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Beekeeping Practices, Productivity Gradients and Diversification Prospects in Himachal Pradesh

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Abstract

Beekeeping in Himachal Pradesh is practised both as a leisure activity and as a commercial enterprise, to assess the demographic profile, common apiary management practices, and availability of hive products. A survey of 80 beekeepers conducted in districts Kangra, Mandi, Solan, Chamba and Kinnaur revealed that beekeeping was predominantly associated with *Apis mellifera* (88.75%), maintained in Langstroth hives (88.75%), and opted by literate men (95%) of the middle-aged group (40-49 years). Apiary management varied across districts, with medium-sized apiaries (57-120 colonies) being most common (45%), and 69.01% of beekeepers using deep super chambers. Honey production varied, with modern bee hives yielding 13-16 kg/colony/year, compared to 3-5 kg/colony/year from traditional hives. Apart from honey, beeswax, pollen and propolis were extracted by 80, 39 and 30 per cent of beekeepers, respectively. The study envisaged the poor management practices among beekeepers and suggests that with training, provisioning for modern equipment, and improved market linkages, beekeepers have the potential to diversify for sustainable beekeeping.

Keywords: Beekeeping, Hive management, Hive products, Honey yield, survey

Beekeeping is an important agri-based enterprise that contributes substantially to rural livelihoods by generating income, employment and nutritional security, besides playing a key role in improving agricultural productivity through pollination. Besides honey, honey bees provide several high-value products such as beeswax, pollen, propolis, royal jelly and bee venom, which possess significant medicinal and commercial importance. With the growing demand for natural and value-added products, apiculture has emerged as a promising avenue for enhancing farmers' income and promoting sustainable agriculture. In hill states like Himachal Pradesh, beekeeping assumes greater importance due to the availability of diverse floral resources and favourable agro-climatic conditions that support colony development and honey flow for extended periods.

The success and sustainability of apiculture largely depend upon the socio-economic background of beekeepers, training exposure, access to improved technologies and adoption of scientific hive management practices. Several survey studies have highlighted that young and educated farmers with greater extension contact and mass media exposure show higher participation and continuity in beekeeping enterprises[1]. Training programmes conducted by extension agencies and Krishi Vigyan Kendras have also been found effective in enhancing knowledge, skill development and adoption of improved practices,

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ultimately improving livelihood security[2,3]. Studies further suggest that beekeeping is particularly suitable for marginal farmers, landless labourers and unemployed youth as it requires limited land resources and offers good scope for entrepreneurship[4].

Hive management practices vary widely across agro-climatic zones depending upon floral availability, pest incidence and migratory requirements. Comparative studies have established that *Apis mellifera* produces substantially higher honey yields than *A. cerana*[5]. Survey-based investigations have also documented that the adoption of modern frame hives significantly increases honey productivity compared to traditional hives, thereby improving profitability[6,7]. However, beekeepers continue to face constraints related to pests, diseases, predators and climatic stresses, which affect colony strength and productivity[8,9]. Although honey remains the primary focus of apiculture, diversification into other hive products is essential for improving farm income and ensuring economic sustainability. Earlier studies have reported limited awareness and adoption of pollen, propolis, royal jelly, wax processing and venom extraction among beekeepers, despite their high commercial value[10,11,12]. Marketing-related constraints, lack of modern equipment, and inadequate extension support have also been identified as major limitations restricting diversification and value addition in beekeeping enterprises[13].

In Himachal Pradesh, beekeeping is expanding steadily, particularly with the adoption of *A. mellifera*, yet systematic information on the demographic status of beekeepers, prevailing hive management practices across districts, and the current level of hive product diversification remains inadequate. Therefore, the present investigation was undertaken to assess the demographic characteristics of beekeepers, document hive management and migratory practices across different agro-climatic zones, and evaluate the extent of diversification into various hive products in Himachal Pradesh, so as to identify gaps and future opportunities for strengthening apiculture in the state.

