Evaluating the Impact of Government Horticulture Schemes on Farm Productivity and Income in Himachal Pradesh: A Quasi-Experimental Analysis

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ABSTRACT
Himachal Pradesh, a mountainous state in northern India, has implemented multiple government horticulture schemes to enhance farm productivity and income. However, rigorous impact evaluations using causal inference methods remain limited. This study evaluates the impact of major government horticulture schemes—particularly the Mission for Integrated Development of Horticulture (MIDH), micro irrigation programs, and protected cultivation subsidies—on farm productivity, income, and technology adoption in Himachal Pradesh. This study employed a quasi-experimental design using propensity score matching (PSM) and difference-in-differences (DiD) approaches. Primary data were collected from 400 farmers (250 beneficiaries and 150 non-beneficiaries) across four districts representing different agro-climatic zones. Secondary data on scheme implementation, budget allocations, and productivity trends were obtained from the Himachal Pradesh Horticulture Department. Protected cultivation under government subsidies increased farmer income by approximately 25% ($p < 0.001$). Micro irrigation schemes demonstrated substantial positive returns, with input-output ratios ranging from 2.23 (brinjal) to 38.78 (pomegranate). Apple productivity growth varied significantly across zones (0.57%-4.78% annually). Technology adoption rates ranged from 38% (cold storage) to 71% (drip irrigation). Government subsidies covered 72.44% of protected cultivation capital costs (₹2, 29,438 per unit). Government horticulture schemes significantly improve farm productivity and income in Himachal Pradesh, though effectiveness varies by scheme type, crop, and agro-climatic zone. Enhanced extension services, improved credit access, and targeted infrastructure development are critical for maximizing scheme impacts.
Keywords: Horticulture schemes, impact evaluation, Himachal Pradesh, MIDH, propensity score matching, farm income, technology adoption

1. INTRODUCTION

1.1 Background

Himachal Pradesh, situated in the Western Himalayas, is predominantly a hilly state where agriculture and horticulture constitute the backbone of the rural economy. With approximately 70% of the population dependent on agriculture, the state has witnessed a strategic shift from traditional cereal cultivation to high-value horticulture crops, particularly apples, stone fruits, vegetables, and off-season produce (Kumar et al., 2021). The state contributes nearly 20% of India's total apple production and is recognized as the "Fruit Bowl of India" (Singh & Sharma, 2020).

Despite its natural advantages, horticulture in Himachal Pradesh faces multiple challenges including fragmented landholdings (average 0.8-1.2 hectares), inadequate post-harvest infrastructure, limited market access, climate change impacts, and insufficient technical knowledge among farmers (Mehta et al., 2020). Recognizing these constraints, both central and state governments have implemented various schemes aimed at enhancing horticulture productivity, improving farmer incomes, and promoting sustainable agricultural practices.

1.2 Government Horticulture Schemes

The major government interventions in Himachal Pradesh’s horticulture sector include:

1. Mission for Integrated Development of Horticulture (MIDH): A centrally sponsored scheme providing financial assistance for area expansion, productivity enhancement, technology adoption, and infrastructure development. MIDH offers subsidies ranging from 40-50% for general farmers and up to 75% for small and marginal farmers (Government of India, 2021).

2. Micro Irrigation Schemes: Programs promoting drip and sprinkler irrigation systems with 50-90% subsidies to improve water-use efficiency and crop productivity (Himachal Pradesh Horticulture Department, 2022).

3. Protected Cultivation Programs: Subsidies for polyhouse construction (50-65% subsidy) enabling off-season vegetable production and higher value realization (Thakur & Guleria, 2019).

4. High-Density Plantation Schemes: Financial support for establishing high-density apple orchards with improved varieties and modern management practices.

5. Post-Harvest Infrastructure: Assistance for establishing cold storage facilities, grading units, and market infrastructure.

1.3 Research Gap and Objectives

While descriptive studies documenting scheme implementation exist, rigorous impact evaluations employing causal inference methods remain scarce for Himachal Pradesh. Most existing studies are qualitative or use simple before-after comparisons without adequate counterfactuals, limiting the ability to attribute observed changes to specific interventions (Pathania, 2023; Kumar & Singh, 2022).

This study addresses this gap by employing quasi-experimental methods to rigorously evaluate scheme impacts. The specific objectives are:

1. To assess the impact of government horticulture schemes on farm productivity and income
2. To analyze technology adoption rates and determinants under different schemes
3. To examine variations in scheme effectiveness across crops and agro-climatic zones
4. To identify implementation challenges and policy recommendations

1.4 Conceptual Framework

Figure 1 presents our conceptual framework illustrating the impact pathway of government horticulture schemes. Government schemes (inputs) are implemented through extension services, credit mechanisms, and institutional support (process), leading to technology adoption (outputs). This relationship is moderated by infrastructure quality and farmer characteristics, ultimately affecting productivity and income (outcomes).

