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Beekeeping potential and floral resource availability in Bangladesh: an ecosystem-based approach

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Abstract

Beekeeping plays an important role in agricultural productivity, biodiversity conservation, and rural livelihoods through pollination services and honey production. Bangladesh possesses substantial potential for sustainable apiculture because of its diverse agro-ecological conditions and seasonally varied bee-flora resources. This review assesses the potential for beekeeping and the availability of bee-forage resources across three major ecosystems of Bangladesh: homestead gardens, agricultural landscapes, and forest ecosystems**.** Information on major nectar and pollen-producing plants was synthesized from published literature, government statistics, institutional reports, and other relevant sources. Homestead gardens provide diverse floral resources throughout the year through fruit trees, vegetables, ornamentals, and medicinal plants, supporting backyard and small-scale beekeeping. Agricultural landscapes provide important seasonal forage through mass-flowering crops such as mustard, sesame, black cumin, sunflower, litchi, jujube, mango, and pulse crops. Forest ecosystems, particularly the Sundarbans and deciduous forests provide diverse bee flora that supports migratory beekeeping and specialty honey production. These ecosystems also contribute to crop pollination, biodiversity conservation, and ecosystem functioning. However, habitat loss, indiscriminate pesticide use, seasonal forage gaps, pests and diseases, climate change, and limited technical knowledge constrain the sustainable development of apiculture. The review highlights the need for ecosystem-based beekeeping strategies, conservation of diverse floral resources, pollinator-friendly agricultural practices, and improved farmer-beekeeper collaboration**.** Strengthening extension services, research, and policy support could enhance honey production, pollination services, rural livelihoods, and the overall sustainability of apiculture in Bangladesh.

Keywords: Agroforestry, apiculture, Bangladesh, crops, home garden, mangrove.

Introduction

Beekeeping is an ecologically sustainable agricultural practice that connects rural livelihoods, agricultural productivity, biodiversity conservation, and ecosystem functioning. Honeybees produce commercially valuable products, including honey, beeswax, pollen, propolis, royal jelly, and bee venom, while providing the essential ecosystem service of pollination. Although insect-pollinated crops contribute substantially to global food production, approximately 75% of the leading global food crops benefit from animal pollination, with managed honeybees and wild bees serving as major pollinators of agricultural crops (Klein *et al.* 2007).

Bangladesh possesses favorable ecological and climatic conditions for apiculture because of its tropical and subtropical climate, fertile agricultural lands, diverse cropping systems, homestead gardens, orchards, forests, wetlands, and mangrove ecosystems. These habitats provide bees with nectar, pollen, resin, and nesting resources throughout the year. Important bee-forage plants include mustard, sesame, litchi, mango, and numerous cultivated, wild, and forest species. The Sundarbans also represents an important natural honey-producing ecosystem, where diverse mangrove vegetation provides forage and nesting opportunities for wild honeybees, particularly *Apis dorsata* (Islam *et al.* 2012).

The availability, diversity, and seasonal continuity of floral resources are critical determinants of colony survival, population development, and honey production. However, floral resources vary considerably with season and geographic location. Periods of forage scarcity may weaken colonies, reduce brood production, and increase dependence on supplemental feeding. At the same time, the diversity of floral sources contributes to variation in the physicochemical and antioxidant properties of Bangladeshi honey. Islam *et al.* (2012) reported considerable variation among monofloral and multifloral honeys from different

regions of Bangladesh, while Karki *et al.* (2024) demonstrated the value of melissopalynological analysis for determining the botanical and geographical origins of honey. Thus, documenting pollen and nectar sources is important for apiary management, honey authentication, geographical branding, product differentiation, and development of premium monofloral honey markets.