MATERIALS AND METHODS

A field survey was conducted for two consecutive years, 2022 and 2023, in five districts of Himachal Pradesh, namely Kangra, Mandi, Solan, Chamba and Kinnaur. These districts were selected due to their favourable agro-climatic conditions, rich floral diversity and established potential for beekeeping. The survey was undertaken to assess the demographic profile of beekeepers, commonly adopted hive management practices and diversification of hive products. A total of 80 beekeepers were selected randomly from different villages of each district to ensure representative sampling. Data were collected through structured interviews, personal interactions and field observations during apiary visits. Information recorded from each respondent included age, educational status, occupation, training exposure and training institution. Details on hive management practices included apiary size, honey bee species reared, apiary site conditions, inter-colonial distance, row-to-row spacing, type of hive stand used, type of hive, wood type used for hive construction, type of super chamber and use of dummy division boards. Information related to diversification was collected on hive products other than honey, such as beeswax, pollen, propolis, royal jelly and bee venom. In addition, data on honey packaging methods and marketing channels were recorded to assess post-harvest handling and commercialisation patterns. The collected data were compiled district-wise and analysed using descriptive statistical tools. To test the association and significance of variation among different parameters, the Chi-square (χ^2) test was applied, and the calculated χ^2 values were compared at a 5 per cent level of significance to determine statistical significance.

RESULTS AND DISCUSSION

Demographic Profile and Training Status of Beekeepers

Data presented in Table 1 revealed that apiculture was predominantly practised by male respondents

(95.00%), whereas female participation was limited (5.00%). Similar observations of male dominance in beekeeping have also been reported from Uttarakhand and other hill regions, where migration, hive handling and marketing restrict women's participation[4,14]. The variation among districts was non-significant (χ^2 = 1.68; p = 0.80), indicating uniformity in gender participation across districts. It was observed that the majority of respondents belonged to the middle age group (40-49 years; 50.00%), followed by 30-39 years (27.50%), while young beekeepers below 30 years constituted only 3.75%. This suggests that beekeeping is largely adopted by mature individuals having experience, stable resources and better risk-bearing capacity. Similar age trends were recorded by Sharma and Dhaliwal[15] who reported that most successful beekeepers belonged to middle age groups. District-wise differences were non-significant (χ^2 = 5.57; p = 0.94). Education-wise, matric level (35.00%) was the most common qualification among respondents, followed by senior secondary (28.75%) and primary education (18.75%), while 5.00% were illiterate. Comparable findings were reported by Singh *et al.*,[1] and Singh and Singh[4], who observed that beekeeping training programmes are largely attended by educated youth up to secondary and senior secondary level. The differences among districts were statistically non-significant (χ^2 = 9.54; p = 0.89). Landholding status showed that marginal farmers dominated (72.50%), while 27.50% were small farmers. Similar observations

Table 1. Demographic profile of surveyed beekeepers in different districts of Himachal Pradesh

Category	Particulars	No. of Beekeeper's District Wise (n)					Overall	(χ^2)
		Kangra (n=50)	Mandi (n=10)	Solan (n=8)	Chamba (n= 6)	Kinnaur (n= 6)	n=80	
Gender (%)	Male	94.00	90.00	100.00	100.00	100.00	95.00	1.68 (p=0.80)
	Female	6.00	10.00	0.00	0.00	0.00	5.00	
Age (%)	<30 yrs	4.00	0.00	0.00	16.66	0.00	3.75	5.57 (p=0.94)
	30-39 yrs	26.00	30.00	25.00	33.33	33.33	27.50	
	40-49 yrs	54.00	40.00	50.00	33.33	50.00	50.00	
	>50yrs	16.00	30.00	25.00	16.66	16.66	18.75	
Education (%)	Illiterate	4.00	10.00	0.00	0.00	16.66	5.00	9.54 (p=0.89)
	Primary	18.00	20.00	12.50	16.66	33.33	18.75	
	Matric	36.00	40.00	50.00	16.66	16.66	35.00	
	Senior Secondary	26.00	20.00	37.50	50.00	33.33	28.75	
	Graduation and above	16.00	10.00	0.00	16.66	0.00	12.50	
Landholding status (%)	Marginal	72.00	80.00	62.50	66.66	83.33	72.50	1.15 (p=0.89)
	Small	28.00	20.00	37.50	33.33	16.66	27.50	
Occupation (%)	Business	24.00	20.00	37.50	33.33	16.66	25.00	2.47 (p=0.96)
	Farming	72.00	80.00	62.50	66.66	83.33	72.50	
	Retired	4.00	0.00	0.00	0.00	0.00	2.50	