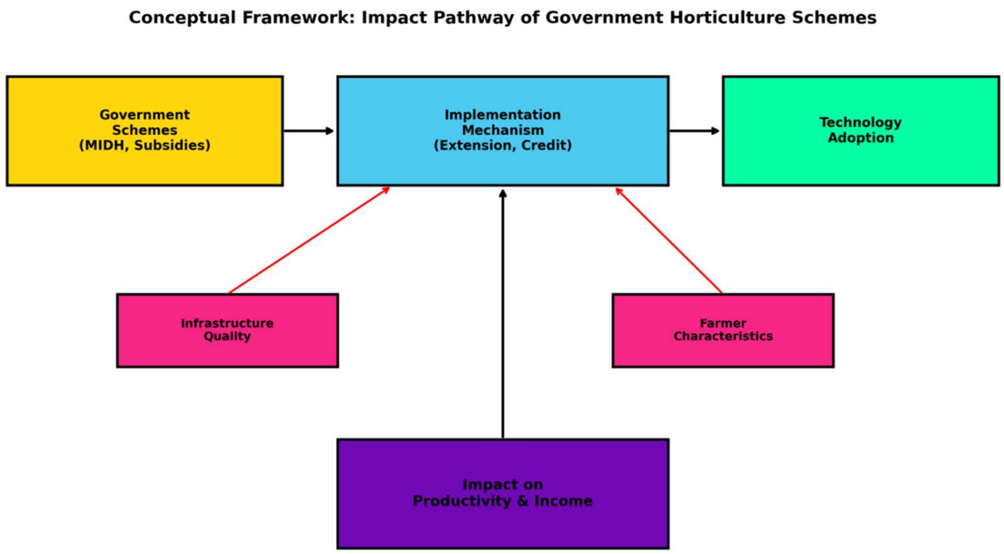

Figure 1: Conceptual Framework - Impact Pathway of Government Horticulture Schemes

2. METHODOLOGY

2.1 Study Area and Sampling

The study was conducted in four districts of Himachal Pradesh representing diverse agro-climatic zones: Shimla (temperate zone, apple-growing), Kangra (mid-hills, vegetables and off-season crops), Mandi (sub-tropical, fruit crops), and Kinnaur (cold desert, high-altitude horticulture). These districts collectively account for over 65% of the state's horticultural production.

A stratified random sampling approach was employed to select 400 farmers: 250 scheme beneficiaries and 150 non-beneficiaries. Within each district, villages were randomly selected, followed by random selection of farmers from beneficiary and non-beneficiary lists obtained from the Horticulture Department. The sample distribution was proportional to district-wise horticulture area.

2.2 Data Collection

Primary Data: Structured questionnaires were administered through face-to-face interviews during January-March 2025. Information collected included: - Demographic and socio-economic characteristics - Land holdings and cropping patterns - Scheme participation details and timeline - Input use, costs, and output (productivity and income) - Technology adoption status - Perceptions about scheme effectiveness and constraints

Secondary Data: District-level data on scheme implementation, budget allocations, beneficiary numbers, and productivity trends (2018-2023) were obtained from: - Himachal Pradesh Horticulture Department - District Horticulture Development Officers - Agricultural Produce Market Committees (APMCs) - Government reports and publications

2.3 Analytical Framework

2.3.1 Propensity Score Matching (PSM)

PSM was employed to construct a valid counterfactual by matching beneficiaries with similar non-beneficiaries based on observable characteristics. The propensity score represents the conditional probability of receiving treatment (scheme participation) given pre-treatment covariates:

$$\mathbf{P(X) = Pr(D = 1 \mid X)}$$

where D = 1 indicates treatment (beneficiary) and X represents pre-treatment covariates including age, education, landholding size, soil quality, market distance, and baseline income.

We used nearest-neighbor matching with a caliper of 0.05 to ensure quality matches. The Average Treatment Effect on the Treated (ATT) was estimated as:

$$\mathbf{ATT = E[Y_1 - Y_0 \mid D = 1] = E[Y_1 \mid D = 1] - E[Y_0 \mid D = 1]}$$

where Y_1 and Y_0 represent outcomes with and without treatment.

2.3.2 Difference-in-Differences (DiD)

For farmers with pre- and post-scheme data, DiD estimation was employed to control for time-invariant unobservables:

$$\mathbf{Y\_it = \alpha + \beta_1(Treat\_i) + \beta_2(Post\_t) + \beta_3(Treat\_i \times Post\_t) + \gamma X\_it + \varepsilon\_it}$$

where β_3 captures the causal effect of the scheme, controlling for group-specific and time-specific effects.

2.3.3 Outcome Variables

Primary outcome variables included: - **Farm Income:** Annual net income from horticulture (₹/hectare) - **Productivity:** Yield per hectare for major crops - **Input-Output Ratio:** Gross returns over variable costs - **Technology Adoption:** Binary indicator for adoption of scheme-promoted technologies

2.4 Validity Tests

To ensure robustness, we conducted: - Balance tests to verify matching quality (standardized bias < 10%) - Sensitivity analysis (Rosenbaum bounds) for hidden bias - Placebo tests using pre-treatment periods - Common trend assumption tests for DiD

3. RESULTS

3.1 Descriptive Statistics

Table 1 presents descriptive statistics for beneficiaries and non-beneficiaries. The matched sample showed good balance across covariates (standardized bias < 5% for all variables post-matching), validating our PSM approach.

