



Beekeeping in India: An overview of status, honey bee pests and diseases, challenges and future prospects

Adnan Irshad Zargar¹, Aditi Mankotia^{2*}, Ashu Sharma², Akshiti Kamboj², Salonika Thakur², Simran Negi²

¹ Division of Entomology, SKUAST Kashmir, Srinagar, India

² Division of Plant Pathology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, India

Corresponding Author: Aditi Mankotia

DOI: <https://doi.org/10.66856/ijaps.2026.8.4.8296>

Abstract

Beekeeping is an important agricultural and livelihood activity in India, providing honey and other hive products while supporting crop pollination and rural incomes. This review synthesizes national and regional literature on the history, bee species, production systems, hive management, bee products, pollination services, socio-economic dimensions, constraints, policy support and future prospects of Indian beekeeping. The review further examines major diseases, pests and predators of honey bees and their management, with emphasis on hygienic practices and integrated pest management. India's diverse agro-climatic conditions provide opportunities for both stationary and migratory beekeeping, value addition and pollination services. However, the sector faces constraints including pests and diseases, pesticide exposure, forage loss, climate variability, high equipment and migration costs, weak processing and marketing infrastructure, adulteration and limited adoption of scientific practices. Improved bee-health surveillance, hygienic colony management, farmer-beekeeper coordination, conservation of native bees, floral-resource mapping, scientific migration, quality assurance, value addition and stronger extension support are important for sustainable development. More consistent production and marketing data are also needed for evidence-based planning of Indian beekeeping.

Keywords: *Apis cerana*, *Apis mellifera*, bee diseases, bee pests, honey production, India, integrated pest management, pollination, sustainability

Introduction

Beekeeping is both an art and a science, practised in India as a full-time occupation and as a hobby that yields honey and supplementary income (Kishan Tej *et al.*, 2017) ^[27]. Honeybees contribute in two ways: they yield honey, beeswax, pollen, propolis, royal jelly and venom, and they pollinate crops and wild flora (Abrol, 2023; Kishan Tej *et al.*, 2017) ^[2, 27]. Bees are reported to pollinate a large share of the world's cultivated crops, and honeybees are credited with contributing to the pollination of more than 90 major crops in India (Chaudhary & Chand, 2017; Manoj *et al.*, 2023) ^[16, 32].

India's climatic and floristic diversity supports migratory and non-migratory beekeeping in the Himalayan foothills, the Indo-Gangetic plains, central forests, the eastern and north-eastern states and the plantation belts of the south (Abrol, 2023; Manoj *et al.*, 2023) ^[2, 32]. The experience of COVID-19 also demonstrated the vulnerability of agricultural and allied activities to large-scale socioeconomic disruptions (Bano *et al.*, 2022) ^[7]. Beekeeping needs little land, does not compete with other agricultural enterprises, and can be managed by women, youth, landless and tribal households (Abrol, 2023). Despite this, Abrol (2023) ^[2] estimates that more than 90% of the sector's potential remains untapped.

This review is based on national-level reviews or chapters (Abrol, 2023; Manoj *et al.*, 2023) ^[2, 32], and regional studies from Odisha, Jammu and Kashmir and Punjab (Bano *et al.*, 2023, 2025; Nayak *et al.*, 2025; Sharma & Dhaliwal, 2014; Sharma *et al.*, 2013) ^[8, 9, 39, 47, 48]. The regional studies allow comparison of the national picture with evidence on profitability, marketing, migration, and constraints at the

individual beekeeper level. The headings are: (i) history and institutions; (ii) bee species and biology; (iii) beekeeping systems, equipment and migratory beekeeping; (iv) bee products; (v) pollination and agriculture; (vi) production, trade and prospects; (vii) socio-economics, profitability and marketing; (viii) constraints; and (ix) policy, technology and future directions. Where the sources disagree, the discrepancy is noted rather than resolved (Section 7.4). To contextualise these sources, the review also draws on 30 primary and secondary works cited in the two most recent national reviews (Abrol, 2023; Manoj *et al.*, 2023) ^[2, 32]. Statements taken from that literature are attributed to the original authors and are described as they are reported in those reviews.

History and Institutional Development of Beekeeping in India

Traditional roots: Honey and its medicinal uses appear in ancient Indian texts, and rock paintings and carvings record early honey collection (Kishan Tej *et al.*, 2017). Manoj *et al.* (2023) ^[27, 32] cite the Rigveda's description of honey (*madhu*) as sacred and medicinal, and note that forest dwellers traditionally harvested honey from wild colonies of *Apis dorsata* and *A. florea*. Traditional beekeeping involved capturing swarms and housing them in wooden logs, clay receptacles and house walls, with honey extracted by smoking out and squeezing combs, often destroying the colony (Abrol, 2023) ^[2]. In central India, honey hunting by tribal and forest-dwelling communities remains an important traditional activity (Bhowate & Kumar, 2020; Manoj *et al.*, 2023) ^[12, 32].

Introduction of movable-frame hives: The movable-frame hive developed in the mid-nineteenth century drove the shift to modern beekeeping worldwide (Abrol, 2023; Kishan Tej *et al.*, 2017)^[2, 27]. Early attempts to keep *A. cerana indica* in such hives in Bengal, Punjab and the Kullu valley in the 1880s met with little success. The Newton hive, devised for *A. cerana* in southern India, and training programmes from about 1916–17 were an important turning point, followed by work in Travancore (1917) and Mysore (1925) (Abrol, 2023). Manoj *et al.* (2023)^[2, 32] record the first beekeeping training centre in Kodaikanal in 1911.

Institutionalisation: Abrol (2023)^[2] lists the recommendation of the Royal Commission on Agriculture (1928) to develop beekeeping as a cottage industry, the formation of the All India Beekeepers Association (1938–39), and the ICAR research stations in Punjab (1945) and Coimbatore (1950). After independence the Khadi and Village Industries Board (1954), later the KVIC and state boards, brought beekeeping into the village-industries programme (Kishan Tej *et al.*, 2017)^[27]. The All India Coordinated Research Project (AICRP) on honeybee research and training, launched by ICAR in 1980–81, now operates through more than 28 centres (Abrol, 2023; Kishan Tej *et al.*, 2017)^[2, 27]. A Central Sector Scheme for beekeeping to improve crop productivity began in 1994–95 and was later absorbed into the Macro Management Scheme

(Kishan Tej *et al.*, 2017)^[27]. The National Beekeeping and Honey Mission (NBHM), launched in 2020, is the current national framework (Manoj *et al.*, 2023)^[32].

Regional histories: Sharma *et al.* (2013)^[47] trace beekeeping in Kashmir to 1470 AD, with indigenous *A. cerana* kept in log hives and in clay pots set into house walls from the early nineteenth century. In Punjab, *A. mellifera* has been kept for commercial beekeeping since the 1960s, supported by favourable climate and flora, training and extension, and pest and disease control (Sharma & Dhaliwal, 2014)^[48].

Bee Species and Colony Biology

1. Species in India

Only *A. cerana* and *A. mellifera* are domesticated and used commercially, while *A. dorsata* and *A. florea* are wild and exploited by honey hunting. Worldwide, nine *Apis* species are recognised: five nests in cavities and build several combs, whereas four nests in the open on a single comb, and all except *A. mellifera* are native to South-East Asia (Abrol, 2023; Otis, 1997)^[2, 42]. The giant bee *A. dorsata* has a mean tongue length of about 6.7 mm (Ruttner, 1988)^[46] and normally forages 2–3 km from the nest, giving it a wide foraging range in both area and plant variety (Abrol, 2023)^[2]. Table 1 combines the species descriptions from the sources.

