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Challenges and Constraints in Adopting Modern Horticulture Practices in Apple Orchards

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ABSTRACT

In many developing countries the adoption rate of new agricultural technology especially by small-scale farmers is low. The factors influencing farmers' adoption of new technologies vary from specific circumstances to local conditions. The most essential aspect in the adoption of new tools and techniques is the farmer's perception of these technologies which often remains unidentified. Using a mixed method approach, this study explored marginal and small-scale apple orchardists of rural Shimla in Himachal Pradesh, India for their perceptions, challenges, and limitations of adaptive capacity to modern horticulture practices. Via in-depth interviews, the growers shared multifaceted challenges and fears impeding their adoption decision, the most noticeable ones were - the high cost of horticulture inputs, unpredictable weather conditions, small orchard size, inadequate labour, insufficient knowledge on modern horticulture practices and lack of information from the government departments. Based on these interviews, a thematic analysis and a survey were conducted - broadly representing the common horticulture problems and factors restricting these orchardists from adopting new technologies.

***Keywords**: Adoption; Horticulture; Technology; Challenges; Small-holder; Apple; Himachal Pradesh*

INTRODUCTION

Advancements in agricultural technology, including machinery, hybrid seeds, sustainable practices, and ICT (Information and Communication Technologies), are crucial for enhancing productivity, food security, and poverty reduction in developing countries (World Bank, 2007; Suprehatin, 2019). Despite their importance for economic development (Foster and Rosenzweig, 2010), adoption rates remain low, with many small-scale farmers relying on traditional methods due to various challenges (Mwangi and Kariuki, 2015). In Himachal Pradesh, the shift from agriculture to horticulture, especially apple cultivation, reflects changing land use patterns driven by economic viability. However, traditional apple varieties are losing appeal due to declining productivity, high costs, and competition from new varieties. Apple orchards, covering 80% of the horticultural area in key districts, face challenges from climate change and market competition, highlighting the need for modern agricultural practices to sustain and enhance their profitability.

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This study seeks to address critical gaps in adopting modern horticultural practices among small-scale apple farmers (orchardists) in Shimla, Himachal Pradesh. It aims to clarify the specific challenges these farmers face in a region where such studies are limited. The role of extension services in supporting these farmers is underexplored, and barriers to accessing modern inputs, along with overlooked socio-economic factors, complicate adoption. Technological challenges, particularly with ICT tools, are also inadequately addressed in existing research. Additionally, there is a lack of actionable policy recommendations tailored to these farmers' needs. This study uses a mixed-method approach, combining thematic analysis and quantitative surveys, to provide a comprehensive understanding of the factors influencing modern horticultural practices in Shimla's apple orchards with the following research questions.

1) What are the challenges faced by small-scale orchardists in practising apple farming in Shimla?
2) What are the determinant factors that influence small-scale orchardists' adoption of new horticulture technologies in Shimla?

METHODOLOGY

The study first employed thematic analysis to explore the challenges of orchard management in rural Shimla, Himachal Pradesh. Initially, unstructured in-depth interviews and observations were conducted with 36 small-scale apple farmers using cluster and quota sampling, with fieldwork completed in October 2022. Data collection ceased upon reaching theoretical saturation. Key themes emerged related to the challenges and constraints in adopting new technologies, including the need for modern varieties, scientific practices, advanced machinery, training, ICT, and financial and systematic government support. Interviews with two Horticulture Department officials provided insights into existing schemes. A mixed-methods approach combined qualitative thematic analysis with a quantitative survey. The survey questionnaire developed from thematic analysis and literature review, used a five-point Likert scale to gauge the adoption intentions and challenges faced by growers and included questions on their demographic profiles.