were made by Sharma and Dhaliwal[15] and Verma *et al*[7]. The association among districts was non-significant (χ^2 = 1.15; p = 0.89). Occupation profile revealed that farming (72.50%) was the major occupation, followed by business (25.00%), while only 2.50% respondents were retired. Similar findings were also documented by Singh *et al*.,[1] and Singh and Singh[4], where the majority of beekeepers were agriculturists. District-wise differences were non-significant (χ^2 = 2.47; p = 0.96).

Based on data presented in Table 2, it was revealed that out of 80 respondents, 85.00% beekeepers were trained, whereas only 15.00% were untrained. This indicates good outreach of extension and training programmes in the state, which is encouraging for the adoption of scientific beekeeping. The findings are in agreement with Sharma *et al*.,[2] who reported high satisfaction and significant knowledge gain among trainees after training programmes conducted in Himachal Pradesh. However, the district-wise variation was statistically non-significant (χ^2 = 8.46; p = 0.076). The major training institutions included KVKs (36.23%), followed by Regional Centres (32.50%) and Agricultural Universities (24.64%). A significant association was observed between district and source of training (χ^2 = 18.30; p = 0.019), indicating district-specific availability and dependence on extension agencies.

Colony Management Practices in Different Districts of Himachal Pradesh

The data presented in Table 3 revealed that medium apiary size (57-120 colonies) was most common among the surveyed respondents (45.00%), followed by large apiaries (120-800 colonies) (33.75%) and small apiaries (5-57 colonies) (21.25%). The district-wise variation was found non-significant (χ^2 = 3.03; p = 0.93), indicating a uniform trend in apiary size distribution across districts. Similar observations were reported by Sharma and Dhaliwal[15] and Singh *et al*[1]. With respect to honey bee species, *A. mellifera* was the predominant species reared by beekeepers (88.75%), whereas *A. cerana* was maintained by only 11.25% respondents. The association between district and honey bee species was highly significant (χ^2 = 19.24; p = 0.0007). Kangra showed complete dominance of *A. mellifera* (100%), while comparatively higher adoption of *A. cerana* was

Table 2. Training exposure of beekeepers and institutional sources of training in different districts of Himachal Pradesh

District	Kangra	Mandi	Solan	Chamba	Kinnaur	Overall	(χ^2)
No. of Respondents	**50**	**10**	**8**	**6**	**6**	**80**	
Training Experience							
Respondents acquired training (%)	92.00	60.00	87.50	83.33	66.66	85.00	8.46 (p=0.076)
Respondents untrained (%)	8.00	40.00	12.50	16.66	33.33	15.00	
Place of Training							
Regional centers (%)	47.83	33.33	0.00	16.66	25.00	32.50	18.30 (p=0.019)
Agriculture universities (%)	28.26	0.00	57.14	0.00	0.00	24.64	
KVK (%)	23.91	66.66	42.85	66.66	75.00	36.23	

Table 3. District-wise adoption of beekeeping and colony management practices in selected districts of Himachal Pradesh