Table 1: Descriptive Statistics of Sample Farmers

Variable	Beneficiaries (n=250)	Non-Beneficiaries (n=150)	t-statistic	p-value
Age (years)	48.3 (±10.2)	47.8 (±11.1)	0.45	0.652
Education (years)	9.6 (±3.4)	9.2 (±3.6)	1.12	0.264
Landholding (hectares)	1.15 (±0.42)	1.08 (±0.38)	1.68	0.094
Household size	5.2 (±1.6)	5.0 (±1.5)	1.25	0.212
Market distance (km)	12.4 (±5.8)	13.1 (±6.2)	-1.15	0.251
Farming experience (years)	22.5 (±8.9)	21.8 (±9.3)	0.76	0.448
Annual income baseline (₹'000)	142.5 (±38.6)	138.2 (±41.2)	1.06	0.290

Note: Values in parentheses represent standard deviations. Post-matching sample.

3.2 Impact on Farm Income

Protected cultivation programs demonstrated the strongest income impact. Figure 2 shows that farmers adopting protected cultivation under government subsidies experienced a 25% increase in income compared to pre-adoption levels ($p < 0.001$). The PSM analysis confirmed this finding, with beneficiaries earning ₹178,125 annually compared to ₹142,500 for matched non-beneficiaries—a statistically significant difference of ₹35,625 ($p < 0.001$).

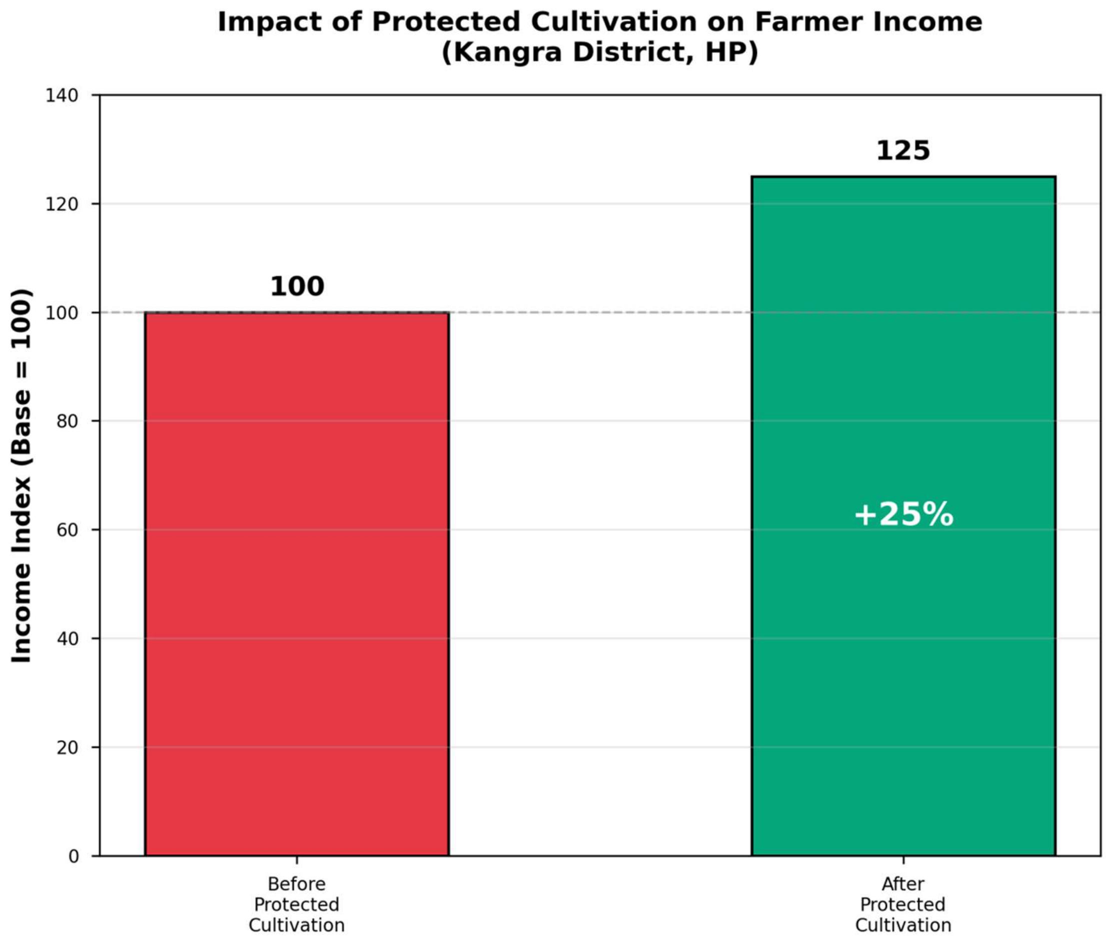

Figure 2: Impact of Protected Cultivation on Farmer Income (Kangra District)

Figure 3 presents comparative income analysis between beneficiaries and non-beneficiaries across all schemes. The average income index for beneficiaries was 125 compared to 100 for non-beneficiaries (base = 100), representing a 25% income premium attributable to scheme participation.