Despite its considerable potential, the beekeeping sector of Bangladesh faces several constraints, including inadequate technical training, limited access to improved equipment and quality colonies, weak processing and marketing facilities, insufficient knowledge of flowering periods, and challenges related to pest and disease management. Indiscriminate pesticide use is an additional concern because bees may be exposed through contaminated pollen, nectar, water, and treated plant surfaces. Jahan *et al.* (2021) identified pesticide use, inadequate training, limited modern technology, and poor marketing as major barriers to apiculture development, while Mostakim *et al.* (2025) highlighted the adverse effects of pesticide exposure on bee health, colony performance, and pollination services.

Therefore, sustainable development of apiculture in Bangladesh requires an ecosystem-based approach that considers bee colonies, wild pollinators, floral resources, agricultural systems, forests, wetlands, pesticide use, and rural communities as interconnected components. Mapping regional floral resources, developing seasonal flowering calendars, conserving natural vegetation, promoting diverse bee-forage plants, establishing pesticide-safe apiary areas, implementing integrated pest management (IPM), and strengthening collaboration among farmers, beekeepers, researchers, and government agencies could enhance the sustainability of the sector. Accordingly, assessing the diversity, availability, and seasonal continuity of floral resources can provide a scientific basis for improving honey production, supporting crop pollination, strengthening rural livelihoods, and conserving agroecosystem biodiversity in Bangladesh.

Present scenario of Apiculture and honey production in Bangladesh

The beekeeping industry in Bangladesh is currently characterized by a blend of traditional and advanced beekeeping techniques. According to a recent study, the industry employs over 25000 beekeepers who produce approximately 12000 metric tons of honey annually, against a national demand of 30000 metric tons (Roy *et al.* 2025). They also estimated that Bangladesh could produce

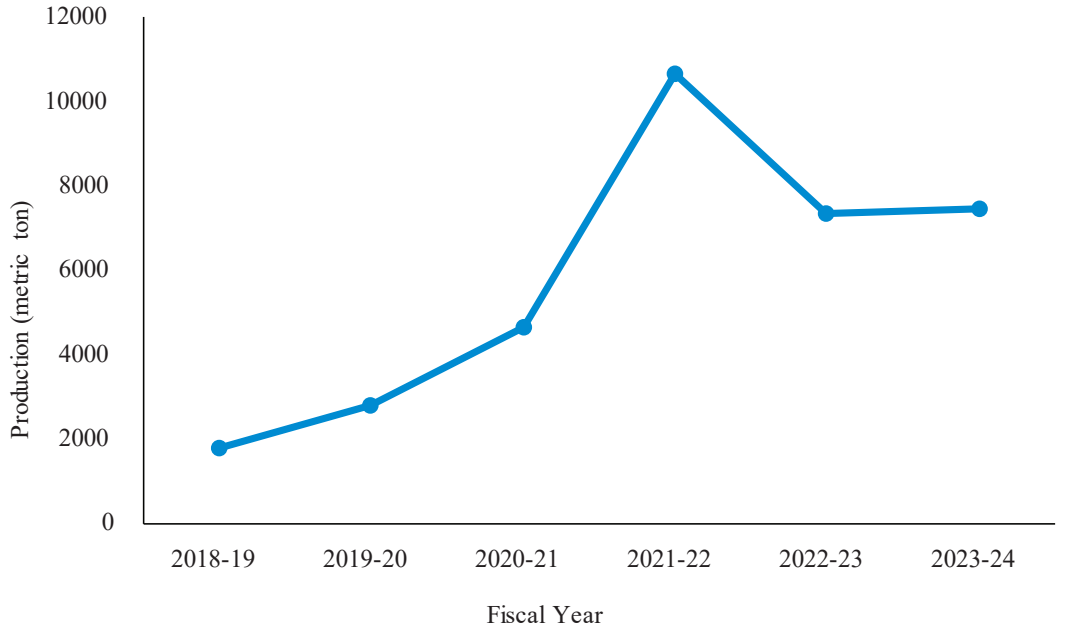


Figure 1. Trends in honey production in Bangladesh during the 2018-19 to 2023-24 fiscal years.