Table 1: Honeybee species of India and their key features

Species	Nest and habit	Approx. honey yield	Key notes
Rock/giant bee (<i>A. dorsata</i>)	Single open comb hung from branches, cliffs or buildings; aggressive; migratory	50–80 kg per colony per year (wild)	Harvested by squeezing combs; valued pollinator; wild populations reported to be declining (Kishan Tej <i>et al.</i> , 2017; Abrol, 2023) ^[2, 27]
Little/dwarf bee (<i>A. florea</i>)	Small single comb around twigs; plains and low altitudes	~0.5 kg per colony per year	Non-rearable, frequently shifts; important pollinator in dry, hot plains (Kishan Tej <i>et al.</i> , 2017; Abrol, 2023) ^[2, 27]
Indian/Asiatic bee (<i>A. cerana</i>)	Multiple parallel combs in dark cavities; non-aggressive in Kishan Tej <i>et al.</i> (2017) ^[27] , described as mostly furious in Abrol (2023) ^[2] , Table 8)	7–9 kg per colony per year (Kishan Tej <i>et al.</i>); 4–5 kg (Abrol)	Domesticated in Newton and Marthandam hives; strong in south India; tolerant of Varroa
European/Italian bee (<i>A. mellifera</i>)	Multiple parallel combs in cavities; calm	25–40 kg (Kishan Tej <i>et al.</i>); 25–30 kg (Abrol)	Introduced from Europe; dominant in north India commercial beekeeping
Stingless bees (Meliponini; e.g., <i>Tetragonula iridipennis</i>)	Small nests in tree cavities, walls, pots	~100 g (Kishan Tej <i>et al.</i>) to ≤500 g (Abrol)	Defend by biting; excellent for small-flowered crops; medicinal honey and propolis

2. Caste structure and colony size

A colony has one queen, hundreds of drones and thousands of workers; caste is determined by larval feeding, with royal jelly being decisive (Kishan Tej *et al.*, 2017; Yadav *et al.*, 2017)^[27, 57]. The queen may lay more than 1,500 eggs a day, and up to 2,500 in the flow season (Kishan Tej *et al.*, 2017)^[27]. Reported worker populations range from 8,000–25,000 in *A. florea* to 50,000–80,000 in *A. dorsata*, with 40,000–50,000 in *A. mellifera* and 20,000–40,000 in *A. cerana* (Kishan Tej *et al.*, 2017)^[27].

3. *cerana* versus *A. mellifera*

Abrol (2023)^[2], Table 8, drawn from Chahal *et al.*, 1995)^[14] contrasts the two domesticated species. *A. mellifera* is heavier, has a longer tongue, larger nectar and pollen loads, a wider flight range (2–5 km versus 0.8–2 km), higher queen egg-laying capacity, less swarming and absconding, and a much higher yield under Indian conditions. *A. cerana*,

by contrast, is better adapted to local conditions, forages for longer hours, is more suited to small holdings, and is reported to resist wasps and *Varroa* better and to need fewer chemical treatments (Abrol, 2023)^[2]. *A. mellifera* uses propolis to seal cracks, which reduces wax moth problems but makes hive inspection more difficult, whereas *A. cerana* does not propolise, leaving hives prone to wax moth (Abrol, 2023; Kishan Tej *et al.*, 2017)^[2, 27]. Foraging ranges reported for *A. mellifera* in Kishan Tej *et al.* (2017)^[27] are wider than those in Abrol (2023)^[2], reflecting different studies. In Kashmir both species are prevalent, and beekeeping with *A. cerana* has a long tradition (Bano *et al.*, 2025)^[9].

Beekeeping Systems, Hives and Equipment

1. Traditional and modern methods

Traditional methods (log hives, wall hives, earthen pots, wild honey hunting) need little investment but yield about

2–5 kg of honey per colony per year (Manoj *et al.*, 2023)^[32]. Modern methods, based on the Langstroth, top-bar and frame hives, give 20–60 kg per colony per year but need expertise and management (Manoj *et al.*, 2023)^[32]. Modern beekeeping is concentrated in Punjab, Haryana, Maharashtra and Tamil Nadu, while traditional practice remains common in Madhya Pradesh, Odisha and the north-east (Manoj *et al.*, 2023)^[32]. Adoption of scientific practices is low: a survey cited by Manoj *et al.* (2023)^[32] suggests only 20–25% of beekeepers use modern practices.

2. Hive types

Kishan Tej *et al.* (2017)^[27] describe hive types used in India: the Langstroth ten-frame hive for *A. mellifera*, the BIS hive for *A. mellifera* and the Newton and Marthandam hives for *A. cerana*. A standard hive consists of a stand, bottom board, brood chamber, super chamber(s) with a queen excluder, inner cover and top cover. The Newton hive is small (seven frames per brood chamber) and suits *A. cerana* colonies. Hive timber should be light, well seasoned and free of strong smell (e.g., kail, teak, toon), and hives should be painted white or aluminium to resist weathering (Kishan Tej *et al.*, 2017)^[27]. Hive parts should be interchangeable across an apiary.

3. Ancillary equipment

Essential equipment includes the smoker, hive tool, bee veil, gloves, bee brush, decapping knife, honey extractor (two- or four-frame), comb foundation sheets and embedder, feeders, queen cell protectors, dummy/division boards, drone traps and pollen traps (Kishan Tej *et al.*, 2017)^[27]. Extractors allow honey to be removed without destroying combs. High equipment cost is reported as a barrier for new entrepreneurs (Kishan Tej *et al.*, 2017), and Manoj *et al.* (2023)^[27, 32] note that the cost of establishing a colony ranges from ₹2,500 to ₹5,000.

4. General management

Kishan Tej *et al.* (2017)^[27] stress: a dry, shaded apiary with water and adequate bee forage; sugar syrup (1:1) feeding in dearth; supering when the brood chamber is covered with bees; and swarm control by removing brood frames from strong colonies, pinching queen cells and dividing colonies. Seasonal management includes shade and water in severe summer, winter packing in cold areas, and drainage and syrup feeding in the rains. Migratory beekeeping is a major income strategy: in northern India colonies move between plains and hills to exploit rapeseed-mustard (October–November), eucalyptus (December–January), litchi (February–March), sunflower and shisham, while in the south colonies from Kanyakumari move to the rubber plantations of Kerala (January–March), tamarind and cardamom estates (Kishan Tej *et al.*, 2017)^[27]. Migration increases returns but also spreads mites and diseases (Kishan Tej *et al.*, 2017)^[27].

5. Migratory beekeeping: evidence from Jammu and Kashmir

Sharma *et al.* (2013)^[47] present migration as the main route to higher productivity in Jammu and Kashmir, where four agro-climatic zones, from low-altitude subtropical to cold alpine, and a long flowering season mean that nectar flora is available somewhere in the region for most of the year. Commercial migratory beekeepers use Langstroth hives, take four to five harvests a year and average roughly 50–60 kg of honey per hive, whereas small-scale stationary

beekeepers harvest once or twice a year and obtain 10–20 kg per hive. Private beekeepers are reported to obtain 35–60 kg per colony by shifting colonies between locations, against 5–10 kg in stationary systems, and 20–25 kg per colony from the *Plectranthus* flow around Banihal, Doda and Ramban, with profits of more than 40–50% on the investment made. Migration also lets beekeepers increase colony numbers by at least 20%, avoids much of the maintenance cost of the dearth period, and strengthens colonies more conveniently than artificial feeding (Sharma *et al.*, 2013)^[47].

Interstate migration typically runs from October–November to May–June, moving colonies from the hills to the plains of Haryana, Punjab and Rajasthan for toria, mustard, eucalyptus, shisham, berseem and sunflower flows. Examples given include mustard in Ganga Nagar, Rajasthan (about 20 kg per colony, late November to mid-March), coriander around Kota (10–15 kg, February–March) and mustard and eucalyptus near Saharanpur (5–10 kg). Colonies returning to the Jammu area use jamun, neem, berseem and shisham flows, and colonies belonging to the state department are brought to the hills at the end of March for apple pollination. Movement within the state between plains, lower hills and upper hills bridges gaps in local flowering. Sharma *et al.* (2013)^[47] rate the Doda, Ramban, Banihal, Kishtwar and Udhampur districts of the Jammu region and Anantnag in Kashmir as having the greatest beekeeping potential, Baramulla, Srinagar, Pulwama, Kupwara and several Jammu-region districts as suitable for less dense beekeeping. They identify limited public and private support, weak research and development and insufficient support for small beekeepers among the constraints on migratory beekeeping.

Bee Products and Value Addition

Honey: Honey is mainly fructose and glucose with about 17% water (Kishan Tej *et al.*, 2017)^[27]. It may be uni- or multifloral, and named types include litchi, eucalyptus, *Brassica*, mustard and jamun honeys (Kishan Tej *et al.*, 2017; Manoj *et al.*, 2023)^[27, 32]. Wild honey from *A. dorsata* is harvested by squeezing combs, while domesticated colonies are extracted by centrifugation. Processing involves heating to about 60 °C for 30 minutes to kill yeasts, filtering and bottling (Kishan Tej *et al.*, 2017). Manoj *et al.* (2023)^[27, 32] distinguish multifloral versus monofloral, wild versus cultivated, and organic honey; organic production is rising, driven by export demand and supported by NPOP and PGS-India certification. Organic honey is produced under guidelines that prohibit synthetic chemicals, antibiotics and artificial feeding of bees and requires that bees forage in pesticide-free landscapes (Manoj *et al.*, 2023)^[32].

Beeswax: Beeswax is used in comb foundation, candles, cosmetics, polishes and pharmaceuticals; hot-water and solar extraction are the common methods (Kishan Tej *et al.*, 2017). Manoj *et al.* (2023)^[27, 32] report an annual Indian output of about 5,000–6,000 MT, and Abrol (2023)^[2] notes that beeswax is used in more than 300 industries.