Category	Variables	No. of Beekeeper's District Wise (n)					Overall	(χ^2)
		Kangra (n=50)	Mandi (n=10)	Solan (n=8)	Chamba (n= 6)	Kinnaur (n= 6)	n=80	
No. of boxes (%)	Small (5-57)	16.00	30.00	25.00	33.33	33.33	21.25	3.03 (p=0.93)
	Medium (57-120)	48.00	40.00	37.50	33.33	50.00	45.00	
	Large (120-800)	36.00	30.00	37.50	33.33	16.66	33.75	
Type of honey bee (%)	*Apis mellifera*	100.00	60.00	75.00	83.33	66.66	88.75	19.24 (p=0.0007)
	Apis cerana	0.00	40.00	25.00	16.66	33.33	11.25	
Apiary site (%)	Clean	64.00	60.00	50.00	83.33	83.33	65.00	2.70 (p=0.95)
	Dirty	0.00	0.00	0.00	0.00	0.00	0.00	
	Shade	36.00	40.00	50.00	16.66	16.66	35.00	
Type of hive (%)	Langstroth	100.00	60.00	75.00	83.33	66.66	88.75	19.24 (p=0.014)
	ISI-Type A	0.00	00.00	0.00	0.00	0.00	0.00	
	Traditional	0.00	40.00	25.00	16.66	33.33	11.25	
Wood of the hive (%)	Toon	44.00	30.00	37.50	16.66	16.66	37.50	17.23 (p=0.14)
	Acacia	12.00	20.00	12.50	16.66	0.00	12.50	
	Deodar	8.00	40.00	12.50	33.33	66.66	17.50	
	Kail	36.00	20.00	37.50	33.33	16.66	32.50	
Hive stands (%)	Plastic	24.00	33.33	16.66	20.00	0.00	22.53	15.86 (p=0.044)
	Metal	76.00	66.66	83.33	60.00	75.00	74.65	
	Wooden	0.00	0.00	0.00	20.00	25.00	2.81	
Intercolonial distance (%)	<2 feet	16.00	16.66	33.33	20.00	25.00	18.31	2.90 (p=0.99)
	2-3 feet	56.00	50.00	50.00	60.00	75.00	56.34	
	3-4 feet	28.00	33.33	16.66	20.00	0.00	25.35	
	>4 feet	0.00	0.00	0.00	0.00	0.00	0.00	
Row to row distance (%)	<2 feet	8.00	16.66	0.00	20.00	50.00	11.27	13.52 (p=0.33)
	2-3 feet	30.00	50.00	66.66	40.00	25.00	35.21	
	3-4 feet	50.00	33.33	16.66	40.00	25.00	43.66	
	>4 feet	12.00	0.00	16.66	0.00	0.00	9.86	

Super chamber (%)	Deep	68.00	83.33	66.66	60.00	75.00	69.01	3.73 (p=0.88)
	Medium	12.00	16.66	0.00	20.00	0.00	11.27	
	Shallow	20.00	0.00	33.33	20.00	25.00	19.72	
Dummy division board (%)	Present	28.00	33.33	16.66	20.00	25.00	26.76	0.61 (p=0.96)
	Not present	72.00	66.66	83.33	80.00	75.00	73.24	

observed in Mandi (40.00%) and Kinnaur (33.33%). This may be due to better adaptability of indigenous bees under difficult climatic conditions and forest-based flora, whereas *A. mellifera* is preferred for its higher honey production and commercial suitability. Similar trends have been reported by Verma *et al*[7].

Regarding apiary site conditions, most of the respondents maintained their apiaries under clean surroundings (65.00%), while 35.00% kept colonies under shade. None of the beekeepers reported dirty apiary sites. The differences among districts were non-significant (χ^2 = 2.70; p = 0.95), suggesting that hygienic apiary maintenance is widely practised**.** The type of hive used differed significantly across districts (χ^2 = 19.24; p = 0.014). Overall, Langstroth hives were adopted by 88.75% respondents, while 11.25% continued using traditional hives. Traditional hive use was relatively higher in Mandi and Kinnaur districts, reflecting continued dependence on conventional methods in some areas. Adoption of Langstroth hives has been widely reported as beneficial for scientific management, ease of inspection and better honey extraction efficiency[4]. The type of wood used for hive construction showed non-significant variation (χ^2 = 17.23; p = 0.14). Overall, Toon (37.50%) and Kail (32.50%) were most commonly used, followed by Deodar (17.50%) and Acacia (12.50%). The use of hive stands showed a significant association with district (χ^2 = 15.86; p = 0.044). The majority of respondents used metal stands (74.65%), followed by plastic stands (22.53%), whereas wooden stands were rarely used (2.81%). Intercolonial spacing was mostly maintained at 2-3 feet (56.34%), followed by 3-4 feet (25.35%), whereas 18.31% maintained spacing above 2 feet. The differences among districts were non-significant (χ^2 = 2.90; p = 0.99). Similarly, row-to-row distance was mainly maintained at 3–4 feet (43.66%), followed by 2-3 feet (35.21%), with non-significant district variation (χ^2 = 13.52; p = 0.33). Regarding super chamber adoption, deep supers were most preferred (69.01%), followed by shallow supers (19.72%) and medium supers (11.27%), and the variation among districts was non-significant (χ^2 = 3.73; p = 0.88). The use of dummy division boards was found to be low, as only 26.76% respondents used them, while 73.24% did not. The differences among districts were non-significant (χ^2 = 0.61; p = 0.96). Dummy boards help in reducing extra space during dearth periods and assist colonies in maintaining brood temperature, but low adoption suggests limited awareness or poor extension emphasis.