up to 100000 metric tons of honey annually by developing adequate infrastructure, modern beekeeping facilities, and training and employment opportunities for young people. On the other hand, according to a recent report given at the 5th National Bee and Honey Conference, between 20000 and 25000 tons of honey were collected in 2024, of which 90-95% were said to come from cultivated sources (The Business Standard 2025). The Figure 1 shows the trend in annual honey production in Bangladesh from 2018 to 2024. This indicates a strong upward trend in honey production in Bangladesh from 2018-19 to 2021-22, followed by a decline in 2022-23 and relative stabilization thereafter (BBS, 2018–2024). Although the sector has considerable potential for further growth, its long-term development will depend on effectively utilizing the country's abundant floral resources through a resilient, scientifically managed, and ecosystem-based beekeeping system.

Season of honey production in Bangladesh

The production of honey is solely dependent on the seasonal blossoming of plants. Migratory beekeeping is practiced by commercial apiculturists. In order to gather honey, they relocate their hives throughout the year to various locations. However, accurate data on the spatial distribution, length of flowering, and carrying capacity of floral resources are necessary for a sustainable migration. The peak season of year for open-field apiculture in Bangladesh is the winter.

Beekeeping as a source of rural income and economic resilience

Beekeeping can provide an average annual household income of approximately BDT 20000-30000, making it particularly valuable for rural communities affected by poverty in Bangladesh. The additional income can reduce household financial vulnerability and enhance resilience to external shocks, including crop losses and market price fluctuations. Moreover, as beekeeping requires relatively limited physical labor and can be practiced close to the household, it offers women an opportunity to contribute to family income while maintaining their domestic responsibilities.

International trade and market potential of Bangladeshi honey

Bangladesh is currently a net importer of natural honey in international trade. According to World Integrated Trade Solutions (WITS), imports of natural honey increased from about 658.8 tons from India in 2023 to 1006.8 tons in 2024**.** The import value also increased from approximately US$1.23 million to US$1.89 million during this period. In comparison, Bangladesh exported only about 48 tons of natural honey in 2024, with Japan being the main export destination (World Bank 2026a, 2026b). According to FAO (2025), Figure 2 presents the import and export quantities of natural honey in Bangladesh from 2020 to 2024. Throughout this period, Bangladesh consistently imported substantially larger quantities of natural honey than it exported. Imports were approximately 1200 tons in 2020, followed by a decline in 2023, before increasing again to 1129.8 tons in 2024. In contrast, honey exports remained considerably lower, at approximately 170 tons in 2020 and a similar level in 2021, followed by an increase in 2022. Exports subsequently declined to approximately 96.87 tons in 2023 and 47.86 tons in 2024.

Figure 3 illustrates the baseline pricing for the import and export value of natural honey from 2020 to 2024. According to FAO (2025), imports of natural honey into Bangladesh totaled more than USD 3000 thousand in 2020, whereas exports amounted to approximately USD 300 thousand. In

Table 1. Seasonal floral resources and their significance for honey production in Bangladesh

Season	Major floral resources	Significance
Winter (December-February)	Mustard and other winter crops	Honey-flow
Spring (February-April)	Litchi, mango, fruit trees	Floral-resources
Late spring-summer (April–June)	Khalshi, Goran, Keora, Baen, Gewa, Kankra	Sundarbans honey-flow
Late monsoon-autumn (July-November)	Various scattered agricultural, homestead and wild flora	Scattered honey flow