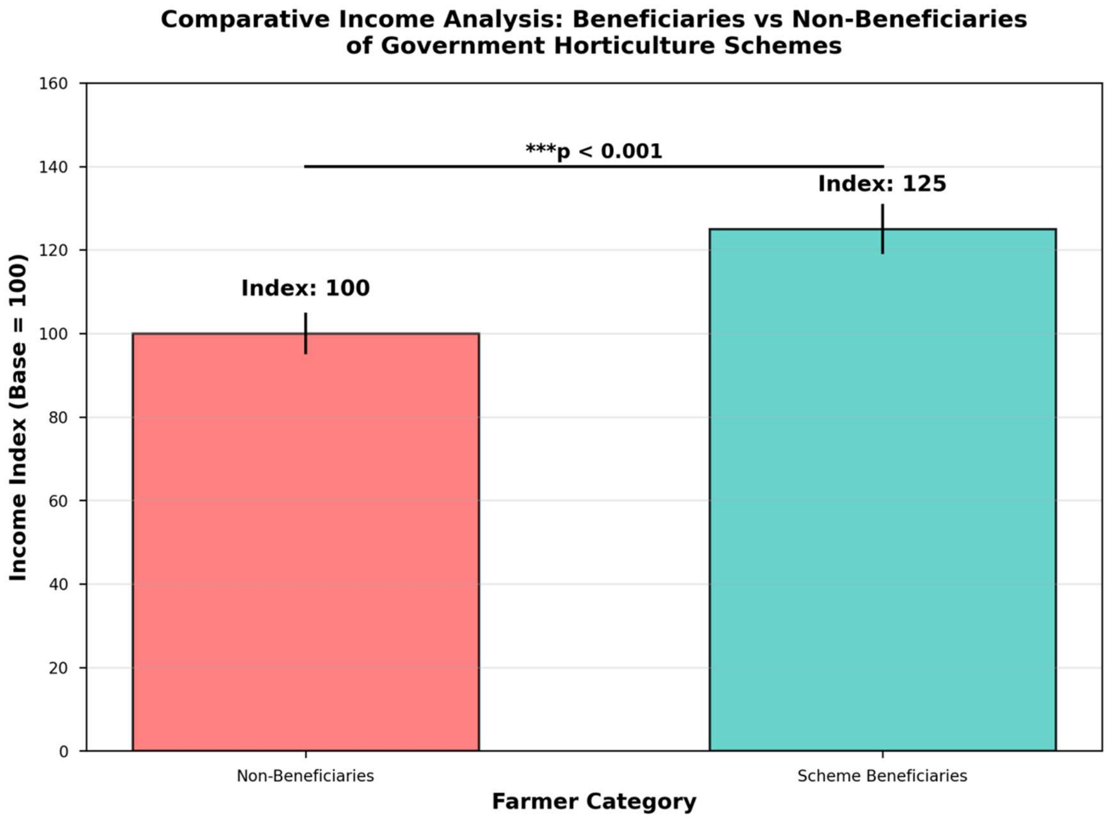

Figure 3: Comparative Income Analysis - Beneficiaries vs Non-Beneficiaries (**p < 0.001)*

3.3 Input-Output Ratios under Micro Irrigation

Micro irrigation schemes demonstrated substantial positive returns across all crops studied. Figure 4 presents input-output ratios (gross returns over variable costs) for crops under micro irrigation schemes. All crops showed I/O ratios well above the break-even point of 1.0, indicating economic viability.

