = 5.71$**), change in social status with an 82.67 per cent gain (mean score 13.70 vs. 7.50, $Z = 58.62$**), change in material possession with a 20.16 per cent increase (mean score 17.58 vs.
14.63, $Z = 3.90$*), and change in land holding with a 14.57 per cent increase (mean of 2.12 ha vs. 1.85 ha, $Z = 0.96$ NS).

Keywords: Protected vegetable cultivation, Socio-economic impact, Employment generation, Annual income, 'Z' test, Jalna district, Maharashtra

1. Introduction

Sustaining the majority of the Indian population, the agricultural sector remains the cornerstone of the nation's socio-economic fabric by serving as the primary source of employment. A substantial proportion of rural households rely directly or indirectly on farming and allied enterprises to secure their living. Enhancing the economic resilience of small and marginal landholders, along with landless agricultural workers, is fundamental to strengthening rural stability, securing household nutrition, and fostering balanced regional growth. Rural human capital advancement remains inextricably linked to farm progress, given that agrarian operations generate on-field work while driving interconnected support services including processing, aggregation, transport, warehousing, and farm input distribution. Consequently, agriculture functions not merely as an economic engine, but as a critical stabilizer for rural social welfare.

Farming across India followed conventional systems until the advent of the Green Revolution in the late 1960s. This transitional phase substantially elevated the yield and total output of key staples, notably wheat and paddy, primarily across canal-irrigated tracts. The introduction of high-yielding cultivars, synthetic fertilizers, expanded irrigation networks, farm mechanization, and standardized agronomic protocols spurred domestic food grain reserves and helped achieve national food autonomy. Nevertheless, the gains accruing from the Green Revolution were geographically and crop-wise skewed, leaving rainfed, dryland, and semi-arid tracts constrained by low yield realization, natural resource degradation, and volatile farm earnings. An over-reliance on cereal monocropping subsequently triggered environmental strains, including soil nutrient exhaustion, sub-surface water depletion, and diminishing returns on input investments. These structural drawbacks underscored the necessity of shifting toward a diversified, ecologically sustainable, and commercially remunerative farming model.

With the limitations of cereal-dominated production patterns becoming increasingly apparent, agricultural diversification toward high-value horticultural commodities emerged as an imperative. Horticulture has expanded as a resilient and remunerative agricultural branch, providing elevated returns per unit area, generating employment, and improving nutritional security. Vegetables occupy a prominent position within this shift owing to their short vegetative cycles, high productivity thresholds, and accelerating market demand driven

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by demographic expansion, urban growth, purchasing power gains, and dietary transitions. Furthermore, horticultural production demands greater labor intensity than traditional field crops, offering expanded employment pathways for rural workforces.

Over recent decades, the Indian agricultural landscape has encountered critical constraints such as land fragmentation, diminishing soil organic health, severe irrigation water scarcity, unpredictable weather anomalies, and escalating pest-pathogen pressures. Anthropogenic climate instability has aggravated production vulnerabilities through irregular monsoon distribution, elevated temperature spikes, and prolonged moisture stress. These constraints are acutely felt across semi-arid, drought-vulnerable zones like the Marathwada region in Maharashtra. In these environments, conventional open-field vegetable farming entails high production uncertainty and reduced profitability. Recurring crop damages, seasonal yield variances, and fluctuating farm-gate prices severely undermine the risk tolerance and financial stability of vegetable producers.

Under these agro-climatic pressures, protected vegetable cultivation offers an effective technological solution to alleviate structural farm-level constraints. Protected cultivation involves raising horticultural crops within fully or partially regulated micro-environments using polyhouses, shade-net facilities, greenhouses, and low or walk-in plastic tunnels. This production system empowers growers to regulate ambient micro-climates—encompassing ambient temperature, relative humidity, solar radiation, and fertigation delivery—thereby insulating the crop canopy against outdoor climatic extremes. The technology enables off-season harvesting, superior product uniformity, enhanced crop yields, minimized post-set losses, and premium price capture, directly fostering income stabilization and household livelihood security.

Maharashtra represents a leading state in the deployment of protected vegetable technologies, supported by diverse agro-ecological conditions, an established commercial horticulture base, organized marketing channels, and enabling administrative initiatives. Within Marathwada, Jalna district has established itself as the leading district in the installation and operation of protected cultivation facilities. This concentrated growth in Jalna is driven by proactive utilization of state and central assistance programs (notably NHM and Project on Climate Resilient Agriculture - PoCRA), active engagement with agricultural extension networks, expanding micro-irrigation infrastructure, direct market linkages, and an enterprising farming community. Jalna has gained recognition as a specialized center for protected horticulture—not only for commercial table vegetables such as color capsicum and cucumber, but also as an established production zone for high-value hybrid vegetable seeds (including tomato, sweet pepper, and cucumber) managed through institutional contract farming models, generating substantial farm returns and rural employment.