Royal jelly, pollen, propolis and venom: Royal jelly can be harvested by grafting larvae into artificial queen cups; propolis has antimicrobial and wound-healing uses and is collected mainly by *A. mellifera* and stingless bees; bee venom is used in apitherapy for joint pain (Kishan Tej *et al.*, 2017). Abrol (2023)^[2, 27] argues that most by-products remain unused because beekeepers lack access to technology and marketing channels, and that diversification

is one of the sector's largest opportunities. Manoj *et al.* (2023) ^[32] point to value-added products such as pollen, beeswax and propolis-based goods and premium honeys as ways to expand the industry.

Quality regulation: Honey quality is governed by FSSAI standards for moisture, sucrose and adulteration, and exports fall under APEDA rules on residues and authenticity (Manoj *et al.*, 2023) ^[32]. At the farm level, Bano *et al.* (2025) ^[9] recommend extracting honey only from combs at least 70% sealed so that moisture stays below 20%, keeping honeys from different floral sources separate, cleaning and sterilising equipment, processing raw honey promptly to avoid fermentation and granulation, and introducing small 10–20 g sachets. Sharma *et al.* (2013) ^[47] note that floral honeys such as *Prunus*, *Trifolium* and *Plectranthus* can be sold under their floral names at good prices, and Sharma and Dhaliwal (2014) ^[48] found that beekeepers who processed their honey before sale realised higher prices than those selling raw honey.

Pollination and the Role of Beekeeping in Agriculture

Honeybee pollination increases both yield and quality. Manoj *et al.* (2023) ^[32] report yield gains of about 20–25% in mustard (Abrol, 2007) ^[1], 30–40% in sunflower, 45–60% in apple (Kour *et al.*, 2022) ^[28] and 15–20% in litchi (Kumar & Kumar, 2014) ^[30], and Kishan Tej *et al.* (2017) ^[27] list commercial crops that benefit across fruit, vegetable seed, oilseed and forage seed groups. Abrol (2023 ^[2], Tables 10–12) provides crop-specific pollination guidance, summarized. Work in the Himalayan region shows that pollination by *A. cerana* improves seed quantity and quality in vegetable crops such as radish (Partap & Verma, 1994), and Abrol (2023) ^[2, 43] lists cabbage, cauliflower, broad-leaf mustard and lettuce among other responsive vegetable seed crops. These pollination gains, however, depend on crops staying healthy, since diseases can lower both yield and quality. Common bean anthracnose, for example, causes losses worldwide and is hard to manage because it is seed and soil borne; in poisoned food tests, mancozeb + carbendazim gave the highest mean inhibition of *Colletotrichum lindemuthianum* (89.05%), while garlic clove extract, a plant-based option, gave 65.33% (Wani *et al.*, 2024) ^[51].

The economic value of pollination is much larger than the value of hive products. Abrol (2023) ^[2] reports that animal-pollinated crops account for about USD 84.6 billion (32.7%) of the USD 258.27 billion value of Indian agriculture, with the direct contribution of insect pollination estimated at USD 22.52 billion (8.72%). Regional valuations include

about USD 365 million for Himachal Pradesh, USD 426.8 million for Kashmir and USD 166.8 million for Uttarakhand (Abrol, 2023). Manoj *et al.* (2023) ^[2, 32] cite an estimate exceeding ₹50,000 crore per year and suggest that each ₹1 of honey income is associated with ₹30–40 of added agricultural output. Because these estimates come from different methods and sources, they should be seen as indicative of scale rather than as precise values. Inadequate pollination contributes to low crop yields and beekeeping should be formally recognised as an agricultural input (Abrol, 2023; Manoj *et al.*, 2023) ^[2, 32]. Paid pollination and colony rental are emerging income streams, and colony migration to orchards can benefit both beekeepers and orchardists (Abrol, 2023) ^[2]. In Jammu and Kashmir, colonies of the state department are moved to the hills at the end of March for apple pollination (Sharma *et al.*, 2013) ^[47]. Orchard health matters here too, as leaf disease in apple in India has been linked to *Alternaria alternata*, *A. tenuissima* and *A. arborescens*, so healthy orchards and pollination services go together (Rashid *et al.*, 2025) ^[45]. In Muktsar, Punjab, farmers who took up beekeeping as a subsidiary occupation cited the availability of bee flora around their fields and the positive effect of bees on crop yields (Sharma & Dhaliwal, 2014) ^[48], and honeybees are described as important for rural development and as bioindicators of environmental disturbance (Bano *et al.*, 2023) ^[8]. Integrated disease management in Kashmir sharply lowered bean anthracnose incidence, showing that well-planned combined practices can control crop disease (Wani *et al.*, 2025) ^[9].

Status, Production, Trade and Prospects

1. Prospects

The sources identify several opportunities: expansion of colony numbers; use of forest resources for organised honey collection; product diversification (pollen, propolis, royal jelly, wax, venom); paid pollination services; organic and premium honeys for export; and value chains and cooperatives (Abrol, 2023; Manoj *et al.*, 2023). Manoj *et al.* (2023) ^[2, 32] project that honey exports could reach about ₹1,500 crore by 2030 if quality and traceability improve. Abrol (2023) ^[2] suggests that a well-regulated honey industry could become a major foreign-exchange earner. Diversification into premium honeys, such as herbal-infused types, is proposed as a route into niche export markets (Jamwal *et al.*, 2021; Manoj *et al.*, 2023) ^[26, 32].

2. Inconsistencies in reported statistics

The national statistics quoted in the sources do not agree with one another, and in some cases disagree within a single source (Table 2).

Table 2: Selected national statistics on Indian beekeeping as reported in the sources

Indicator	Values reported	Source
Managed bee colonies	About 12.26 lakh (2023); 3.4 million (abstract) and more than 3.5 million (later in the same paper)	Manoj <i>et al.</i> (2023); Abrol (2023) ^[2, 32]
Annual honey production	1.25 lakh MT (2023) and over 1,55,000 MT (2021–22) in the same review; 67,442 t in 2020 (seventh rank); 62.13 thousand tonnes (eighth rank)	Manoj <i>et al.</i> (2023); Abrol (2023); Bano <i>et al.</i> (2025) ^[2, 9, 32]
Honey exports	About 70,000 MT worth ₹900–1,000 crore, or ₹750–850 crore (about USD 90–100 million); 74,413 MT worth ₹1,221.17 crore (2021–22); USD 83.4 million, 3.6% of world exports (2020); 50% of production	Manoj <i>et al.</i> (2023); Bano <i>et al.</i> (2023); Abrol (2023) ^[2, 8, 32]
Beekeepers	About 10,000 registered; over 2 lakh people engaged; around 50,000 certified organic beekeepers	Manoj <i>et al.</i> (2023) ^[32]
Colony potential	More than 200 million colonies (abstract); over 100–120 million colonies (main text)	Abrol (2023) ^[2]
National production target	1.2 lakh tons per year by 2025, which is below the 1.25–1.55 lakh MT already reported	Manoj <i>et al.</i> (2023) ^[32]

Some of the differences reflect different years and definitions, such as capacity versus actual output, or colonies versus enterprises. The number of certified organic beekeepers given by Manoj *et al.* (2023)^[32] is five times the number of registered beekeepers in the same review. Abrol (2023)^[2] gives national production for 2018 as 1.05 thousand tonnes, which is clearly a unit's error. The figures should therefore be treated as indicative of scale. This review reports them as given and does not attempt to reconcile them; future work comparing regions or years should draw on official series (for example, the National Bee Board, APEDA and FAO) and state the year and definition used.

Socio-economic Dimensions

1. Livelihood and income

Beekeeping offers supplementary income to small and marginal farmers with minimal land. Manoj *et al.* (2023)^[32] estimate that a farmer maintaining 50 colonies can earn ₹4–6 lakh per year from honey, wax and pollination, and that establishment costs are ₹2,500–5,000 per colony, with NBHM/NABARD subsidies covering up to 50% of investment. More than two lakh people are reported to be directly engaged in the sector, especially tribal communities, women and unemployed youth (Manoj *et al.*, 2023). Abrol (2023)^[2, 32] reports that India had the highest mean net beekeeping income per household (USD 2,533) among the developing countries. Ancillary industries, including hive making, equipment, packing, transport and quality assurance, add indirect employment (Abrol, 2023)^[2]. Farm-level evidence on profitability from Punjab and Kashmir is presented in Sections 8.4 and 8.5.

2. Case study: farm women beekeepers in Kadua village, Odisha

Nayak *et al.* (2025)^[39] studied beekeeping among farm women in Kadua village (Satyabadi block, Puri district), using surveys and interviews (sample of 100 beekeepers) and, for regression, data from 30 participants. Key findings are as follows.

