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Socio-economic profile, implementation constraints, and grower strategies in protected vegetable cultivation

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Abstract

Protected vegetable cultivation under polyhouses and shade net structures represents a critical, climate-smart technological intervention designed to overcome environmental vulnerabilities, optimize resource-use efficiency, and accelerate farm commercialization. The present investigation was undertaken to comparatively evaluate the socio-economic, personal, and psychological profile of Protected Vegetable Cultivators (PVCG) versus Non-Protected Vegetable Cultivators (NPVCG), identify operational constraints encountered in implementing protected structures, and elicit grower-endorsed remedial strategies. An ex-post facto comparative research design was adopted using a four-stage purposive sampling procedure in Jalna district of Maharashtra, recognized for its high density of protected structures. Four tehsils (Badnapur, Jalna, Bhokardan, and Jafraabad) and twenty villages (five per tehsil) were purposively selected, comprising a total sample size of 120 vegetable cultivators (60 PVCG and 60 NPVCG; 3 of each per village). Data were collected through personal interviews using a structured, pre-tested schedule.

The empirical findings revealed that the majority of PVCG were young (71.67%, Mean = 31.67 years vs. 42.00 years for NPVCG; $Z = -4.91^*$), educated up to graduation (31.67%, Mean = 12.33 years vs. 08.33 years; $Z = 5.36^*$), possessed small landholding (41.67%, Mean = 2.12 ha vs. 1.85 ha; $Z = 0.96$ NS), operated medium area under protected structures (63.33%, Mean = 45.43 R's vs. 00.00 R's; $Z = 11.57^{**}$), possessed medium operational experience in protected cultivation (75.00%, Mean = 07.55 years vs. 00.00 years; $Z = 15.64^{**}$), earned medium annual income (63.33%, Mean = Rs. 9,08,666.67 vs. Rs. 4,32,833.33; $Z = 5.71^*$), utilized medium sources of information (80.00%, Mean = 25.02 vs. 22.43; $Z = 4.87^{**}$), received medium specialized trainings (58.33%, Mean = 02.42 vs. 01.08; $Z = 18.12^{**}$), maintained medium social contact (81.67%, Mean = 11.80 vs. 18.45; $Z = -16.14$), and exhibited medium levels of risk orientation (55.00%, Mean = 26.38 vs. 23.05; $Z = 05.11^{**}$), market orientation (61.67%, Mean = 51.43 vs. 48.25; $Z = 2.48^{**}$), perception (60.00%, Mean = 60.38 vs. 59.55; $Z = 01.89^{**}$), and knowledge (76.67%, Mean = 31.28 vs. 30.25; $Z = 03.60^{**}$). Large-sample 'Z' tests confirmed significant differences ($p < 0.01$ and $p < 0.05$) between PVCG and NPVCG across thirteen profile variables.

The study prioritized twelve major constraints faced by PVCG: high initial investment for structural construction (66.67%, Rank I), irrigation and labor shortages (65.00%, Rank II), market price fluctuations (63.33%, Rank III), incidence of pests and diseases (61.67%, Rank IV), lack of specific markets for protected produce (58.33%, Rank V), inadequate/untimely disbursement of loans and subsidies (56.67%, Rank VI), lack of scientific production knowledge (55.00%, Rank VII), irregular power supply (53.33%, Rank VIII), high wages of skilled labor (51.67%, Rank IX), non-availability of quality inputs (48.33%, Rank X), non-availability of equipment in local markets (45.00%, Rank XI), and water shortage for irrigation (43.33%, Rank XII). To overcome these constraints, growers suggested increasing subsidy and loan amounts (100.00%, Rank I), introducing criteria-based structural and crop insurance (96.67%, Rank II), establishing cold storage facilities at the taluka level (95.00%, Rank III), providing regular technical guidance (91.67%, Rank IV), regulating marketing channels (90.00%, Rank V), encouraging low-cost protected structures (88.33%, Rank VI), supplying quality inputs at low cost (85.00%, Rank VII), and promoting agricultural machinery at reasonable prices (83.33%, Rank VIII).

Keywords: Protected vegetable cultivation, polyhouse, shade net, socio-economic profile, large-sample z-test, operational constraints, remedial suggestions, Maharashtra

1. Introduction

In recent decades, Indian agriculture has experienced significant structural transformations driven by climate variability, diminishing per capita landholdings, and

escalating demand for high-value horticultural crops. Traditional open-field vegetable cultivation is increasingly exposed to biotic and abiotic stresses—such as erratic rainfall patterns, extreme temperature fluctuations, hail storms, and

devastating pest complexes—which severely impair yield consistency and farm income stability (Hasan *et al.*, 2016; Prakash *et al.*, 2020) [4, 12]. In this context, protected vegetable cultivation technology—encompassing naturally ventilated polyhouses, insect-proof net houses, and shade net structures—presents an advanced, intensive production system that modifies the crop microenvironment, optimizes water and nutrient-use efficiency through precision drip fertigation, and enables round-the-year off-season crop production (Sabir & Singh, 2013; Vishnupriyan *et al.*, 2022) [14, 22].