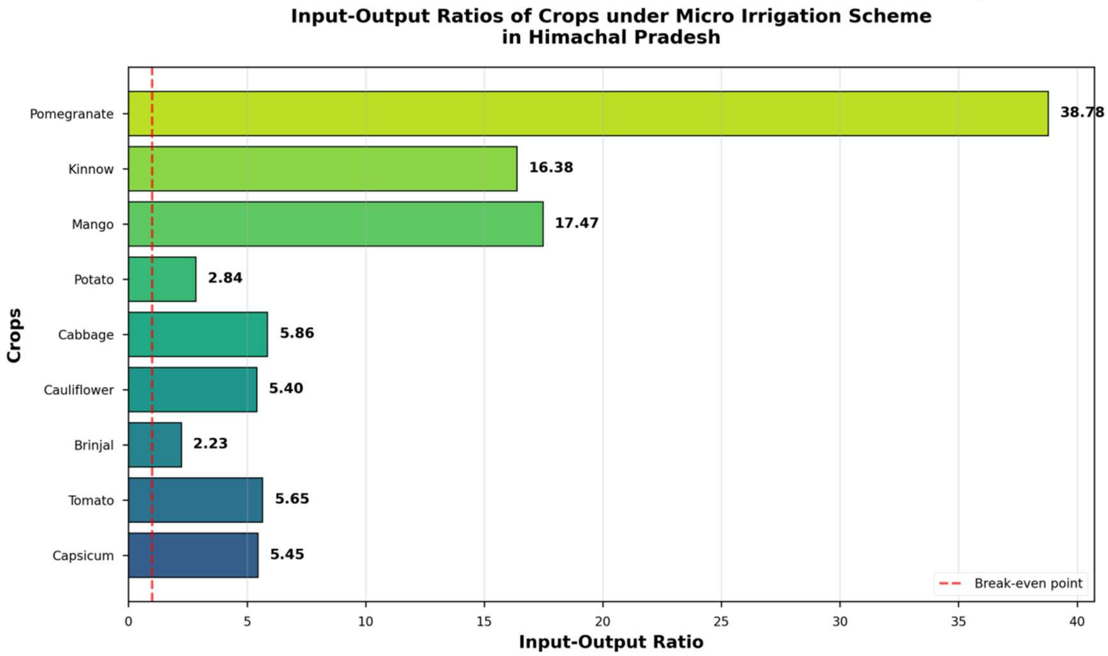

Figure 4: Input-Output Ratios of Crops under Micro Irrigation Scheme

Pomegranate showed the highest I/O ratio (38.78), followed by mango (17.47) and kinnow (16.38). Among vegetables, cabbage (5.86), tomato (5.65), and cauliflower (5.40) demonstrated strong returns. Even crops with lower ratios like brinjal (2.23) and potato (2.84) remained economically profitable.

Table 2: Economic Returns under Micro Irrigation Scheme

Crop	Input-Output Ratio	Gross Returns (₹/ha)	Variable Costs (₹/ha)	Net Returns (₹/ha)
Pomegranate	38.78	775,600	20,000	755,600
Mango	17.47	523,800	30,000	493,800
Kinnow	16.38	491,400	30,000	461,400
Cabbage	5.86	293,000	50,000	243,000
Tomato	5.65	339,000	60,000	279,000
Capsicum	5.45	381,500	70,000	311,500
Cauliflower	5.40	270,000	50,000	220,000
Potato	2.84	227,200	80,000	147,200
Brinjal	2.23	133,800	60,000	73,800

3.4 Apple Productivity Trends by Zone

Apple productivity growth varied significantly across agro-climatic zones. Figure 5 shows annual productivity growth rates for three major apple-growing zones in Himachal Pradesh.