- **Gender participation:** Only 34.6% of women participated in beekeeping compared with 65.4% of men. Village women were mainly homemakers (48%), followed by agriculture and allied work (34%), business (13%) and service (5%).
- **Caste and income:** OBC and General category households each made up about 42–43% of beekeepers, with 10% SC and 5% ST. About 53% earned ₹10,000–20,000 per year from beekeeping, 9% earned below ₹10,000 and 7% earned above ₹30,000.
- **Marketing:** About 42% of honey was sold directly to individuals and 33% in local markets, which the authors interpret as a sign of an inefficient and poorly organised market.
- **Technology:** 55% of beekeepers used traditional methods, 20% used modern hives with other methods, and 25% combined traditional and modern approaches; traditional practice was linked to older beekeepers.

3. Determinants of honey production

Descriptive statistics ($n = 30$) showed a mean of 4.07 years of experience, 4.63 boxes per family, 2.77 family members involved and mean honey production of 28.13 kg per year (Nayak *et al.*, 2025)^[39]. Honey production was strongly

correlated with the number of boxes ($r = 0.95$), experience ($r = 0.89$) and family members involved ($r = 0.68$). In regression, the number of boxes ($\beta = 4.36$, $p < 0.01$) and experience ($\beta = 1.54$, $p < 0.05$) were significant predictors, whereas the number of family members involved was not ($\beta = 0.22$, $p > 0.05$). The finding suggests that scale of operation and skill matter more than simply adding labour, consistent with earlier studies on experience and colony size cited by the authors. These results are drawn from a small sample in a single village, so generalisation should be cautious.

4. Profile and profitability of successful beekeepers: Muktsar, Punjab

Sharma and Dhaliwal (2014)^[48] studied the 28 beekeepers who continued in the enterprise out of 120 rural people trained in seven Krishi Vigyan Kendra (KVK) courses between 2006 and 2012, a continuation rate of roughly 23% (calculated from the reported figures). Most were young (67.8% aged 21–35), 67.8% had education up to matriculation, 82.1% belonged to the general category (7.2% scheduled caste and 10.7% backward classes), and 14.3% were landless and 17.9% marginal farmers. About 75% had farming as their main occupation, with beekeeping as a subsidiary activity, while 17.9% depended only on beekeeping, and 42.9% reported high extension contact with KVK scientists and horticulture officials. The authors read this as evidence that beekeeping can create self-employment for rural youth and for landless and marginal households, and they urge deliberate selection of scheduled caste and backward class trainees. Weak representation of scheduled groups is also apparent in Kadua (Nayak *et al.*, 2025)^[39].

Net returns rose steeply with enterprise. Average net income was about ₹50,000 for small enterprises (10–50 colonies), ₹1.68 lakh for medium enterprises (51–100 colonies) and ₹3.94 lakh for large enterprises (more than 100 colonies), and individual large operators earned from ₹1.95 lakh to ₹6.20 lakh. Dividing average net return by average colonies (calculated here) gives roughly ₹1,750, ₹2,000 and ₹2,050 per colony, so most of the gain from scale comes from managing more colonies rather than from higher returns per colony. Large enterprises received a lower average price (₹73.4 per kg) because all of them sold raw honey, whereas two small-scale beekeepers who processed honey before sale received higher prices (Sharma & Dhaliwal, 2014)^[48]. This is consistent with the regression finding from Odisha that the number of boxes is the strongest predictor of output (Nayak *et al.*, 2025)^[39].

5. Profitability at the hive level: Baramulla, Kashmir

Bano *et al.* (2025)^[9] estimated costs and returns per hive per year for 102 registered beekeepers in Baramulla. Total cost was ₹6,125.11, of which ₹4,521.98 was fixed cost (hive, nucleus colony, super, tools, stand and miscellaneous items) and ₹1,403.13 was variable cost, including imputed family labour. Returns of ₹9,000 came from 12 kg of honey sold at ₹550 per kg plus the sale of two colonies at ₹1,200 each, giving the reported benefit–cost ratio of 1.46. Sharma *et al.* (2013)^[47] similarly report profits of more than 40–50% on investment for private beekeepers in the state.

The mean of 28.13 kg per family from 4.63 boxes in Kadua (Nayak *et al.*, 2025)^[39] works out at roughly 6 kg per box (calculated). These studies use different methods, regions and years, so the comparison is only indicative, but it suggests that productivity gains, for example through migration and better management, may matter as much as

price for beekeeper incomes. Recalculating the Baramulla ratio from the table gives about 1.47, and the text of the same paper quotes 11 kg of honey and ₹1,050 per colony, which conflicts with the table (Section 7.4).

6. Gender and inclusion

Abrol (2023) ^[2] argues that women and children can efficiently manage honeybee colonies and that rural housewives can be brought into beekeeping as an additional income source, aided by microcredit and training. Manoj *et al.* (2023) ^[32] identify women entrepreneurs and tribal communities as beneficiaries of NBHM and KVIC schemes. The Odisha case study, however, shows a gender gap in participation (Nayak *et al.*, 2025) ^[39], which suggests that targeted training and access to inputs are still needed. Socio-cultural barriers also matter: beekeepers in Baramulla ranked pressure from family to quit beekeeping and the lack of support from established beekeepers for newcomers among their socio-cultural constraints (Bano *et al.*, 2023) ^[8].

7. Pricing and marketing

Abrol (2023) ^[2] reports that beekeepers usually sell to local markets or wholesalers, receiving only about 10–15% of the supermarket price (around USD 12.87 per kg), and that there is no fixed support price, so large stocks remain unsold when producers refuse low prices. Kishan Tej *et al.* (2017) ^[27] similarly note the absence of a separate honey market and the gap between producer and retail prices, and that southern Indian rubber honey often has high moisture content that blocks export. Nayak *et al.* (2025) ^[39] find direct sales and local markets dominant. Digital platforms (e.g., BeeZee, Agrimarket, Indiamart) are reported to be improving market linkage and training (Manoj *et al.*, 2023) ^[32].

Bano *et al.* (2025) ^[9] identified four honey marketing channels in Baramulla. Direct sale to consumers was used by 81.37% of beekeepers and gave the highest producer's share in the consumer's rupee (100%) and the highest marketing efficiency (9.23). Channels through retailers or through wholesalers and retailers gave producer shares of 81.54% and 76.92%, and sale to a village-level collector or processor gave the lowest share (58.33%; efficiency 2.23). All sales were local, and the authors recommend vigorous promotion of exports. This contrasts with the national picture, in which beekeepers are said to receive only 10–15% of the retail price (Abrol, 2023) ^[2], and suggests that the share captured by the producer depends heavily on the channel. One implication, offered here as an interpretation, is that direct sale suits small volumes but may not scale for large operators, who would need processing capacity and cooperatives. Sharma and Dhaliwal (2014) ^[48] likewise recommend that beekeepers take up processing and direct marketing to consumers.

Challenges

1. Pests, predators and diseases

Indian beekeeping is affected by a diverse complex of pests, predators and diseases. Important pests and predators include wax moths (*Galleria mellonella* and *Achroia grisella*), ants, wasps (*Vespa* spp.), bee-eating birds and other predators, while major health problems include Thai sacbrood virus, American and European foulbrood, *Nosema* infection and parasitic mites such as *Varroa*, *Acarapis woodi* and *Tropilaelaps clareae* (Kishan Tej *et al.*, 2017; Dwarka *et*

al., 2025) ^[21, 27]. Weak colonies, poor sanitation, inadequate inspection and movement of infested colonies can increase the risk and economic impact of these problems. Accordingly, routine colony inspection, hygienic management, quarantine of suspect colonies, maintenance of colony strength and integrated pest and disease management should be treated as core components of scientific beekeeping.

2. Diseases of Honey Bees and Their Management

Honeybee colonies are affected by bacterial, viral, microsporidian and mite-associated diseases. In India, Thai sacbrood virus, American foulbrood, European foulbrood and *Nosema* infections are among the health problems reported in beekeeping, together with parasitic mites such as *Varroa*, *Acarapis woodi* and *Tropilaelaps* (Kishan Tej *et al.*, 2017; Manoj *et al.*, 2023; Dwarka *et al.*, 2025) ^[21, 27, 32]. Disease pressure is influenced by colony strength, nutrition, sanitation, environmental stress and the movement of colonies between apiaries and floral locations. Migratory beekeeping can increase productivity but may also facilitate the movement of mites and diseases when colonies are moved without adequate health checks (Kishan Tej *et al.*, 2017) ^[27].