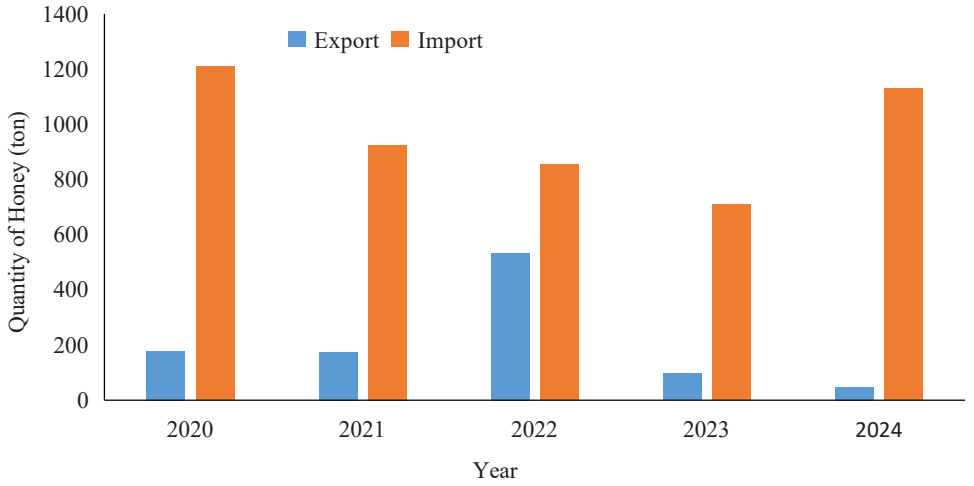


Figure 2. Trends in the export and import quantities of natural honey in Bangladesh, 2020–2024.

2021, the value of honey imports decreased slightly to USD 2.703 million, but remained significantly higher than the value of exports. In 2022, exports increased substantially to USD 996000, representing the strongest export performance during the period, while imports declined further to USD 2.404 million. However, both import and export values decreased in 2023. In 2024, honey exports remained low at approximately USD 118000, whereas imports increased again to USD 2.619 million. The substantial gap between imports and exports suggests that domestic honey production remains insufficient to meet national demand, resulting in Bangladesh's heavy reliance on imported natural honey. The figure also highlights fluctuations in the international honey trade, with imports consistently exceeding exports and exports remaining relatively limited. This persistent trade imbalance indicates considerable scope for Bangladesh to strengthen honey quality, processing, certification, packaging, and access to international markets.

Bee-assisted pollination improves productivity

Bee-mediated pollination promotes effective fertilization and can enhance seed productivity and oil content while contributing to improved commercial shelf life and reduced post-harvest losses. Hossain *et al.* (2020) reported that honey bee pollination significantly enhanced crop production. In case of Table 2, cabbage exhibited the highest increases, whereas lettuce showed the lowest overall response. Across the vegetable crops, pod



Figure 3. Export and import values of natural honey in Bangladesh during 2020 to 2024.

Table 2. Effects of honey bee pollination on crop productivity and quality

Crop	Pod formation (%)	Seed set (%)	Seed weight (%)
Cabbage	28	35	40
Cauliflower	24	34	37
Radish	23	24	34
Lettuce	12	21	9
Vegetable crops	12-28	21-35	9-40
Mustard	14	11	15

formation, seed set, and seed weight increased respectively. In mustard, honey bee pollination increased these traits by 14%, 11%, and 15%**,** respectively, highlighting the important contribution of honey bees to crop productivity.

Assessment of floral resource availability in Bangladesh

Nectar: Nectar is the primary source of simple sugars and daily energy for honey bees. Constant sugar intake is necessary for movement, nest defense, and body heat production within the hive. By draining the water content, bees convert excess nectar into honey. Leucas, sisso, jujube, palash, mustard, mango, guava, sesame, and litchi are important sources of nectar. Among these, mustard is a key component in nectar production.

According to the Agricultural Wing of the Bangladesh Bureau of Statistics (2018-2025), Figure 4 illustrates a clear upward trend in rapeseed and mustard production, with the highest production recorded in 2024-25. This trend indicates strong potential for integrating mustard cultivation with commercial beekeeping. The expansion of mustard-growing areas can provide abundant floral resources for honey bees, support stronger and more productive colonies, and consequently enhance the production of mustard honey.