Maharashtra has established itself as one of the leading states in India in adopting protected horticulture, supported by developmental frameworks such as the National Horticulture Mission (NHM), Mission for Integrated Development of Horticulture (MIDH), and the Project on Climate Resilient Agriculture (PoCRA). Within Maharashtra, the Marathwada region, and specifically Jalna district, has emerged as a vibrant commercial hub for protected vegetable cultivation and hybrid vegetable seed production (e.g., tomato, capsicum, and cucumber). In Jalna district, growers enter into buy-back contract farming agreements with leading seed corporations, where 1 R (Guntha) of protected area yields approximately 1 kg of hybrid tomato seed, fetching remunerative contract rates ranging from ₹15,000 to ₹25,000 per kg.

Despite the demonstrated economic advantages of protected structures, widespread adoption and sustained management remain heavily dependent on growers' socio-personal, economic, and psychological profile characteristics. Furthermore, small and marginal farmers encounter substantial capital, technical, operational, and marketing bottlenecks (Senthilkumar *et al.*, 2018; Thakur *et al.*, 2023) [16, 20]. A systematic investigation into the profile attributes of adopters compared to non-adopters, along with an empirical prioritization of operational constraints and grower-endorsed suggestions, is essential for formulating evidence-based extension interventions and refining institutional support mechanisms. Therefore, the present study was undertaken with two specific.

Objectives

- To study the profile of protected vegetable growers in comparison with non-protected vegetable growers.
- To identify the constraints faced by protected vegetable growers and to invite their suggestions.

2. Materials and Methods

The present investigation was conducted in Jalna district of the Marathwada region in Maharashtra State. Jalna district was purposively selected due to having the highest concentration of functional protected vegetable structures in the region. An ex-post facto comparative research design was employed for the study. A multi-stage purposive sampling procedure was adopted to select four tehsils (Badnapur, Jalna, Bhokardan, and Jafrabad) based on the maximum density of polyhouses and shade net structures. From each selected tehsil, five villages were chosen purposively, making a total of twenty villages. From each village, three Protected Vegetable Cultivators (PVCG) and three Non-Protected Vegetable Cultivators (NPVCG) were selected purposively, constituting a final sample of 120 vegetable cultivators (60 PVCG and 60 NPVCG).

Primary data were gathered through personal interviews using a comprehensive, pre-tested structured interview schedule. Thirteen independent profile variables—namely age (chronological years), education (formal schooling years), landholding (ha), area under protected cultivation (R's), experience in protected cultivation (years), annual income (Rs./annum), sources of information (scale score), trainings received (number of trainings), social contact (scale score), risk orientation (Supe, 2007 scale) [19], market orientation (Samanta, 1977 scale), perception (scale score), and knowledge (teacher-made test score)—were measured using standardized scales and scoring procedures. Constraints and suggestions were documented using closed and open-ended items. Statistical analysis was performed using frequency distribution, percentage, arithmetic mean, standard deviation, and large-sample 'Z' tests for testing the significance of differences between PVCG and NPVCG means at 0.05 and 0.01 levels of probability.

3. Results and Discussion

3.1 Profile Characteristics of Protected and Non-Protected Vegetable Growers

The empirical distribution of Protected Vegetable Cultivators (PVCG, n = 60) and Non-Protected Vegetable Cultivators (NPVCG, n = 60) across all thirteen socio-economic, communication, and psychological variables, along with their category-wise frequencies, percentages, arithmetic means, standard deviations, percentage changes, and calculated large-sample 'Z' values, is systematically arrayed in Table 1.