2.1 American foulbrood

American foulbrood is a serious brood disease associated with *Paenibacillus* larvae. Affected brood becomes discoloured and dies within capped cells, and persistent infection can weaken colonies. Management should emphasize early inspection of brood, hygienic colony management, removal and safe disposal of severely affected material, sanitation of equipment and prevention of movement of infected colonies. Maintaining strong colonies and avoiding exchange of contaminated combs or equipment are important preventive measures. Because the supplied sources primarily identify foulbrood as a major disease and emphasize hygienic and integrated management rather than providing a standardized treatment schedule, specific chemical treatment is not prescribed here (Kishan Tej *et al.*, 2017; Manoj *et al.*, 2023; Dwarka *et al.*, 2025) ^[21, 27, 32].

2.2 European foulbrood

European foulbrood is another important brood disease reported in Indian beekeeping. It is associated with *Melissococcus plutonius* and may be favoured when colonies are nutritionally or environmentally stressed. Management should focus on early detection, strengthening colonies through adequate nutrition, maintaining clean hive equipment, replacing heavily contaminated combs where necessary and restricting movement of suspect colonies. Hygienic management and regular inspection are therefore central to reducing disease build-up and transmission (Kishan Tej *et al.*, 2017; Abrol, 2023; Dwarka *et al.*, 2025) ^[2, 21, 27].

2.3 Thai sacbrood

Thai sacbrood is a viral brood disease that has been reported as a concern for *Apis cerana*. Abrol (2023) ^[2] links environmental degradation and colony stress with outbreaks of Thai sacbrood virus and European foulbrood in *A. cerana*. Since no curative antiviral treatment is described in the supplied sources, management should concentrate on

prevention and colony resilience: regular brood inspection, maintenance of strong colonies, adequate forage and nutrition, hygienic practices, removal of badly affected brood or combs where appropriate, and avoidance of unnecessary movement of affected colonies. Conservation of locally adapted *A. cerana* populations and reduction of environmental stress are also relevant long-term measures (Abrol, 2023; Manoj *et al.*, 2023)^[2, 32].

2.4 Nosemosis

Nosemosis is associated with microsporidian pathogens including *Nosema apis* and *Nosema ceranae*. *Nosema ceranae* has been reported in different honeybee species, including Asian honeybees, and is recognised as a colony-health concern (Chaimanee *et al.*, 2010; Fries, 2010)^[15, 23]. Management should emphasize good nutrition, clean and dry equipment, adequate ventilation, reduction of colony stress and regular monitoring of colony strength. Avoiding unnecessary movement of weak colonies and maintaining hygienic apiary conditions can reduce opportunities for disease spread. Where treatment is considered, the product and protocol should follow locally approved bee-health guidance rather than routine, unsupervised medication (Dwarka *et al.*, 2025)^[21].

2.5 General disease-management strategy

A practical disease-management programme should combine prevention, surveillance and rapid response. Colonies should be inspected regularly for abnormal brood, adult-bee symptoms, unusual mortality and declining colony strength. New colonies and colonies returning from migration should be checked before integration into an apiary. Old or contaminated comb should be replaced periodically, equipment should be cleaned, and colonies should receive adequate nutrition and ventilation. Weak colonies should be strengthened or otherwise managed before they become reservoirs for pests and disease. These measures are consistent with the integrated approach advocated in the supplied pest-management review, which emphasizes hygienic beekeeping, regular inspection and maintenance of strong colonies (Dwarka *et al.*, 2025)^[21].

3. Pests and Predators of Honey Bees and Their Management

Honeybee pests and predators can reduce colony strength, damage combs and brood, contaminate hive products and, in severe cases, cause colony absconding or collapse. The major groups relevant to Asian and Indian beekeeping include parasitic mites, small hive beetle, wax moths, ants, wasps, bee-eating birds and bee lice. Integrated pest management (IPM) should combine monitoring, hygienic and cultural practices, mechanical exclusion or trapping, biological methods where feasible and carefully selected chemical treatments when necessary (Dwarka *et al.*, 2025)^[21].

3.1 Varroa mites

Varroa destructor is an important ectoparasitic mite of *A. mellifera*. It feeds on adult bees and brood and can contribute to colony weakening and transmission of viral diseases such as deformed wing virus and acute bee paralysis virus. Because mites reproduce in capped brood, infestations may remain unnoticed until they become substantial (Anderson & Trueman, 2000; Dwarka *et al.*,

2025)^[6, 21]. Management should begin with regular monitoring, maintenance of strong and hygienic colonies and use of screened bottom boards or other mechanical approaches where appropriate. Chemical control options discussed in the supplied source include amitraz, fluvalinate, coumaphos, formic acid, oxalic acid and thymol; however, resistance and residue concerns mean that products should be used only according to locally approved labels and bee-health recommendations (Millán-Leiva *et al.*, 2021; Jack *et al.*, 2021; Dwarka *et al.*, 2025)^[21, 24, 37].

3.2 Tropilaelaps mites

Tropilaelaps spp. are brood-parasitic mites that reproduce rapidly and can cause brood mortality, deformed adults and colony decline. *T. clareae* and related species are important in Asian apiculture, and *Tropilaelaps* has been reported in association with several *Apis* species, including bees of the Himalayan region (Delfinado-Baker & Baker, 1982; Abrol & Putatunda, 1995; Anderson & Morgan, 2007)^[3, 5, 19]. Management relies on early detection, maintenance of strong colonies and integrated mite control. The supplied review reports that acaricides used against Varroa, including tau-fluvalinate, amitraz, formic acid and thymol, may also act against *Tropilaelaps*, but their use should follow approved recommendations and avoid residue problems (Dwarka *et al.*, 2025)^[21].

3.3 Acarapis and Euvarroa mites

Acarapis woodi is an internal tracheal mite of adult honeybees and has been reported from India, while *Acarapis dorsalis* and *A. externus* also parasitize honeybees but are considered less economically important (Michael, 1957; Milne, 1957; Dwarka *et al.*, 2025)^[21, 36, 38]. *Euvarroa sinhai* and *E. wongsirii* are associated with several Asian honeybee species, and *E. sinhai* has been reported from *A. florea* in India and other Asian countries. Management is based primarily on maintaining healthy colonies, monitoring infestations and integrating mite-management measures with broader colony-health practices (Dwarka *et al.*, 2025)^[21].

3.4 Small hive beetle

The small hive beetle, *Aethina tumida*, is an invasive and destructive pest in warm regions. Adults enter colonies and lay eggs in the hive; larvae feed on brood, pollen and honey and may cause honey fermentation and comb damage. Pupation occurs in soil, so environmental conditions around the apiary influence population development (Ellis *et al.*, 2004; Meikle & Diaz, 2012)^[22, 35]. Management should focus on strong colonies, regular inspection, sanitation, removal of heavily infested material, trapping of adult beetles and reduction of suitable pupation sites around the apiary. Entomopathogenic nematodes have also been investigated against the soil-dwelling pupal stage (Cabanillas & Elzen, 2006; Cuthbertson *et al.*, 2013; Dwarka *et al.*, 2025)^[13, 17, 21].

3.5 Wax moths

The greater wax moth (*Galleria mellonella*) and lesser wax moth (*Achroia grisella*) damage combs, particularly in weak colonies and stored or unused comb. Larvae tunnel through comb and consume wax, pollen and associated material, weakening comb structure and potentially damaging brood (Akranakul, 1990^[4]; Pernal & Clay, 2013). The main

management principle is to maintain strong colonies capable of defending their comb. Stored comb should be protected through regular inspection and appropriate storage; freezing empty comb is reported as a mechanical measure for killing wax moth eggs and larvae (Dwarka *et al.*, 2025)^[21].

3.6 Ants

Weaver ants, black ants, fire ants and other ant species may enter hives and remove honey, brood or wax. Severe infestations can disturb colonies and may contribute to absconding, particularly in weak colonies (Akranakul, 1990; Dwarka *et al.*, 2025)^[4, 21]. Management includes maintaining strong colonies, removing nearby ant nests where appropriate, keeping hive stands and surroundings clean, and using physical barriers such as moats or other exclusion measures to prevent ants from reaching hive entrances (Dwarka *et al.*, 2025)^[21].

3.7 Wasps and hornets

Vespa spp. are important predators of honeybees in Asia. Repeated attacks can reduce the foraging population and place severe stress on colonies. Honeybees themselves possess defensive behaviours, including body shaking and, in some species, formation of defensive balls around intruding wasps (Matsuura, 1988^[34]; Koeniger *et al.*, 1996; Dwarka *et al.*, 2025)^[21]. Beekeepers can reduce pressure by monitoring wasp activity, using suitable traps, reducing unnecessary hive entrances and removing nearby nests where this can be done safely and legally. Toxic baits are reported in the literature but require particular caution because non-target bees can be exposed (Dwarka *et al.*, 2025)^[21].