FINDINGS AND DISCUSSION

From the thematic analysis, the prominent themes that emerged were:

a) *Desire of Orchardists to Transform Their Orchards from Conventional to Modern (High-density plantation - HDP)*

Orchardists in rural Shimla are increasingly inclined to replace traditional orchards with modern high-density plantations due to the latter's shorter gestation period and higher productivity. While HDP offers better yield potential and space utilization, it also demands significant capital and specialized management, making it challenging for small-scale farmers. The adoption of HDP is more feasible in valley areas, with semi-intensive density plantations (600-1000 trees per hectare) being more suitable for the region's terrain.

b) *Traditional Orchards are Unable to Breakeven the Maintenance Costs*

Traditional apple orchards are struggling to break even due to rising maintenance costs, inadequate yields, and low apple prices. Establishing new HDP orchards requires substantial capital, which many small-scale farmers lack, limiting their ability to adopt these technologies. The potential returns from HDP are significantly higher than those from conventional orchards (Mir et al; 2022), but the initial investment and ongoing costs pose a significant barrier.

c) *Lack of Information from the State Horticulture Department and Non-Availability of Desired Products*

Small-scale farmers face challenges in accessing information and essential horticultural resources. Despite government support through subsidies and training programmes, delays, complex procedures, and limited awareness hinder the adoption of new technologies. Many farmers are unaware of the available subsidies or find the process too cumbersome to benefit from them.

d) *Small Orchard Size Restrains Large-Scale Development*

The small size of most orchards in rural Shimla (average 1.0 hectares) restricts the large-scale adoption of modern farming techniques. Mechanization, irrigation, and smart farming technologies are difficult to implement in these small, terraced fields, limiting the efficiency and productivity gains that could be achieved with larger operations.

e) *Unpredictable Weather has Become an Invincible Enemy*

Climate change, including erratic weather patterns, is increasingly threatening apple production. Strategies like using anti-hail nets, micro-irrigation, and adopting climate-resilient apple varieties are suggested to mitigate these effects, but adaptation remains a significant challenge for many farmers.

Orchard and Orchardist Characteristics

Demographic features such as age, education, experience, and availability of family labour have been reported as potential variables influencing the adoption of newer technologies in past studies (Feder et al., 1985; Knowler and Bradshaw, 2007). Socio-economic characteristic knowledge of the sample is important as it will help in understanding the existing orchardist's profile and conditions influencing the adoption of modern horticulture practices. The thematic analysis discussed Various orchard features that emerged as prominent attributes. These are – orchard size, orchard type, elevation, source of irrigation, distance from roadhead, and major horticulture assets.

The data presented in Table 1 depicts the sample (N=410) consisting of 63.2% male and 36.8% female respondents, with a majority (70%) aged between 18-35 years. The literacy rate was notably high at 97.8%, with many respondents holding graduate (30%) or postgraduate (31.5%) degrees, reflecting a well-educated farming community. However, small landholdings (78.8% had less than 2 acres) and limited financial resources remain significant barriers to technology adoption, despite education being a key factor (Rao and Qaim, 2011; Sahara et al., 2015).

Over half of the respondents (55.4%) reported an annual income from farming between 2-5 lakh INR, and those with additional income sources showed a higher interest in modern technologies (Ellis and Freeman, 2004; Diiro, 2013). Additionally, nearly half of the orchards were located at elevations between 5001-7000 feet. While factors such as education and off-farm income facilitate technology adoption, challenges like small landholdings and the financial burden continue to hinder progress (Bonabana-Wabbi, 2002; Joshi et al., 2006; Minot and Roy, 2007).

Table 1: Orchard and Orchardist Characteristics (n=410)

Sl.No.	Variable		Frequency	Percentage
1	Gender	Male	259	63.2
		Female	151	36.8
2	Orchard Size (in acres)	<1	122	29.8
		1-2	201	49.0
		2.1-5	57	13.9
		5.1-10	14	3.4
		>10	16	3.9
3	Age (in years)	<18	11	2.7
		18-35	287	70.0
		36-55	103	25.1
		>55	9	2.2
4	Education Level	No formal education	13	3.2
		Primary	22	5.4
		Middle	28	6.8
		Diploma	5	1.2
		Sen. Secondary	88	21.5
		Graduation	123	30.0
		P. G	129	31.5
		Doctorate	2	0.5
5	Religion	Hindu	383	93.4
		Islam	2	0.5
		Buddhism	17	4.1
		Other	8	2.0
6	Community	General	200	48.8
		SC	106	25.9
		ST	80	19.5
		OBC	23	5.6
		Other	1	0.2