While protected vegetable cultivation continues to expand, systematic empirical inquiry assessing its multidimensional impact on growers remains vital. Evaluating how protected farming alters farm income, agricultural employment generation, operational farm acreage, asset building, and social status compared to conventional open-field cultivation provides critical empirical baseline data for upgrading extension delivery and agricultural policy.

In view of these considerations, the present research paper focuses strictly on the following

Specific objective:

1. To assess the impact of protected vegetable cultivation on growers.

Materials and Methods

The investigation was carried out across the Marathwada division of Maharashtra state. Jalna district was purposively selected as the primary locale for this research due to its preeminent concentration of protected vegetable cultivation infrastructure within the region. Geographically, Jalna district spans 7,718 sq km between 19°01′ to 20°03′ N latitudes and 75°04′ to 76°04′ E longitudes with an average elevation of 516 m above mean sea level, featuring a tropical semi-arid agro-climate with an average annual precipitation of 700 to 750 mm.

The study adopted an ex-post facto research design. A multi-stage purposive sampling framework was adopted. Within Jalna district, four talukas/tehsils—namely Jalna, Badnapur, Bhokardan, and Jafrabad—were purposively identified due to their leading proportion of protected vegetable cultivation units. Within each tehsil, five villages exhibiting the densest concentration of protected vegetable structures were chosen, yielding an aggregate of 20 sampled villages (Ghanewadi, Gondegao, Kumbephal, Pachanwadgaon, Waghrul in Jalna tehsil; Bawane Pangri, Chanegao, Dagadwadi, Keligavhan, Tupewadi in Badnapur tehsil; Longao, Malegaon, Nalni, Rajur, Tapovan in Bhokardan tehsil; Ambewadi, Ganeshpur, Niwdunga, Pokhri, Satephal in Jafrabad tehsil). Within every selected village, 3 protected vegetable cultivation growers (PVCG) and 3 non-protected vegetable cultivation growers (NPVCG) were drawn, generating a cohort of 15 PVCG and 15 NPVCG per tehsil, establishing a total sample size of 120 respondents (60 PVCG and 60 NPVCG).

Primary empirical data were gathered via structured personal interviews using a pre-tested interview schedule administered face-to-face in the regional language (Marathi).

The dependent variable, impact of protected vegetable cultivation, was operationalized as the overall percentage change brought about in the socio-economic and farming conditions of PVCG over NPVCG across five core dimensions: change in annual income (ΔAI), change in employment generation (ΔEG), change in land holding (ΔLH), change in material possession (ΔMP), and change in social status (ΔSS). The mathematical formulations applied were:

Change in Annual Income (%):

$$\Delta AI = \frac{AI_{\text{pvcg}} - AI_{\text{npvcg}}}{AI_{\text{npvcg}}} \times 100$$

Change in Employment Generation (%):

$$\Delta EG = \frac{EG_{\text{pvcg}} - EG_{\text{npvcg}}}{EG_{\text{npvcg}}} \times 100$$

Change in Land Holding (%):

$$\Delta LH = \frac{LH_{\text{pvcg}} - LH_{\text{npvcg}}}{LH_{\text{npvcg}}} \times 100$$

Change in Material Possession (%):

$$\Delta MP = \frac{MP_{\text{pvcg}} - MP_{\text{npvcg}}}{MP_{\text{npvcg}}} \times 100$$

Change in Social Status (%):

$$\Delta SS = \frac{SS_{\text{pvcg}} - SS_{\text{npvcg}}}{SS_{\text{npvcg}}} \times 100$$

$$\text{Overall Composite Mean Impact (\%)} = \frac{\text{\% Change in Annual Income} + \text{\% Change in Employment Generation} + \text{\% Change in Land Holding} + \text{\% Change in Material Possession} + \text{\% Change in Social Status}}{5}$$

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To derive valid statistical inferences, tabulated data were analyzed using frequency distributions, percentages, arithmetic means, standard deviations, and large-sample two-sample 'Z' tests (for testing significance of difference between means of PVCG and NPVCG).

Results and Discussion

The impact of protected vegetable cultivation on growers was comprehensively evaluated across five dimensions: change in annual income, change in employment generation, change in land holding, change in material possession, and change in social status, culminating in an overall composite impact index.