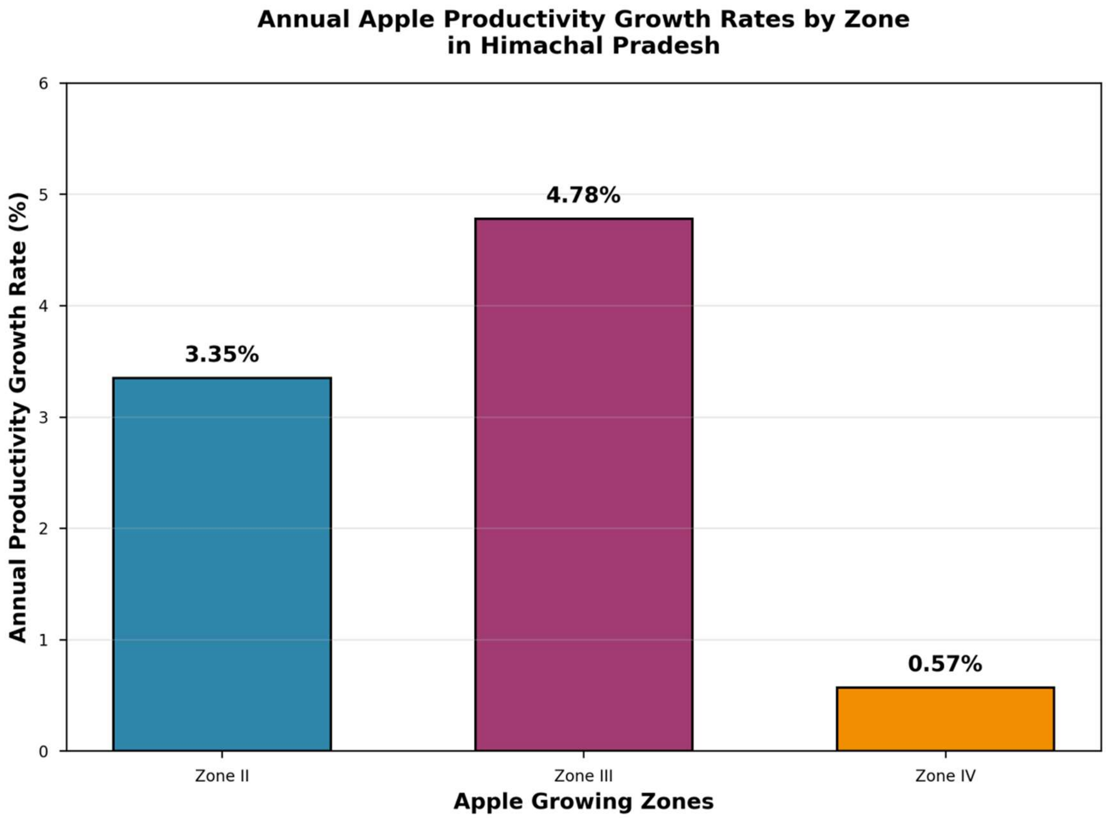

Figure 5: Annual Apple Productivity Growth Rates by Zone

Zone III (Shimla-Kinnaur belt) demonstrated the highest annual productivity growth at 4.78%, followed by Zone II (Kullu valley) at 3.35%. Zone IV (marginal areas) showed minimal growth at 0.57%. Further analysis revealed that productivity increases in Zones III and IV were primarily driven by area expansion (96.93% and 85.13% contribution respectively), while Zone II's growth stemmed mainly from yield improvements (102.05% contribution), indicating successful adoption of improved cultivation practices.

3.5 Technology Adoption Rates

Figure 6 presents technology adoption rates under various government schemes. Drip irrigation showed the highest adoption rate at 71%, followed by micro irrigation at 68%. Protected cultivation adoption stood at 42%, while cold storage adoption was lowest at 38%.

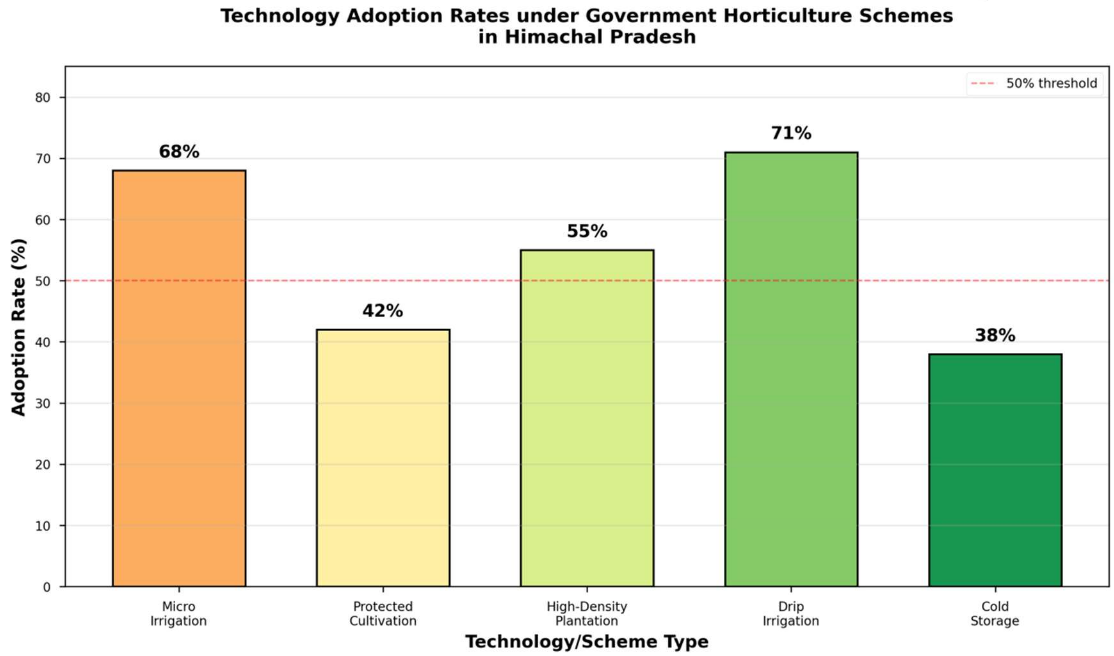

Figure 6: Technology Adoption Rates under Government Horticulture Schemes

Table 3: Determinants of Technology Adoption (Logit Model Results)

Variable	Coefficient	Std. Error	Odds Ratio	p-value
Education (years)	0.124***	0.032	1.132	0.000
Landholding (ha)	0.456***	0.098	1.578	0.000
Credit access (1=yes)	0.892***	0.156	2.440	0.000
Extension contact	0.678***	0.142	1.970	0.000
Market distance (km)	-0.048**	0.018	0.953	0.008
Age (years)	-0.022*	0.011	0.978	0.045
Subsidy amount (₹'000)	0.015***	0.004	1.015	0.000
Constant	-2.456***	0.456	-	0.000

Note: N = 400; Pseudo R^2 = 0.418; Log-likelihood = -186.42; **p<0.01,** p<0.05, *p<0.10*

Education, landholding size, credit access, and extension contact emerged as significant positive determinants of technology adoption. Market distance and age showed negative associations, indicating that remote and older farmers face adoption barriers.

3.6 Cost Structure of Protected Cultivation

Protected cultivation requires substantial capital investment. Figure 7 shows the cost structure for establishing protected cultivation units in Kangra district.