Sl.No.	Variable		Frequency	Percentage
7	Marital status	Married	188	45.9
		Unmarried	216	52.7
		Divorced	2	0.5
		Widowed	4	1.0
8	Engaged in farming (years)	<5	105	25.6
		5-10	211	51.5
		11-15	44	10.7
		>15	50	12.2
9	Annual income (in lakhs)	<2	100	24.4
		<2	100	24.4
		2-5	227	55.4
		6-8	69	16.8
		>8	14	3.4
10	Elevation of orchard	<5000	118	28.8
		5001-7000	203	49.5
		>7000	89	21.7

Factor Analysis

Exploratory Factor Analysis (EFA) was done using principal component analysis and varimax rotation. The communality of the scale was assessed and found over 0.50 for each indicator, suggesting the amount of variance in each dimension.

Bartlett's test of sphericity (for the overall significance of the correlation matrix) provided a measure of the statistical probability. The results were significant, x^2 (n=410) = 3683.602 ($p<0.001$) indicating its suitability for factor analysis.

The Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) indicated the appropriateness of data for factor analysis at .896. Data with MSA values above 0.800 are considered appropriate for factor analysis.

The factor solution derived from this analysis yielded 4 factors for the scale

The four factors (with eigenvalue over 1) were identified as part of this EFA.

Factor 1 (HRP) refers to **Horticulture Practices and Rural pride** with 5 items (HRP1-5), Factor 2 gathers items ITOTR 1, 2, 3, and 4 which represents Intention to transform traditional orchard, Factor 3 includes items ESG 1,2,3 and 4 which represents expectation from the government/ government support. Factor 4 includes items CHAL 3-6 which represents challenges.

Model fit indicators:

Confirmatory factor analysis (CFA) was performed using IBM SPSS AMOS 23 to test the measurement model. Measurement model is used to assess the quality criteria of the constructs i.e., reliability and validity of the constructs. A good fitting model is accepted if the value of CMIN/df is <5, the goodness of fit (GFI) indices; the Tucker and Lewis index (TLI); and the Confirmatory fit index (CFI) is >0.90.

In addition, an adequate fitting model is accepted if the computed value of standardized root mean square residual (RMR) <0.05, and the root mean square error approximation (RMSEA) is between 0.05 and 0.08. The fit indices for the model fall within the acceptable range.

Table 2: Model fit statistics

Fit indices	Recommended value	Sources	Obtained value
P	Insignificant	Bagozzi and Yi (1988)	.000
CMIN/df	3-5	Less than 2 (Ullman,2001) to 5 (Schumacker & Lomax,2004)	2.115
GFI	>.90	Hair et al (2010)	.930
CFI	>.90	Bentler (1990)	.940
TLI	>.90	Bentler (1990)	.927
SRMR	<.08	Hu & Bentler (1998)	.041
RMSEA	<.08	Hu & Bentler (1998)	.054

Construct reliability was assessed using Cronbach's alpha and composite reliability. Cronbach alpha for each construct was found over the required limit of .70, composite reliability ranged from 0.731-0.848 above the 0.70 benchmark. Hence, construct reliability was established for each construct in the study.

The convergent validity of scale items was estimated using the Average Variance Extracted. The AVE values were above the threshold value of 0.50 for all latent constructs and the composite reliability is well over the required values, we can conclude that these constructs are valid. Therefore, the scales used for the present study have the required convergent validity.

As part of CFA, factor loadings were assessed for each item with criteria of factor loading >.50, 2 items were removed (CHAL 1 & 2) due to low factor loading. The model-fit measures were used to assess the model's overall goodness of fit (CMIN/ df, GFI, CFI, TLI, SRMR, and RMSEA) and all values were within their respective common acceptance levels. The 4-factor model yielded a good fit for the data.