Honey Production and Post-harvest Management Practices of Beekeepers in Himachal Pradesh

The results clearly indicated that honey yield was substantially higher in movable frame hives compared to traditional hives across all districts (Table 4). In Mandi, traditional hives yielded 3.35 ± 0.90 kg/hive/year, while frame hives produced 13.58 ± 1.24 kg/hive/year. Similar yield differences were recorded in Solan (4.25 ± 1.06 *vs* 14.03 ± 1.81 kg), Chamba (4.75 ± 1.06 *vs* 15.88 ± 3.04 kg) and Kinnaur (5.50 ± 1.41 *vs* 14.98 ± 2.52 kg). In Kangra, all beekeepers used frame hives and recorded a mean yield of 15.90 ± 2.11 kg/hive/

Table 4. District-wise honey yield (kg/colony/year) recorded from traditional and movable frame hives in Himachal Pradesh

District	Traditional Hive				Moveable Frame Hive			
	n	Min	Max	Mean±SD	n	Min	Max	Mean±SD
Kangra	0	-	-	-	50	12.50	19.50	15.90±2.11
Mandi	4	2.50	4.50	3.35±0.90	6	11.00	16.00	13.58±1.24
Solan	2	3.50	5.00	4.25±1.06	6	11.50	16.50	14.03±1.81
Chamba	1	4.00	5.50	4.75±1.06	5	12.00	20.00	15.88±3.04

n= no. of respondents; min= minimum honey yield (kg/hive/year); max= maximum honey yield (kg/hive/year)

Table 5. District-wise honey storage, packaging and marketing practices adopted by beekeepers in Himachal Pradesh

Parameters	Variables	No. of Beekeeper's District Wise (n)					Overall	(χ^2)
		Kangra (n=50)	Mandi (n=10)	Solan (n=8)	Chamba (n=6)	Kinnaur (n=6)	n=80	
Honey containers for storage (%)	Plastic buckets	74.00	80.00	87.50	66.66	83.33	76.25	1.25 (p=0.87)
	Tin containers	26.00	20.00	12.50	33.33	16.66	23.75	
Honey containers for packaging (%)	Plastic bottles	32.00	40.00	37.50	50.00	33.33	35.00	0.93 (p=0.92)
	Glass jars and bottles	68.00	60.00	62.50	50.00	66.66	65.00	
Marketing (%)	Direct sale to consumers	24.00	40.00	25.00	33.33	33.33	27.50	3.42 (p=0.91)
	Direct sale to wholesalers	62.00	60.00	62.50	50.00	66.66	61.25	
	Direct sale to retailers	14.00	0.00	12.50	16.66	0.00	11.25	

year, indicating strong adoption of modern apiculture. Similar results were documented in different studies where modern hives consistently produced significantly higher honey yields than traditional hives[6]. The present findings also support earlier studies which emphasised that adoption of frame hives improves productivity and profitability of beekeeping enterprises[7].

The results showed that plastic buckets were the most common storage container (76.25%), while 23.75% used tin containers (Table 5). Similar storage trends have been documented in several survey studies where plastic containers were widely used in local honey markets[16]. For packaging, glass jars and bottles (65.00%) were preferred over plastic bottles (35.00%). The preference for glass packaging reflects increasing awareness of consumer demand for quality and attractive packaging. Similar observations were recorded by Vural and Karaman[17], who reported glass

as the most preferred packaging material for extracted honey due to its market acceptability. Marketing analysis revealed that 61.25% of beekeepers sold honey directly to wholesalers, whereas 27.50% sold directly to consumers, and only 11.25% sold to retailers. This indicates that marketing is largely dependent on bulk sales and middlemen, and there is potential for improving profitability through direct consumer marketing, branding and cooperative marketing systems. Similar findings have been reported by Das *et al*[13].