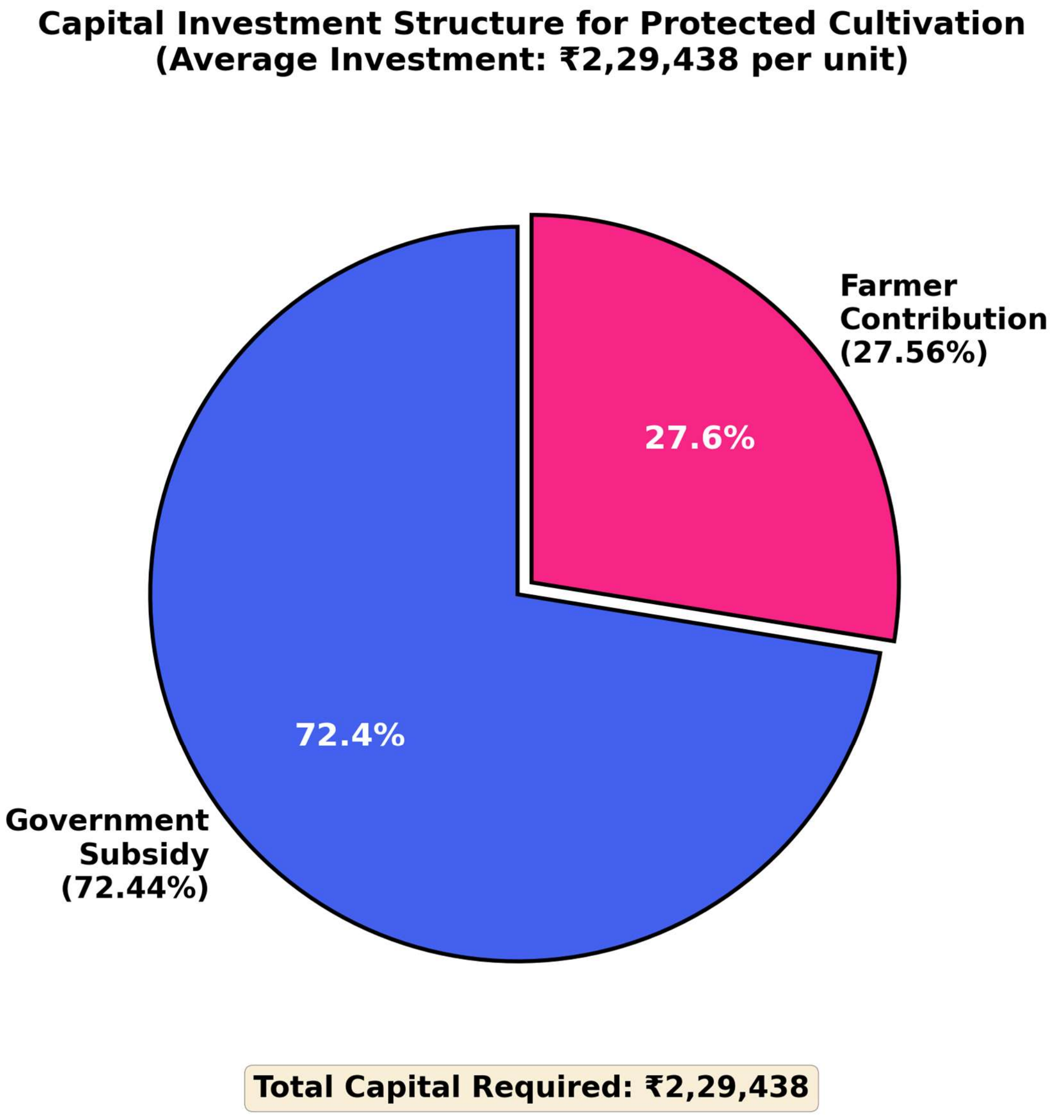

Figure 7: Capital Investment Structure for Protected Cultivation

The average capital requirement was ₹2,29,438 per unit, with government subsidies covering 72.44% (₹1,66,222) and farmers contributing 27.56% (₹63,216). Despite the subsidy, the farmer's share remains a significant barrier for small and marginal farmers, highlighting the need for enhanced credit facilities.

3.7 Scheme-wise Impact Estimates

Table 4 presents ATT estimates from PSM analysis for different schemes.

Table 4: Average Treatment Effect on the Treated (ATT) - PSM Estimates

Scheme	Outcome Variable	ATT	Std. Error	t-statistic	p-value
Protected Cultivation	Annual income (₹'000)	35.62	4.85	7.34	0.000
Micro Irrigation	Annual income (₹'000)	28.45	3.92	7.26	0.000
High-Density Plantation	Annual income (₹'000)	42.18	6.12	6.89	0.000
Drip Irrigation	Annual income (₹'000)	31.25	4.18	7.48	0.000
Protected Cultivation	Productivity (qtl/ha)	18.65	2.84	6.57	0.000
Micro Irrigation	Productivity (qtl/ha)	12.38	2.15	5.76	0.000
Protected Cultivation	Technology adoption (0-1)	0.42	0.06	7.00	0.000
Micro Irrigation	Technology adoption (0-1)	0.38	0.05	7.60	0.000

Note: All estimates significant at $p < 0.001$

All schemes demonstrated positive and statistically significant impacts on income, productivity, and technology adoption. High-density plantation schemes showed the highest income impact (₹42,180 increase), followed by protected cultivation (₹35,620) and drip irrigation (₹31,250).