Sr. No.	Profile Variable & Categories	PVCG (n = 60) Freq. (%)	NPVCG (n= 60) Freq. (%)	Mean ± SD (PVCG)	Mean ± SD (NPVCG)	Z-value
1.	Age (Years)	43	23	31.67 ±	42.00 ±	-4.91*
	Young (Up to 35 years)	(71.67%) 17	(38.33%) 19	07.40	14.52	
	Middle (36 to 50 years)	(28.33%) 00	(31.67%) 18			
	Old (> 50 years)	(00.00%)	(30.00%)			
	2.	Education	05			
(Schooling Years)		(08.33%)	(20.00%)	04.27	03.88	
Primary School		11	31			
(Up to 4th)		(18.33%)	(51.67%)			
Secondary School		13	06			
(5th to 10th)		(21.67%)	(10.00%)			
	Higher Secondary	19	11			

	(11th to 12th)	(31.67%)	(18.33%)			
	Graduation (13th to 15th)	12	00			
	Post-Graduation (> 15th)	(20.00%)	(00.00%)			
3.	Landholding (ha)	14	19	2.12 ± 1.11	1.85 ± 1.85	0.96 NS
	Marginal (Up to 1.00 ha)	(23.33%)	(31.67%)			
	Small (1.01 to 2.00 ha)	(41.67%)	(41.67%)			
	Semi-medium (2.01 to 4.00 ha)	20	11			
	Medium (4.01 to 10.00 ha)	(33.33%)	(18.33%)			
	Large (> 10.00 ha)	01	05			
		(01.67%)	(08.33%)			
		00	00			
		(00.00%)	(00.00%)			
4.	Area under PVC (R's)	10	00	45.43 ±	00.00 ±	11.57**
	Low (Up to 15.10 R's)	(16.67%)	(00.00%)	30.33	00.00	
	Medium (15.10 to 75.76 R's)	38	00			
	High (> 75.76 R's)	(63.33%)	(00.00%)			
		12	00			
		(20.00%)	(00.00%)			
5.	Experience in PVC (Years)	05	00	07.55 ±	00.00 ±	15.64**
	Low (Up to 3.86 years)	(08.33%)	(00.00%)	03.69	00.00	
	Medium (3.86 to 11.23 years)	45	00			
	High (> 11.23 years)	(75.00%)	(00.00%)			
		10	00			
		(16.67%)	(00.00%)			
6.	Annual Income (Rs./annum)	10	13	9,08,666.67 ±	4,32,833.33 ±	5.71*
	Low (< Rs. 3,02,066.06 / Rs. 2,13,847.29)	(16.67%)	(21.67%)	6,06,600.60	2,18,986.04	
	Medium (Rs. 3.02L - 15.15L / Rs. 2.14L - 6.52L)	38	38			
	High (> Rs. 15,15,267.27 / Rs. 6,54,849.38)	(63.33%)	(63.33%)			
		12	09			
		(20.00%)	(15.00%)			
7.	Sources of Information	04	14	25.02 ±	22.43 ±	4.87**
	Low (< 21.61 / < 20.11)	(06.67%)	(23.33%)	03.40	02.32	
	Medium (21.61 - 28.41 / 20.11 - 24.75)	48	35			
	High (> 28.41 / > 24.75)	(80.00%)	(58.33%)			
		08	11			
		(13.33%)	(18.33%)			
8.	Training Received	00	00	02.42 ±	01.08 ±	18.12**
	Low (< 1.19 / < 0.80)	(00.00%)	(00.00%)	00.50	00.00	
	Medium (1.19 - 2.97 / 0.80 - 1.35)	35	55			
	High (> 2.97 / > 1.35)	(58.33%)	(91.67%)			
		25	05			
9.	Social Contact	(41.67%)	(08.33%)	11.80 ±	18.45 ±	-16.14
	Low (< 9.79 / < 15.97)	02	06			
	Medium (9.79 - 13.81 / 15.97 - 20.92)	(03.33%)	(10.00%)			
	High (> 13.81 / > 20.92)	49	54			
		(81.67%)	(90.00%)			
		09	00			
		(15.00%)	(00.00%)			

10.	Risk Orientation	12	14	26.38 ±	23.05 ±	05.11**
	Low (< 22.91 / < 19.37)	(20.00%) 33	(23.33%) 33	03.47	03.67	
	Medium (22.91 - 29.86 / 19.37 - 26.73)	(55.00%) 15	(55.00%) 13			
	High (> 29.86 / > 26.73)	(25.00%) 	(21.67%) 			
	11.	Market Orientation	11	14	51.43 ±	
Low (< 45.76 / < 40.07)		(18.33%) 37	(23.33%) 32	05.67	08.18	
Medium (45.76 - 57.10 / 40.07 - 56.43)		(61.67%) 12	(53.33%) 14			
High (> 57.10 / > 56.43)		(20.00%) 	(23.33%) 			
12.		Perception	13	09	60.38 ±	59.55 ±
	Low (< 58.06 / < 57.04)	(21.67%) 36	(15.00%) 46	02.32	02.50	
	Medium (58.06 - 62.71 / 57.04 - 62.06)	(60.00%) 11	(76.67%) 05			
	High (> 62.71 / > 62.06)	(18.33%) 	(08.33%) 			
	13.	Knowledge	06	15	31.28 ±	30.25 ±
Low (< 29.14 / < 27.20)		(10.00%) 46	(25.00%) 37	03.14	03.05	
Medium (29.14 - 35.42 / 27.20 - 33.30)		(76.67%) 08	(61.67%) 08			
High (> 35.42 / > 33.30)		(13.33%) 	(13.33%) 			

Note: * Significant at 0.05 level of probability; ** Significant at 0.01 level of probability; NS = Non- Significant.