Table 3: Loadings, Reliability, and Convergent Validity

Items	Loadings	Alpha	Eigen Values	Composite Reliability	Average Variance Extracted
Rural Pride (Horti -practices)		.774	7.459	0.848	0.586
HRP 4	.64				
HRP 5	.68				

Items	Loadings	Alpha	Eigen Values	Composite Reliability	Average Variance Extracted
HRP 2	.60				
HRP 3	.65				
HRP 1	.63				
Challenges		.798	1.893	0.761	0.544
CHAL 4	.64				
CHAL 6	.74				
CHAL 5	.65				
CHAL 3	.63				
Intention		.723	1.117	0.741	0.519
ITOTR 1	.68				
ITOTR 4	.60				
ITOTR 3	.61				
ITOTR 2	.66				
Govt Support		.847	2.885	0.731	0.507
ESG 1	.85				
ESG 2	.85				
ESG 3	.68				
ESG 4	.66				

Discriminant validity in the study was not entirely established using Fornell and Larcker criteria and when assessed using Heterotrait-Monotrait ratio (HTMT), all the values were below .85. Hence, discriminant validity was established.

Table 4: Discriminant Validity

Challenges	Rural Pride	Intention	Govt. support
0.666			
0.090	0.766		
0.086	0.450***	0.647	
0.224**	0.530***	0.621***	0.638

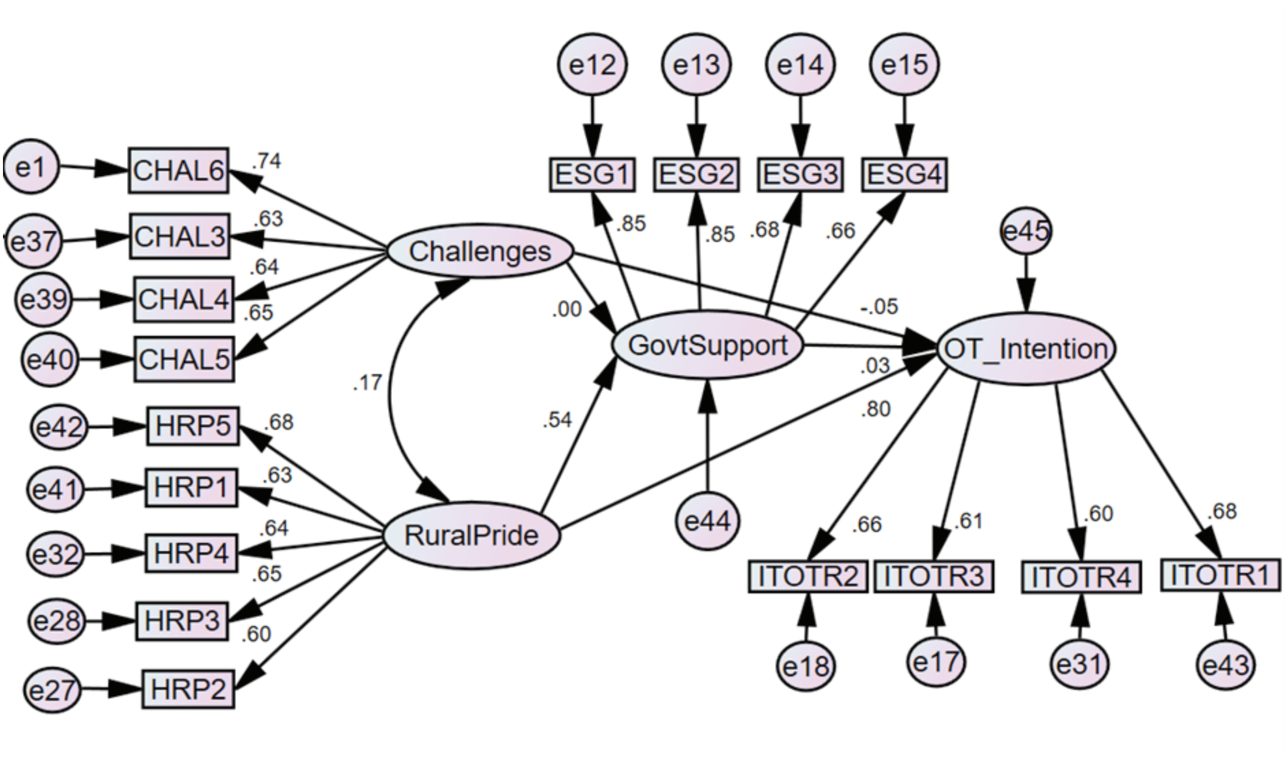

Figure 1. Structural model

A structural equation model using Amos was generated to test the relationships. The model fit was reported to be good and values were well within the desired range (Table 2).