3.1 Change in annual income

Annual income reflects the tangible financial gains and economic empowerment derived from adopting protected cultivation. Table 1 presents the distribution of respondents according to change in annual income.

Table 1 reveals that a majority (63.33%) of the PVCG were in the medium annual income category, followed by 20.00 per cent in the high annual income category and 16.67 per cent in the low annual income category.

Similarly, among NPVCG, 63.33 per cent were in the medium category, followed by

21.67 per cent in the low and 15.00 per cent in the high annual income category. The substantial financial disparity between both cohorts is demonstrated by the mean annual income of PVCG (Rs. 9,08,666.67) compared to NPVCG (Rs. 4,32,833.33), establishing an impressive positive change of 109.93 per cent.

This indicates that protected vegetable cultivation creates a profound economic impact by shielding crops from extreme temperatures, heavy rains, and pest infestations, thereby tripling yields per unit area and enabling cultivators to supply premium-grade vegetables (such as capsicum, cucumber, and tomato) during high-demand, off-season market periods. In contrast, NPVCG suffer from seasonal price gluts and open-field weather vulnerabilities, which restrict their annual profit margins.

Table 1. Distribution of PVCG and NPVCG according to change in Annual Income

Sr. No.	Category	PVCG Freq.	(%)	NPVCG Freq.	(%)	'Z' Value
1.	Low	10	16.67	13	21.67	5.71**
2.	Medium	38	63.33	38	63.33	
3.	High	12	20.00	09	15.00	
	Total	60	100.00	60	100.00	
	Mean (Rs.)	9,08,666.67		4,32,833.33		
	Standard Deviation (S.D.)	6,06,600.60		2,18,986.04		
	Per cent Change (% Δ)	109.93%				

The calculated 'Z' value (5.71**, $p < 0.01$) confirms a statistically significant difference between PVCG and NPVCG. These findings are supported by Barbade (2014) [1], Hasan *et al.* (2016) [2], Prakash *et al.* (2020) [3], Kale (2020) [4], and Tilgame (2021) [5].

4.2 Change in employment generation

Employment generation measures the capacity of the technology to create gainful on-farm labor absorption. Table 2 presents the distribution of respondents according to change in employment generation.

Table 2 indicates that a majority (61.67%) of the PVCG were in the medium employment generation category, followed by 21.67 per cent in high and 16.67 per cent in low category. Among NPVCG, 63.33 per cent were in the medium category, followed by 20.00 per cent in high and 16.67 per cent in low category. The mean on-farm labor utilization of PVCG was

885.92 man-days/year compared to 228.50 man-days/year for NPVCG, demonstrating an extraordinary positive change of 287.14 per cent.

This indicates that protected vegetable cultivation generates continuous, multi-season employment because crops inside polyhouses/shade nets are cultivated for extended durations (8 to 10 months) requiring daily intercultural operations (such as fertigation scheduling, temperature regulation, pest scouting, daily harvesting, and packaging for direct market dispatch).

In contrast, NPVCG practice seasonal open-field farming characterized by sporadic labor requirements during sowing and harvesting, followed by extended periods of idle farm labor.

The 'Z' value (11.92**, $p < 0.01$) was highly significant. These findings are supported by Kumari *et al.* (2020) [6], Prakash *et al.* (2020) [3], and Prakash *et al.* (2023) [7].

4.3 Change in land holding

Change in operational land holding reflects long-term wealth accumulation and capacity to reinvest farm surpluses. Table 3 presents the distribution according to change in land holding.

Table 3 shows that a plurality (41.67%) of both PVCG and NPVCG belonged to the small land holding category. Semi-medium holders accounted for 33.33 per cent of PVCG compared to

Table 2. Distribution of PVCG and NPVCG according to change in Employment Generation

Sr. No.	Category	PVCG Freq.	(%)	NPVCG Freq.	(%)	'Z' Value
1.	Low	10	16.67	10	16.67	11.92**
2.	Medium	37	61.67	38	63.33	
3.	High	13	21.67	12	20.00	
	Total	60	100.00	60	100.00	
	Mean (days/year)	885.92		228.50		
	Standard Deviation (S.D.)	421.71		65.66		
	Per cent Change (% Δ)	287.14%				

18.33 per cent of NPVCG, while marginal holders accounted for 23.33 per cent of PVCG and

31.67 per cent of NPVCG. The mean operational holding of PVCG was 2.12 ha compared to

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1.85 ha for NPVCG, reflecting a modest positive change of 14.57 per cent.