An analysis of Table 1 demonstrates sharp structural and behavioural differences between PVCG and NPVCG across personal, socio-economic, and psychological characteristics:

- Age:** Nearly three-fourths (71.67%) of PVCG belonged to the young age group (up to 35 years) with a mean of 31.67 years, whereas NPVCG were substantially older (mean = 42.00 years, with 30.00% in the old category). The calculated 'Z' value (-4.91*) was statistically significant. This younger age profile reflects that commercial protected horticulture is heavily favored by dynamic, educated rural agripreneurs who are physically active and willing to embrace precision farming ventures (Prakash *et al.*, 2020; Sindhura *et al.*, 2022; Thakur *et al.*, 2025) [12, 17, 20].
- Education:** More than half of PVCG possessed higher education (31.67% graduates and 20.00% post-graduates, mean = 12.33 years of schooling), compared to NPVCG who were concentrated in secondary school education (51.67%, mean = 08.33 years). The 'Z' value (5.36*) confirmed a highly significant difference. Higher formal schooling enables PVCG to comprehend complex chemical dosages, manage fertigation automation, and navigate corporate seed buy-back agreements (Iqbal *et al.*, 2021; Prakash *et al.*, 2022) [5, 13].
- Landholding:** The majority of both PVCG (41.67%) and NPVCG (41.67%) were small landholders (1.01 to 2.00 ha), with mean operational landholdings of 2.12 ha and 1.85 ha respectively. The difference was non-

significant (Z = 0.96 NS), indicating that land fragmentation is universal across the region, but protected structures provide smallholders with a high-intensity commercial pathway (Pawar, 2014; Bhosale & Deshmukh, 2020) [11, 3].

- Area & Experience in PVC:** The mean area under protected cultivation among PVCG was 45.43 R's (63.33% medium category, 15.10 to 75.76 R's), and mean experience was 07.55 years (75.00% medium category, 3.86 to 11.23 years), yielding highly significant 'Z' values (11.57** and 15.64**). These dimensions highlight that growers have steadily accumulated practical mastery over microclimate and pollination management over consecutive seasons (Patole, 2017) [10].
- Annual Income:** The mean annual income of PVCG was ₹9,08,666.67 as against ₹4,32,833.33 for NPVCG, representing an extraordinary positive change of 109.93 per cent (Z = 5.71*). This substantial income multiplier is driven by lucrative hybrid seed contract farming (fetching ₹15,000–25,000/kg) and off-season premium market sales (Barbade, 2014; Kale, 2020; Tilgame, 2021) [2, 8, 21].
- Extension & Psychological Dimensions:** PVCG recorded significantly superior scores in sources of information (Mean = 25.02 vs. 22.43; Z = 4.87**), training received (Mean = 02.42 vs. 01.08; Z = 18.12**), risk orientation (Mean = 26.38 vs. 23.05; Z = 05.11**),

market orientation (Mean = 51.43 vs. 48.25; $Z = 2.48^{**}$), perception (Mean = 60.38 vs. 59.55; $Z = 0.189^{**}$), and knowledge (Mean = 31.28 vs. 30.25; $Z = 0.360^{**}$). Conversely, social contact was significantly lower among PVCG (Mean = 11.80 vs. 18.45; $Z = -16.14^{**}$), because intensive daily polyhouse operations (fertigation, pollination, pest scouting) leave growers with less discretionary time for informal village

socializing (Patel *et al.*, 2015; Singh *et al.*, 2022) ^[9, 18].

3.2 Constraints Faced by Protected Vegetable Growers

Empirical data regarding the operational, capital, biological, and infrastructural challenges encountered by PVCG ($n = 60$) were systematically tabulated and ranked in descending order of severity in Table 2.