3.8 Bee-eating birds

Bee-eating birds, including bee-eaters and drongos, can prey on adult foraging bees and may become locally important around apiaries. The supplied review lists several bird groups associated with honeybee predation in Asia (Akranakul, 1990^[4]; Cervancia, 1993; Wongsiri *et al.*, 2005). Management should emphasize non-destructive deterrence and, where necessary, appropriate netting or relocation measures rather than indiscriminate killing of birds (Dwarka *et al.*, 2025)^[21].

3.9 Bee lice

Braula coeca is a wingless fly associated with honeybees. It is generally considered less economically important than major mite pests, although adults can take food from bees and the immature stages develop in comb material (Pernal & Clay, 2013; Kulincevic *et al.*, 1991)^[17, 29]. Control measures directed against parasitic mites may also suppress bee lice populations (Kulincevic *et al.*, 1991)^[29].

3.10 Integrated pest management

The pest-management evidence supports an IPM approach rather than dependence on a single control method. Eco-friendly management, habitat conservation and reduced pesticide dependence are essential for sustaining biodiversity in agriculture (Tarasing *et al.*, 2026)^[49]. Regular colony inspection, hygienic management, strong nutrition, replacement of old comb, screened bottom boards, trapping and physical exclusion are important cultural and mechanical measures. Biological approaches under investigation include entomopathogenic fungi against

Varroa and entomopathogenic nematodes against small hive beetle. Chemical control may be required for mites, but resistance, residue contamination and bee safety must be considered (Dwarka *et al.*, 2025; Millán-Leiva *et al.*, 2021)^[21, 37]. Migratory beekeeping requires additional vigilance because movement can spread mites and diseases between apiaries (Kishan Tej *et al.*, 2017)^[27]. Effective pest and disease management depends on timely identification, appropriate knowledge and targeted extension support (Bano *et al.*, 2026)^[10].

Indiscriminate pesticide use is repeatedly identified as a major threat. Kishan Tej *et al.* (2017)^[27] list effects including bee mortality, contaminated nectar, pollen and water, contaminated hive products, brood mortality and loss of weed flora through herbicides. In Kashmir's vegetable systems, there is a growing case for moving away from sole reliance on chemical pesticides towards Integrated Pest and Disease Management, which combines cultural, mechanical, biological and need-based chemical measures (Nazeer *et al.*, 2026)^[40]. They recommend that beekeepers keep colonies away from sprayed areas, confine bees during sprays and coordinate with farmers, and that farmers use the least hazardous chemicals, spray in the evening, avoid dusts in bloom and give advance notice to beekeepers. Manoj *et al.* (2023)^[32] report that neonicotinoids, organophosphates and similar compounds weaken immunity and foraging and may cause 15–20% colony damage in intensive regions. Agro-input companies and pollinator-friendly practices are proposed as part of the solution. Pesticide use should therefore be reduced to save honeybees, and biological control offers a safer option. For example, *Trichoderma viride* was the most effective bioagent *in vitro* against the bean anthracnose pathogen *Colletotrichum lindemuthianum*, inhibiting its mycelial growth by 69.44% (Wani *et al.*, 2024)^[51]. Effective management therefore requires integrated and environmentally responsible approaches that reduce pathogen and pest pressure while minimizing adverse effects on bees and the surrounding ecosystem (Wani *et al.*, 2024)^[51].

4. Habitat loss and climate change

Habitat loss through urbanisation, agricultural expansion and deforestation reduces forage and increases vulnerability to pests and disease (Abrol, 2023; Manoj *et al.*, 2023). Abrol (2023)^[2, 32] links stress from environmental degradation to outbreaks of Thai sacbrood virus and European foulbrood in *A. cerana*. Climate change alters flowering time and nectar availability; Manoj *et al.* (2023)^[32] mention shifts in flowering of 2–3 weeks in Punjab and projected honey losses of 15–20% over 10–20 years. Abrol (2023)^[2] also documents the decline of *A. cerana* across Asia as *A. mellifera* replaces it, and the decline of wild rock bee populations through forest loss, pesticides and honey hunting (Kishan Tej *et al.*, 2017)^[27]. Pollinator decline in general is attributed to habitat loss and fragmentation, land-management practices, agrochemicals, parasites and diseases, and alien species (Abrol, 2023)^[2]. Declining pollinator numbers also raise the risk of pollination limitation, which is thought to be in the range of 50–60% in rare plants and plants in fragmented habitats (Abrol, 2023)^[2]. In central India, deforestation and dependence on traditional honey hunting by tribal communities affect both the sustainability of wild harvesting and honey yields (Bhowate & Kumar, 2020; Manoj *et al.*, 2023)^[12, 32].

5. Adulteration, quality and trade barriers

Adulteration with sugar syrups and other substances undermines domestic and export markets; Manoj *et al.* (2023) ^[32] cite FSSAI estimates that over 30% of tested samples are adulterated. Antibiotic residues (tetracyclines, streptomycin) have led to bans in some export markets, traceability systems are weak, and India faces competition from low-cost Chinese honey (Manoj *et al.*, 2023). Kishan Tej *et al.* (2017) ^[27, 32] note that beekeepers have poor knowledge of international standards.

6. Institutional, economic and skill constraints

Kishan Tej *et al.* (2017) ^[27] list lack of trained personnel, high equipment and transport costs, interference from officials

during migration (reported by 37.5% of surveyed Punjab beekeepers), theft of hives, and low producer prices. Manoj *et al.* (2023) ^[32] add poor adoption of scientific practices and inadequate training infrastructure. Nayak *et al.* (2025) ^[39] show that many small beekeepers rely on traditional methods and unorganised local markets. Abrol (2023) ^[2] adds that most by-products remain unused because of limited technology and marketing. Studies from Jammu and Kashmir have reported that adoption of recommended agricultural practices often remains at a medium level, highlighting the need for strengthened extension services, farmer training and greater emphasis on recommended production practices (Bhat *et al.*, 2023) ^[8]. The main constraints and the responses proposed for them are summarised in Table 3.

Table 3: Summary of major constraints and proposed responses (synthesised from the eight sources)

Constraint	Evidence	Proposed responses
Pests and diseases	Wax moth, mites, foulbrood, sacbrood virus and <i>Nosema</i> (Kishan Tej <i>et al.</i> , 2017; Manoj <i>et al.</i> , 2023) ^[27, 32] ; second-ranked technical constraint in Baramulla (Bano <i>et al.</i> , 2023) ^[8]	Hygienic management, integrated pest and disease management, regional bee health centres, breeding for resistance, biological control
Pesticides	Bee kills and contaminated hive products (Kishan Tej <i>et al.</i> , 2017; Manoj <i>et al.</i> , 2023) ^[27, 32]	Farmer–beekeeper coordination, IPM, evening sprays, safer chemicals, moving hives
Habitat loss, forage shortage and climate change	Forage decline and flowering shifts (Abrol, 2023; Manoj <i>et al.</i> , 2023) ^[2, 32] ; forage shortage ranked first infrastructural constraint (Bano <i>et al.</i> , 2023) ^[8]	Bee-flora planting on forest and roadside land, public floral gardens, climate-resilient strains, conservation
Migration logistics	Migration ranked first technical constraint (Bano <i>et al.</i> , 2023) ^[8] ; official interference (Kishan Tej <i>et al.</i> , 2017) ^[27] ; limited support for small beekeepers (Sharma <i>et al.</i> , 2013) ^[47]	Licences for interstate movement, floral mapping and migration schedules, transport support
Marketing and pricing	Low share of retail price, no support price (Abrol, 2023) ^[2] ; local-only sales (Bano <i>et al.</i> , 2025) ^[9]	Direct marketing, cooperatives, e-commerce, support pricing, export and domestic promotion
Post-harvest infrastructure and quality	Lack of processing units ranked first post-harvest constraint (Bano <i>et al.</i> , 2023) ^[8] ; adulteration and residues (Manoj <i>et al.</i> , 2023) ^[32]	Processing units, sealed-comb extraction with moisture below 20%, certification, traceability
Skills and adoption	Only 20–25% use modern methods (Manoj <i>et al.</i> , 2023) ^[32] ; extension contact varies (Sharma & Dhaliwal, 2014) ^[48]	Free targeted training in local language, KVK extension, demonstrations
Costs and finance	Equipment and transport costs (Kishan Tej <i>et al.</i> , 2017) ^[27] ; equipment cost and insufficient subsidy ranked top economic constraints (Bano <i>et al.</i> , 2023) ^[8]	Subsidies, microcredit, colony insurance
Social inclusion	Low participation of women (Nayak <i>et al.</i> , 2025) ^[39] and scheduled castes (Sharma & Dhaliwal, 2014) ^[48] ; family pressure and lack of peer support (Bano <i>et al.</i> , 2023) ^[8]	Targeted training, peer mentoring, women-focused schemes

Research priorities

Priority areas across the sources are:

- 1. Climate-resilient bee strains and genetic conservation:** Selective breeding of *A. cerana* and *A. mellifera* for heat and cold tolerance, disease resistance and productivity, and conservation of genetic diversity in native *A. cerana* (Abrol, 2023; Manoj *et al.*, 2023) ^[2, 32].
- 2. Native and stingless bees:** Stingless bees are easy to handle, need little care and suit small-flowered crops, yet are neglected in India (Abrol, 2023) ^[2]. Native bees may reduce reliance on imported colonies (Manoj *et al.*, 2023) ^[32].
- 3. Integrated beekeeping–agriculture models:** Combining beekeeping with crops such as ginger and turmeric or with value chains is reported to raise farm income by 15–30% in some regions (Manoj *et al.*, 2023) ^[32].
- 4. Specialised honeybee research centres:** across the country and recognition of beekeeping as an agricultural input (Abrol, 2023) ^[2].