Table 3. Distribution of PVCG and NPVCG according to change in Land Holding

Sr. No.	Category	PVCG Freq.	(%)	NPVCG Freq.	(%)	'Z' Value
1.	Marginal	14	23.33	19	31.67	0.96 NS
2.	Small	25	41.67	25	41.67	
3.	Semi-medium	20	33.33	11	18.33	
4.	Medium	01	01.67	05	08.33	
5.	Large	00	00.00	00	00.00	
	Total	60	100.00	60	100.00	
	Mean	2.12		1.85		
	Standard Deviation (S.D.)	1.11		1.85		
	Per cent Change (% Δ)	14.57%				

Enhanced profitability from protected vegetable production enables cultivators to gradually accumulate financial savings and reinvest in expanding their operational land resources over time, whereas NPVCG remain largely constrained to subsistence parcel sizes.

The calculated 'Z' value (0.96) was non-significant, indicating that structural land holding changes occur gradually over extended horizons. Similar findings were reported by Pawar (2014) [8], Bhosale *et al.* (2020) [9], and Sindhura *et al.* (2022) [10].

4.4 Change in material possession

Material possession reflects the accumulation of productive farm machinery, micro-irrigation assets, and household durables. Table 4 presents the distribution of respondents according to change in material possession.

Table 4. Distribution of PVCG and NPVCG according to change in Material Possession

Sr. No.	Category	PVCG Freq.	(%)	NPVCG Freq.	(%)	'Z' Value
1.	Low	14	23.33	12	20.00	3.90*
2.	Medium	29	48.33	34	56.67	
3.	High	17	28.34	14	23.33	
	Total	60	100.00	60	100.00	
	Mean Score	17.58		14.63		
	Standard Deviation	04.82		03.17		
	Per cent Change (% Δ)	20.16%				

Table 4 indicates that nearly half (48.33%) of the PVCG had a medium level of material possession, followed by 28.34 per cent in high and 23.33 per cent in low category. Among NPVCG, 56.67 per cent were in the medium category, followed by 23.33 per cent in high and 20.00 per cent in low category.

The mean material possession score of PVCG was 17.58 compared to 14.63 for NPVCG, establishing a significant positive change of 20.16 per cent. This positive shift is attributed to the reinvestment of regular financial surpluses generated from shade net vegetable sales into high-value farm assets (such as power tillers, micro-irrigation infrastructure, motorized sprayers, and transport vehicles) as well as modern electronic household goods.

In contrast, NPVCG face seasonal income uncertainties and tighter liquidity, which limits their asset acquisition capacity. The calculated 'Z' value (3.90*, $p < 0.05$) confirmed a statistically significant difference. These findings align with Singh *et al.* (2018) [11], Singh *et al.* (2022) [12], and Bharti *et al.* (2023) [13].

Change in social status

Social status denotes the prestige, living standards, and community recognition accorded to a cultivator within rural society. Table 5 presents the distribution according to change in social status.

Table 5. Distribution of PVCG and NPVCG according to change in Social Status

Sr. No.	Category	PVCG Freq.	(%)	NPVCG Freq.	(%)	'Z' Value
1.	Low	13	21.67	00	00.00	58.62**
2.	Medium	47	78.33	59	98.33	
3.	High	00	00.00	01	01.67	
	Total	60	100.00	60	100.00	
	Mean Score	13.70		07.50		
	Standard Deviation (S.D.)	00.62		00.54		
	Per cent Change (% Δ)	82.67%				

Table 5 indicates that a majority (78.33%) of the PVCG were in the medium category of social status, followed by 21.67 per cent in low and none (00.00%) in high category. Among NPVCG, an overwhelming majority (98.33%) were in the medium category, with 01.67 per cent in high and none in low category.

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The mean score of PVCG was 13.70 compared to 07.50 for NPVCG, demonstrating a substantial positive change of 82.67 per cent. Practicing protected cultivation requires advanced technical acumen, precision fertigation management, and institutional linkages, which earn growers higher esteem among village peers, enhanced credibility in local cooperatives and social organizations, and frequent invitations to share technical experiences at farmers' field schools and agricultural exhibitions. The 'Z' value (58.62**, $p < 0.01$) was highly significant. These findings are in line with Shashidhara (2006) [14], Gaikwad *et al.* (2018) [15], and Rajesh *et al.* (2023) [16].

Overall composite mean impact and significance testing across dimensions

Synthesizing the five core socio-economic dimensions provides a comprehensive measure of technological impact. Table 6 summarizes dimension-wise mean scores and per cent impact, while Table 7 presents the statistical testing of significance of difference of means.