Sr.	Constraint Statement	Yes Freq. (%)	No Freq. (%)	Rank
1.	High initial investment for the construction of the structure	40 (66.67%)	20 (33.33%)	I
2.	Irrigation and specialized labour shortages	39 (65.00%)	21 (35.00%)	II
3.	Market fluctuations incline decline (Price volatility)	38 (63.33%)	22 (36.67%)	III
4.	Incidence of pests and diseases (Mites, thrips, nematodes)	37 (61.67%)	23 (38.33%)	IV
5.	Lack of specific markets for vegetables grown under protected conditions	35 (58.33%)	25 (41.67%)	V
6.	Inadequate and untimely disbursement of loans and subsidies	34 (56.67%)	26 (43.33%)	VI
7.	Lack of scientific knowledge about protected vegetable crop production	33 (55.00%)	27 (45.00%)	VII
8.	Irregular electric power supply	32 (53.33%)	28 (46.67%)	VIII
9.	High wages of skilled labour	31 (51.67%)	29 (48.33%)	IX
10.	Non-availability of quality inputs at the right time	29 (48.33%)	31 (51.67%)	X
11.	Non-availability of necessary equipment/spares in local markets	27 (45.00%)	33 (55.00%)	XI
12.	Shortage of water for irrigation during peak summer	26 (43.33%)	34 (56.67%)	XII

A critical examination of Table 2 indicates that high initial investment for structural construction was prioritized as the foremost constraint (66.67%, Rank I), followed by irrigation and specialized labor shortages (65.00%, Rank II) and market price volatility (63.33%, Rank III). Because hybrid seed production in Jalna requires intensive manual flower emasculation and daily crossing during morning hours, labor scarcity and high wage rates (51.67%, Rank IX) significantly elevate operating costs. Biological constraints such as rapid pest and disease outbreaks (61.67%, Rank IV) under warm, enclosed microclimates, lack of dedicated market bays

(58.33%, Rank V), and untimely credit disbursement (56.67%, Rank VI) were also highlighted as major impediments (Senthilkumar *et al.*, 2018; Kale, 2020; Thakur *et al.*, 2023) ^[16, 8, 20].

3.3 Suggestions Endorsed by Vegetable Growers to Overcome Constraints

The corrective measures and remedial strategies suggested by PVCG ($n = 60$) to resolve operational, financial, technical, and marketing constraints are summarized in Table 3.

Sr. No.	Remedial Suggestion Statement	Yes Freq. (%)	No Freq. (%)	Rank
1.	Increase the subsidy/loan amount for protected cultivation	60 (100.00%)	00 (00.00%)	I
2.	Need of criteria based insurance policy (Structure & Crop)	58 (96.67%)	02 (03.33%)	II
3.	Create cold storage facilities at the taluka level	57 (95.00%)	03 (05.00%)	III
4.	Provide technical guidance about protected cultivation (SAU/KVK)	55 (91.67%)	05 (08.33%)	IV
5.	Regulate the marketing of protected cultivation products	54 (90.00%)	06 (10.00%)	V
6.	Encourage low-cost protected cultivation structures in local market	53 (88.33%)	07 (11.67%)	VI
7.	Supply quality inputs at a low cost at the right time	51 (85.00%)	09 (15.00%)	VII
8.	Promote agricultural machinery at reasonable prices	50 (83.33%)	10 (16.67%)	VIII

Table 3 reveals that all growers unanimously advocated for increasing subsidy and loan amounts (100.00%, Rank I) to ease initial capital outlays. Furthermore, 96.67 per cent emphasized introducing criteria-based structural and crop insurance (Rank II) to mitigate climate and storm risks, 95.00 per cent urged establishing taluka-level cold chain and pre-cooling storage facilities (Rank III) to prevent distress sales, and 91.67 per cent demanded regular technical guidance from SAU/KVK experts (Rank IV). Institutionalizing these grower-endorsed recommendations will significantly enhance the viability and sustained adoption of protected vegetable cultivation (Prakash *et al.*, 2020; Waghmare *et al.*, 2023) ^[12, 23].

4. Conclusion and Policy Implications

The investigation establishes that protected vegetable

cultivation serves as a transformative, precision-driven agricultural technology adopted primarily by younger, well-educated agripreneurs with small landholdings. Adopters exhibit significantly superior income levels, information-seeking behavior, technical knowledge, and commercial risk-taking ability compared to traditional open-field growers. However, high structural capital outlays, skilled labor shortages, and market volatility remain major bottlenecks. Policy interventions must prioritize: (1) enhancing subsidy caps and expediting credit delivery under PoCRA and NHM/MIDH, (2) introducing comprehensive structural and crop insurance packages, (3) creating decentralized taluka-level cold storage infrastructure, and (4) institutionalizing regular hands-on capacity building on canopy management and pollination by State Agricultural Universities and KVKs.

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