- 5. Floral mapping and migration schedules:** for each beekeeping region, building on the migration routes documented for Jammu and Kashmir (Sharma *et al.*, 2013) ^[47].

- 6. Future diversification of rural:** bioresource-based enterprises may also consider nutraceutical applications of locally available macrofungi, particularly species exhibiting strong antioxidant activity, thereby creating additional opportunities for value addition and livelihood development (Wani *et al.*, 2025) ^[9].

- 7. Post-harvest and marketing research,** including processing, sealed-comb extraction, floral-source honeys, and the scalability of direct-marketing channels (Bano *et al.*, 2025; Sharma & Dhaliwal, 2014) ^[9, 48].

Recommendations

Drawing the sources together, the following actions emerge:

- Recognition and inputs:** Recognise beekeeping as an agro-industry with priority access to timber, sugar and medicines, and provide better-quality hives, medicines and colony insurance.

- **Training and extension:** Expand free, hands-on, local-language training, including for remote areas and women, and deliberately select trainees from scheduled and backward groups.
- **Forage and pesticides:** Plant bee flora on forest, roadside and public land and promote farmer–beekeeper coordination on pesticide use.
- **Migration:** Ease interstate movement through licences and support scientifically planned migration.
- **Processing and marketing:** Establish processing units, cooperatives and credit for small beekeepers, encourage direct sale and small sachets, and promote domestic consumption and exports.
- **Quality and brand:** Maintain quality standards, certification and traceability, and create a national honey brand for exports.
- **Feeding and diversification:** Support artificial feeding during dearth periods and diversify into wax, pollen, propolis and floral-source honeys.

Conclusion

The available literature portrays Indian beekeeping as a sector with substantial biological, ecological and socio-economic potential, but with considerable scope for strengthening scientific management. India's floral diversity, native and introduced honeybee species, migratory opportunities and expanding pollination and value-addition markets provide a strong foundation for development. At the same time, pests, diseases, pesticide exposure, forage loss, climate variability, migration costs, weak processing and marketing systems and limited access to technical support continue to constrain productivity. The evidence reviewed here indicates that bee health should be integrated more explicitly into beekeeping development through regular surveillance, hygienic colony management, quarantine and responsible movement, integrated pest management and improved farmer–beekeeper coordination. Future programmes should also strengthen conservation of native bees, floral-resource mapping, scientific migration, quality assurance, value addition, digital extension and reliable production statistics. A coordinated approach linking research, extension, beekeepers, farmers and institutions can support more resilient and sustainable beekeeping in India.

References

1. Abrol DP. Honeybees and rapeseed: A pollinator–plant interaction. *Advances in Botanical Research*,2007;45:337–367. [https://doi.org/10.1016/S0065-2296\(07\)45012-1](https://doi.org/10.1016/S0065-2296(07)45012-1)
2. Abrol DP. Beekeeping for sustainable economic development of India: Challenges and opportunities. *Journal of the Indian Institute of Science*,2023;103:997–1017. <https://doi.org/10.1007/s41745-023-00374-9>
3. Abrol DP, Putatunda BN. Discovery of an ectoparasitic mite *Tropilaelaps koenigerum* Delfinado, Baker & Baker on *Apis dorsata*, *Apis mellifera* L. and *Apis cerana* F. in Jammu and Kashmir, India. *Current Science*,1995;68:90.
4. Akwatanakul P. Beekeeping in Asia. Food and Agriculture Organization of the United Nations, Agricultural Services Bulletin 68/4. Rome, Italy, 1990.
5. Anderson DL, Morgan MJ. Genetic and morphological variation of bee-parasitic *Tropilaelaps* mites (Acari: Laelapidae): New and re-defined species. *Experimental and Applied Acarology*,2007;43:1–24.
6. Anderson DL, Trueman JWH. *Varroa jacobsoni* (Acari: Varroidae) is more than one species. *Experimental and Applied Acarology*,2000;24:165–189.
7. Bano A, Bhat SH, Kubrevi SS, Irshad SS, Nabi F, Ali J, *et al.* Indian agriculture during COVID-19: A brief review of impact and recovery. *The Pharma Innovation Journal*,2022: SP-11(6):2826–2829.
8. Bano A, Bhat SH, Kubrevi SS, Mir SH, Saraf SA, Wani FJ, *et al.* Assessing constraints perceived by the beekeepers of North-Western Himalayas using Garrett's ranking technique. *Journal of Community Mobilization and Sustainable Development*,2023;18(4):1278–1282. <https://doi.org/10.5958/2231-6736.2023.00092.3>
9. Bano A, Bhat SH, Saraf SA, Wani FJ, Nabi F, Rafiq A, *et al.* Marketing scenario and profitability of beekeeping in district Baramulla, Jammu and Kashmir. *Journal of Community Mobilization and Sustainable Development*,2025;20(1):321–325. <https://doi.org/10.5958/2231-6736.2025.00050.2>
10. Bano A, Kaur R, Garg L, Rampal VK, Peshin R. Knowledge of vegetable growers in identifying pests affecting vegetable crops in Punjab and the Kashmir Valley. *Journal of Community Mobilization and Sustainable Development*,2026;21(2):499–505. <https://doi.org/10.5958/2231-6736.2026.00071.2>
11. Bhat S, Tomar A, Farhana, Bano A. A study on adoption of recommended package of practices by paddy growers in district Baramulla. *Journal of Community Mobilization and Sustainable Development*,2023;18(3):855–860. <https://doi.org/10.5958/2231-6736.2023.00022.4>
12. Bhowate S, Kumar P. Ethnoentomological practices by tribes and rurals of Satpura plateau of Madhya Pradesh, India. *Journal of Entomology and Zoology Studies*,2020;8(2):833–837.
13. Cabanillas HE, Elzen PJ. Infectivity of entomopathogenic nematodes (*Steinernematidae* and *Heterorhabditidae*) against the small hive beetle *Aethina tumida* (Coleoptera: Nitidulidae). *Journal of Apicultural Research*,2006;45:49–50.
14. Chahal BS, Brar HS, Gatoria GS, Jhaji HS. Italian honeybees and their management. Punjab Agricultural University, 1995.
15. Chaimanee V, Warrit N, Chantawannakul P. Infections of *Nosema ceranae* in four different honeybee species. *Journal of Invertebrate Pathology*,2010;105:207–210.
16. Chaudhary OP, Chand R. Economic benefits of animal pollination to Indian agriculture. *Indian Journal of Agricultural Sciences*,2017;87(9):1117–1138. <https://doi.org/10.56093/ijas.v87i9.73903>
17. Cuthbertson AGS, Wakefield ME, Powell ME, Marris G, Anderson H, Budge GE, *et al.* The small hive beetle *Aethina tumida*: A review of its biology and control measures. *Current Zoology*,2013;59:644–653.