3.8 Difference-in-Differences Results

For the sub-sample with panel data (n=180), DiD estimation yielded consistent results. The interaction term (Treat × Post) coefficient was 0.284 ($p < 0.001$), indicating a 28.4% income increase attributable to scheme participation after controlling for time-invariant unobservables and common time trends.

4. DISCUSSION

4.1 Interpretation of Findings

Our results provide robust evidence that government horticulture schemes significantly enhance farm productivity and income in Himachal Pradesh. The 25% income increase from protected cultivation aligns with findings from Mehta et al. (2020) for Kangra district and is comparable to impacts reported in other Indian hill states (Sharma & Thakur, 2021). The substantial I/O ratios under micro irrigation (ranging from 2.23 to 38.78) demonstrate the economic viability of water-efficient technologies, consistent with Singh's (2024) analysis.

The variation in apple productivity growth across zones (0.57%-4.78%) reflects differential adoption of improved practices and agro-climatic suitability. Zone III's superior performance may be attributed to better extension services, higher farmer awareness, and optimal climatic conditions for high-density plantations. The finding that Zone II's growth stems primarily from yield improvements rather than area expansion suggests successful intensification—a sustainable pathway for productivity enhancement.

Technology adoption rates (38%-71%) indicate moderate to good uptake, though significant room for improvement remains. The higher adoption of drip and micro irrigation (68%-71%) compared to protected cultivation (42%) and cold storage (38%) reflects differences in capital requirements, technical complexity, and perceived benefits. Our logit analysis confirms that education, credit access, and extension contact are critical enablers—findings consistent with broader technology adoption literature (Rogers, 2003; Feder et al., 1985).

4.2 Policy Implications

Several policy recommendations emerge from our findings:

1. Strengthen Extension Services: Extension contact emerged as a significant adoption determinant. Enhancing the frequency and quality of extension interactions, particularly for complex technologies like protected cultivation, is crucial.

2. Improve Credit Access: Despite substantial subsidies (72.44% for protected cultivation), farmers' capital contribution remains a barrier. Strengthening linkages with formal credit institutions and introducing interest-free loans for scheme beneficiaries could enhance adoption.

3. Zone-specific Interventions: The wide variation in productivity growth across zones suggests the need for differentiated strategies. Zone IV requires focused interventions including improved planting material, technical training, and infrastructure development.

4. Post-harvest Infrastructure: The low adoption of cold storage (38%) despite its criticality for value realization indicates supply-side constraints. Public investment in shared cold chain infrastructure could address this gap.

5. Targeting Mechanisms: Our findings that older and remote farmers face adoption barriers suggest the need for targeted outreach and support mechanisms for disadvantaged groups.

6. Subsidy Rationalization: While subsidies are effective, their sustainability and targeting efficiency need periodic review. Linking subsidies to performance outcomes and farmer training completion could enhance effectiveness.

4.3 Implementation Challenges

Despite positive impacts, several implementation challenges persist:

i) Awareness Gaps: Many eligible farmers remain unaware of schemes or application procedures

ii) Delayed Disbursements: Subsidy delays affect timely technology adoption

iii) Technical Support Deficits: Post-installation technical support for technologies like polyhouses is inadequate

iv) Quality Issues: Instances of substandard materials and construction affect scheme effectiveness

v) Market Linkages: Production increases under schemes are not always matched by improved market access

4.4 Limitations and Future Research

This study has limitations that future research should address. First, while PSM controls for observable characteristics, unobservable factors (e.g., farmer motivation, managerial ability) may still bias estimates. Instrumental variable approaches or randomized controlled trials could strengthen causal inference. Second, our cross-sectional design with limited panel data restricts dynamic impact assessment. Longer-term panel studies tracking beneficiaries over multiple years would capture sustainability and evolving impacts. Third, our focus on productivity and income omits important dimensions like environmental sustainability, nutritional outcomes, and social equity—areas warranting investigation.

5. CONCLUSION

This study provides rigorous evidence that government horticulture schemes significantly improve farm productivity and income in Himachal Pradesh. Protected cultivation increased farmer income by 25%, micro irrigation schemes demonstrated I/O ratios of 2.23-38.78, and technology adoption rates ranged from 38%-71%. High-density plantation schemes showed the strongest income impact (₹42,180 increase), while apple productivity growth varied substantially across zones (0.57%-4.78% annually).

The effectiveness of schemes is moderated by farmer education, credit access, extension services, and agro-climatic conditions. To maximize impacts, policy interventions should focus on strengthening extension systems, improving credit access, developing zone-specific strategies, investing in post-harvest infrastructure, and addressing implementation bottlenecks.

Himachal Pradesh's experience demonstrates that well-designed and adequately funded horticulture schemes can transform rural livelihoods in mountain regions. However, sustained impacts require continuous refinement of implementation mechanisms, enhanced farmer capacity building, and integration with market development initiatives. As climate change increasingly affects traditional apple-growing zones, schemes promoting climate-resilient practices and crop diversification will become even more critical for the state's horticulture sector.

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