Table 6. Dimension-wise Mean Scores and Per Cent Impact between PVCG and NPVCG

Sr. No.	Impact Dimension	Mean PVCG	Mean NPVCG	% Change (% Δ)
1.	Change in annual income (Rs.)	9,08,666.67	4,32,833.33	109.93%
2.	Change in employment generation (days/year)	885.92	228.50	287.14%
3.	Change in land holding (ha)	02.12	01.85	14.57%
4.	Change in material possession (score)	17.58	14.63	20.16%
5.	Change in social status (score)	13.70	07.50	82.67%
	Overall Composite Mean Impact			102.89%

Table 7. Testing the Significance of Difference of Means Across Impact Dimensions

Sr. No.	Impact Dimension	Mean Score PVCG	Mean Score NPVCG	'Z' Value	Significance Level
1.	Change in annual income (Rs.)	9,08,666.67	4,32,833.33	05.71**	Significant ($p < 0.01$)
2.	Change in employment generation (days/year)	885.92	228.50	11.92**	Significant ($p < 0.01$)
3.	Change in land holding (ha)	02.12	01.85	00.96	Non-Significant (NS)
4.	Change in material possession	17.58	14.63	03.90*	Significant ($p < 0.05$)
5.	Change in social status	13.70	07.50	58.62**	Significant ($p < 0.01$)

Table 6 and Table 7 show that among all individual indicators, the highest impact was recorded in change in employment generation (287.14%), followed by change in annual income (109.93%), change in social status (82.67%), change in material possession (20.16%), and change in land holding (14.57%). The synthesized composite mean impact of protected vegetable cultivation was computed to be 102.89 per cent for PVCG over NPVCG.

The 'Z' test confirmed that differences in employment generation (Z = 11.92**), annual income (Z = 5.71**), social status (Z = 58.62**), and material possession (Z = 3.90*) were statistically significant, leading to the rejection of the null hypothesis (H_0) and acceptance of the empirical hypothesis (H_1) for these dimensions.

The probable reason for this outstanding composite impact (102.89% overall gain) is that protected cultivation functions as a synergistic techno-economic enterprise rather than an isolated agronomic practice. Regulating the crop microclimate inside polyhouses and shade net

structures eliminates abiotic risks (such as extreme heat, frost, and unseasonal rainfall), ensures multi-fold yield increases per unit area, and enables continuous, high-value off-season vegetable production.

The resulting financial liquidity and regular cash flows allow PVCG to generate round-the-year employment, reinvest in modern agricultural implements, expand their operational land base, and gain high respect and opinion leadership in the rural community. Similar findings were reported by Prakash *et al.* (2020) [3], Vishnupriyan *et al.* (2022) [17], Sharma *et al.* (2023) [18], and Maitra *et al.* (2024) [19].

Conclusion and policy implications

Conclusions

Based on the empirical findings, the following conclusions are drawn:

Overall Technological Impact: The overall impact of protected vegetable cultivation on PVCG was highly significant and transformative, resulting in an overall mean impact of 102.89 per cent over NPVCG, driven predominantly by massive gains in on-farm employment generation (287.14%) and annual income (109.93%), accompanied by substantial gains in social status (82.67%), material possession (20.16%), and land holding (14.57%).

Statistical Significance: Large-sample 'Z' tests confirmed that the mean gains in employment generation (Z = 11.92**), annual income (Z = 5.71**), social status (Z = 58.62**), and material possession (Z = 3.90*) were statistically significant at 0.01 and 0.05 probability levels, demonstrating genuine technological superiority over traditional open-field farming.

Policy Implications

Mandating Structural and Crop Insurance for Natural Calamities: To protect growers against catastrophic losses from high-velocity windblasts and hailstorms that tear poly- cladding sheets and distort galvanized frameworks, the government and regulatory bodies must introduce specialized criteria-based insurance covering both physical greenhouse structures and high-value standing crops.

Financial Continuity and Capital Subsidies: State implementing agencies under schemes like PoCRA, NHM, and MIDH should raise capital subsidy limits, streamline approval documentation, and arrange secondary maintenance grants to assist growers in replacing cladding films after their five-year operational lifespan.

Strengthening Technical Extension and Capacity Building: Agricultural universities, Krishi Vigyan Kendras, and the State Department of Agriculture must systematically provide hands-on training modules focusing on precision fertigation, manual emasculation and pollination for hybrid seed production, and biological pest management.

Market Regulation and Cold Storage Infrastructure: State Agricultural Marketing Boards should formally regulate protected produce marketing by establishing dedicated auction

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bays and grading standards in APMC mandis, alongside promoting taluka-level cold storage and contract farming linkages with seed companies.

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