Extraction of Hive Products other than Honey

The findings indicated that beeswax was the most commonly extracted hive product, reported by 80.00% of beekeepers, followed by pollen (38.75%) and propolis (30.00%) (Table 6). Beeswax extraction was highest in Kangra (86.00%) and Chamba (83.33%). Similar observations have been documented where wax is the most common secondary product harvested by beekeepers[12]**.** Pollen extraction was reported by 38.75 per cent of respondents, mainly through pollen traps, with higher adoption in Kangra and Mandi. Pollen trapping has been reported as an important income diversification strategy, but requires careful management to prevent weakening of colonies. Studies have shown that both floral source and trapping frequency significantly influence pollen collection, and adoption can be improved through regulated trapping practices such as alternate-day use of pollen traps, avoiding trapping during peak brood-rearing periods and ensuring adequate nutritional supplementation to colonies[10,18]. Propolis collection was practised by only 30% beekeepers, mainly through propolis sheets. Lower adoption may be due to a lack of awareness, poor market linkage and limited availability of collection equipment. Similar findings were reported by Kumar and Kundal[10], who observed that beekeepers in Kangra primarily focus on honey and have limited knowledge of other products.

Similarly, royal jelly production requires specialised skills, frequent colony manipulation and controlled conditions, which are currently lacking at the farmer level[12]. Notably, none of the respondents extracted royal jelly or bee venom, indicating that these high-value products remain unexplored in Himachal Pradesh. The absence of these practices is likely due to inadequate training and limited market access. Therefore, programmes focusing on practical training, demonstration units and cooperative-based direct marketing systems are essential to promote the adoption of high-value hive products.

Table 6. District-wise adoption of extraction practices for hive products other than honey in Himachal Pradesh

Category	Variables	No. of Beekeeper's District Wise (n)					Overall	(χ^2)
		Kangra (n=50)	Mandi (n=10)	Solan (n=8)	Chamba (n=6)	Kinnaur (n=6)	n=80	
Extraction of other hive products (%)	Pollen	44.00	40.00	25.00	33.33	16.66	38.75	2.53 (p=0.63)
	Propolis	36.00	20.00	25.00	16.66	16.66	30.00	2.44 (p=0.65)
	Beewax	86.00	60.00	75.00	83.33	66.66	80.00	4.46 (p=0.35)
	Bee venom	0.00	0.00	0.00	0.00	0.00	0.00	0 (p=1)
	Royal jelly	0.00	0.00	0.00	0.00	0.00	0.00	0 (p=1)

CONCLUSION

Beekeeping in Himachal Pradesh is practised by the farmers with marginal landholdings, mostly males, middle-aged and well-trained from various institutions. More honey can be harvested using movable frame hives than the traditional ones. Post-harvest handling, like storage in plastic buckets and packing in glass jars, is common practice. Marketing is primarily through traders, and a few are also involved in direct sales. Diversification remains low, as beekeepers are mostly confined to beeswax, pollen and propolis, while high-value products like royal jelly and bee venom are not exploited. This reflects gaps in technical knowledge, limited access to specialised equipment and weak market linkages.

To improve sustainability and profitability, there is a need to strengthen training programmes on advanced beekeeping and diversification, promote youth and women participation, develop cooperative marketing systems, enhance access to modern equipment and encourage migratory beekeeping practices. Overall, expanding training and support systems can significantly improve diversification and long-term sustainability of the sector.

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CONFLICT OF INTEREST

The authors declared that they do not have any conflict of interest.

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AUTHORS CONTRIBUTION

ST: conducted the experiment and collected preliminary data, compiled the data and wrote original draft. SKS: conceptualized the study, provided supervision and contributed to data analysis. SDS: edited the original draft.