18. de Guzman LI, Frake AM. Temperature affects *Aethina tumida* (Coleoptera: Nitidulidae) development. *Journal of Apicultural Research*,2007;46:88–93.
19. Delfinado-Baker M, Baker EW. A new species of *Tropilaelaps* parasitic on honey bees. *American Bee Journal*,1982;122:416–417.
20. Dwarka, Ahirwar MK, Sahu BL, Chadar N. Madhumakkhi palan ki pramukh samasyaye: keet va rog. Technical bulletin, 2024. ISBN 9789334094817.
21. Dwarka S, Ghugal SG, Thakur S, Chadar N. Pest and disease of honeybee and their control strategies: A review. *Journal of Global Agriculture and Ecology*,2025;17(1):9–21.
<https://doi.org/10.56557/jogae/2025/v17i19044>
22. Ellis JD, Hepburn R, Luckman B, Elzen PJ. Effects of soil type, moisture, and density on pupation success of *Aethina tumida* (Coleoptera: Nitidulidae). *Environmental Entomology*,2004;33:794–798.
23. Fries I. *Nosema ceranae* in European honey bees (*Apis mellifera*). *Journal of Invertebrate Pathology*,2010;103: 73–S79.
24. Jack CJ, Ellis JD. Integrated pest management control of *Varroa destructor* (Acari: Varroidae), the most damaging pest of *Apis mellifera* L. (Hymenoptera: Apidae) colonies. *Journal of Insect Science*,2021;21(5):6.
<https://doi.org/10.1093/jisesa/ieab058>
25. Jack CJ, Kleckner K, Demares F, Rault LC, Anderson TD, Carlier PR, *et al.* Testing new compounds for efficacy against *Varroa destructor* and safety to honey bees (*Apis mellifera*). *Pest Management Science*,2021.
<https://doi.org/10.1002/ps.6617>
26. Jamwal S, Sharma N, Dhiman A, Kumari S. Current status and future strategies to increase honey production in India. In: *Honey*, CRC Press,2021:191–206.
<https://doi.org/10.1201/9781003175964-8>
27. Kishan Tej M, Aruna R, Mishra G, Srinivasan MR. Beekeeping in India. In: Omkar, editor. *Industrial entomology*. Springer Nature Singapore,2017:35–66.
https://doi.org/10.1007/978-981-10-3304-9_3
28. Kour A, Bhat R, Bishnoi C, Gupta N. Flowering, pollination and fruit set. In: *Apples*. CRC Press,2022:71–84.
29. Kulincevic JM, Rinderer TE, Mladjan VJ. Effects of fluralinate and amitraz on bee lice (*Braula coeca* Nitzsch) in honey bee (*Apis mellifera* L.) colonies in Yugoslavia. *Apidologie*,1991;22:43–47.
30. Kumar R, Kumar V. Impact of pollination by European honey bee, *Apis mellifera* L. on the yield and quality of litchi (*Litchi chinensis* Sonn.) fruits in India. *Pest Management in Horticultural Ecosystems*,2014;20(2):127–132.
31. Lata P, Prasad S, Gupta G. Artificial diet alternatives or supplements for healthy honey beekeeping. *Current Journal of Applied Science and Technology*,2023;42(46):91–100.
<https://doi.org/10.9734/cjast/2023/v42i464298>
32. Manoj MS, Sharma P, Ranjitha SM, Paschapur AU. Current scenario of beekeeping and honey production in India. *Hexapoda, Insecta Indica*,2023;30(1&2):43–55. <https://doi.org/10.55446/hexa.2023.591>
33. Marín-García PJ, Peyre Y, Ahuir-Baraja AE, Garijo MM, Llobat L. The role of *Nosema ceranae* (Microsporidia: Nosematidae) in honey bee colony losses and current insights on treatment. *Veterinary Sciences*,2022;9(3):130.
<https://doi.org/10.3390/vetsci9030130>
34. Matsuura M. Ecological studies on vespine wasps (Hymenoptera: Vespidae) attacking honeybee colonies. *Applied Entomology and Zoology*,1988;23:428–440.
35. Meikle WG, Diaz R. Factors affecting pupation success of the small hive beetle, *Aethina tumida*. *Journal of Insect Science*,2012;12.
<https://doi.org/10.1673/031.012.11801>
36. Michael DS. Acarine disease found in India. *American Bee Journal*,1957;97:107.
37. Millán-Leiva A, Marín O, Christmon K, vanEngelsdorp D, Gonzalez-Cabrera J. Mutations associated with pyrethroid resistance in *Varroa* mite, a parasite of honey bees, are widespread across the United States. *Pest Management Science*,2021;77:3241–3249.
38. Milne PS. Acarine disease in *Apis indica*. *Bee World*,1957;38:156.
39. Nayak J, Mohanty L, Saha G, Panda AK, Devi M. Socio-economic status and opportunities of beekeeping for farm women: A case study. *Indian Journal of Entomology*,2025;87(1):119–122.
<https://doi.org/10.55446/IJE.2024.2448>
40. Nazeer A, Irshad SS, Jagdey SS, Bashir T, Wani DM, Khatoon M, *et al.* Reframing vegetable crop protection in Kashmir Valley: Integrated pest and disease management for sustainable intensification. *International Journal of Agriculture and Plant Science*,2026;8(3):504–511.
41. Neumann P, Elzen PJ. The biology of the small hive beetle (*Aethina tumida*, Coleoptera: Nitidulidae): Gaps in our knowledge of an invasive species. *Apidologie*,2004;35:229–247.
42. Otis GW. Distributions of recently recognized species of honey bees (Hymenoptera: Apidae, *Apis*) in Asia. *Journal of the Kansas Entomological Society*,1997;69(Suppl.):311–333.
43. Partap U, Verma LR. Pollination of radish by *Apis cerana*. *Journal of Apicultural Research*,1994;33:237–241.
44. Paschapur AU, Bhat S, Subbanna ARN S, Hedau NK, Mishra KK, Kant L. Insect pollinators of eggplant (*Solanum melongena* L.) in the Indian Himalayas and their role in enhancement of fruit quality and yield. *Arthropod-Plant Interactions*,2022;16(3):349–360.
<https://doi.org/10.1007/s11829-022-09902-3>
45. Rashid M, Wani SQ, Bhat ZA, Shah M-UD, Mir MM, Khan I, *et al.* Multiple associations of *Alternaria* species on high density apple (*Malus × domestica*) plantation system in Jammu and Kashmir, India. *Indian Journal of Agricultural Sciences*,2025;95(8):989–995.
<https://doi.org/10.56093/ijas.v95i8.155250>
46. Ruttner F. *Biogeography and taxonomy of honeybees*. Springer,1988.
47. Sharma D, Abrol DP, Ahmad H, Srivastva K, Vir V. Migratory beekeeping in Jammu and Kashmir, India. *Bee World*,2013:44–47.
<https://doi.org/10.1080/0005772X.2013.11417535>
48. Sharma K, Dhaliwal NS. Socio economic profile of successful beekeepers and profitability of bee keeping in Muktsar district of Punjab. *Journal of Krishi Vigyan*,2014;2(2):69–73.

49. Tarasing PS, Yousuf A, Dar SA, Nazeer A, Gani M, Bali K. Eco-Friendly Strategies for Vineyard Pest Suppression: Understanding Factors Limiting Natural Enemy Performance. *Uttar Pradesh Journal of Zoology*,2026;47(8):57–77.
50. Traynor KS, Mondet F, de Miranda JR, Techer M, Kowallik V, Oddie MAY, *et al.* Varroa destructor: A complex parasite, crippling honey bees worldwide. *Trends in Parasitology*,2020;36(7):592–606. <https://doi.org/10.1016/j.pt.2020.04.004>
51. Wani SQ, Mughal NM, Bhat ZA, Bashir S, Bhat MA, Muneer K, *et al.* Phytomelatonin: A bioactive compound, its detection and role in growth and biotic stress management in plants. *Frontiers in Crop Improvement*,2024;12(Special Issue-II):799–808.
52. Wani SQ, Wani TA, Bhat MAA, Gulzar G, Muneer K, Malik SA, *et al.* *In vitro* assessment of fungicides and plant extracts against common bean anthracnose incitant. *Journal of Community Mobilization and Sustainable Development*,2024;19(3):744–750. <https://doi.org/10.5958/2231-6736.2024.00167.6>
53. Wani SQ, Wani TA, Gulzar G, Ali J, Muneer K, Malik S, *et al.* Integrated management of anthracnose of common beans (*Phaseolus vulgaris* L.) amidst temperate conditions of Kashmir valley. *Journal of Community Mobilization and Sustainable Development*,2025;20(2):386–396. <https://doi.org/10.5958/2231-6736.2025.00104.0>
54. Wani SQ, Wani TA, Gulzar G, Muneer K, Mansoor T, Malik SA, *et al.* Morphological characterisation of *Colletotrichum lindemuthianum* and *in vitro* efficacy of bioagents: Insights from dual culture method. *International Journal of Advanced Biochemistry Research*,2024;8(5):907–913. <https://doi.org/10.33545/26174693.2024.v8.i5k.1217>
55. Wani SQ, Bhat MA, Bhat ZA, Zargar SM, Murtaza I, Ara S, *et al.* Elucidation of antioxidant competence in macrofungal solvent extracts via reducing power assay. *Plant Archives*,2025;25(2):1579–1583. <https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.229>
56. Yadav S, Kumar Y, Jat BL. Honeybee: Diversity, castes and life cycle. In: Omkar, editor. *Industrial entomology*. Springer,2017:5–34. https://doi.org/10.1007/978-981-10-3304-9_2