H1 evaluates whether challenge has a direct and significant effect on Government support

H2 evaluates whether challenge has a direct and significant effect on Intention

H3 evaluates whether Rural Pride has a direct and significant effect on Government support

H4 evaluates whether Rural Pride has a direct and significant effect on the Intention

H5 evaluates whether Government support has a direct and significant effect on Intention.

The results report H1 and H2 not supported and H3 and H4 supported. It establishes the direct and significant effect of Rural Pride on Government Support and intention respectively.

The study also assessed the mediating roles

H6 Government support mediates the relationship between challenges and intention.

H7 Government support mediates the relationship between Rural Pride and intention.

Table 5: Hypotheses Results and Mediation analysis

	Hypothesized Relationship	95% CI		P (<.05)	Conclusion
		Lower	Upper		
H_1	Challenges->Govt Support	-.116	.124	NS	Not Supported
H_2	Challenges->OT_Intention	-.166	.061	NS	Not Supported
H_3	Rural Pride->Govt Support	.408	.649	***	***Supported***
H_4	Rural Pride->OT_Intention	.695	.909	***	***Supported***
H_5	Govt Support->OT_Intention	.000	.000	NS	Not Supported
H_6	Challenges->Govt Support->OT_Intention	-.014	.009	NS	No Mediation
H_7	Rural Pride->Govt Support->OT_Intention	-.068	.095	NS	No Mediation

Mediation analysis was carried out using the Bootstrap technique to examine if the constructs of challenges and Rural pride have an indirect effect through Government support to the construct of Intention. The direct path between challenges and intention and Rural pride and intention was also added to find out the type of mediation if reported. Bias-corrected confidence intervals (lower and upper) at 95 % confidence level were reported.

The results show that there is no mediation of government support in the relationship between challenges and intention. Thus, H6 was not supported. Similarly, there is no mediation of government support in the relationship between Rural pride and intention. Thus, H7 was also not supported. Therefore the results emphasises the need for promoting HDP among the smallholder apple farmers.

CONCLUSION

The findings of this study underscore the critical need to institutionalize High-Density Planting (HDP) among small-scale apple orchardists in Shimla, as a strategic extension practice. Implementing HDP offers a more remunerative alternative to traditional apple cultivation methods, potentially significantly enhancing productivity and profitability. However, the success of this transition hinges on the tailored support provided to small growers, who often rely heavily on government support systems due to their limited access to open markets and other resources.

To effectively integrate HDP, extension services must be designed to address the unique challenges faced by these orchardists. Key demands include enhanced exposure to extension services, comprehensive training, improved market accessibility, and robust marketing support for Apple. Additionally, there is a pressing need for the availability of essential horticultural aids, particularly M9 rootstock, simplified subsidy norms, and greater access to credit facilities. The provision of advanced storage facilities, such as cold storage, is also essential to regulate supply in response to market demand, thereby enabling farmers to achieve higher profit margins.

Moreover, enhancing the role of Information and Communication Technology (ICT) in agriculture could further empower small growers by providing them with timely information on market trends, weather conditions, and best practices. The establishment of adequate processing facilities for culled fruits could also add value to their produce, ensuring that growers receive fair prices and maximizing their returns. By addressing these critical areas, HDP can be institutionalized as a sustainable practice among small-scale apple orchardists, contributing to the long-term viability of apple farming in rural Shimla. Well-structured extension strategies that focus on education, resource accessibility, and support systems will not only boost the resilience and competitiveness of Shimla's apple farming sector but can also serve as a model for other small-scale agricultural practices. Ultimately, these efforts will pave the way for a more prosperous and sustainable future for small cultivators in the region.

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