The percentage distribution of production among six nectar-source crops during the 2024-2025 fiscal year is shown in Figure 5. Mango was the most important nectar-source crop, accounting for 74% of the total with a production number of 1,872 thousand metric tons. Guava came in second place with 266.4 thousand MT, or 10% of the total. Lentils produced 168.12 thousand MT, approximately 7% of the total. About 4% of the overall

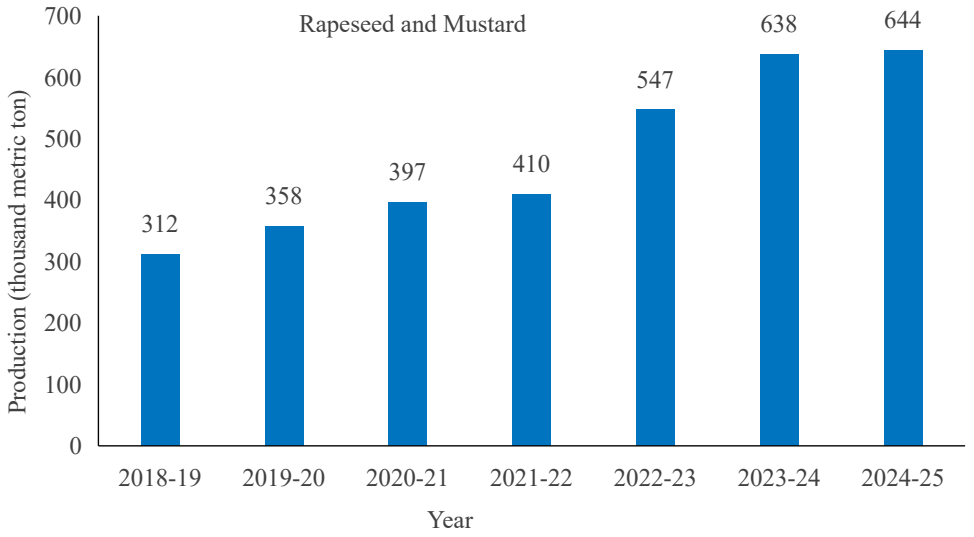


Figure 4. Production trends of major nectar-source crops in Bangladesh.

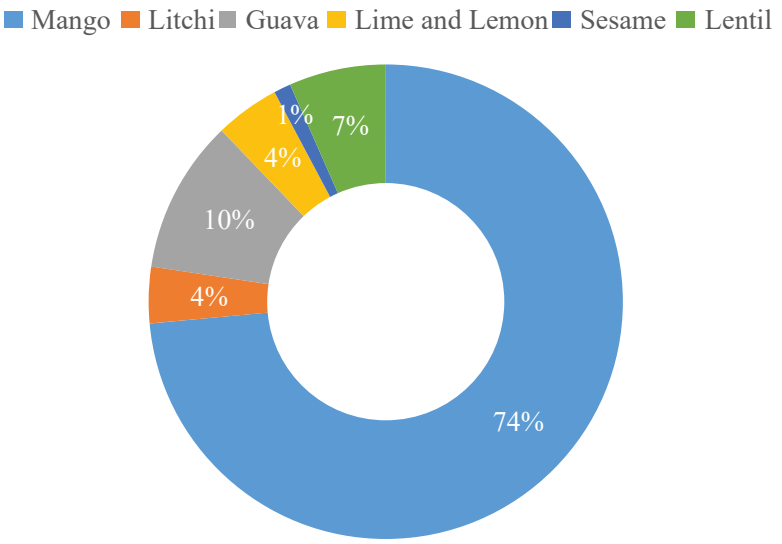


Figure 5. Proportional distribution of major pollinator-friendly crops in Bangladesh during 2024-2025.

production was made up of litchi, lime, and lemon. Sesame, on the other hand, produced the least amount-just 1% of the total. As a result, the production of nectar-source crops in 2024-2025 concentrated primarily in mango, which produced about three-quarters of the total. The dominating share of mangoes indicates a particularly good seasonal opportunity to locate managed colonies close to important mango-growing regions.

Pollen: It is the primary source of protein, fats, vitamins, and minerals which are required for larval development. Nutrients from pollen help bees make wax and royal jelly, feed the queen, and build strong bodies to live longer. Important pollen resources are sorghum, sweet potato, maize, tobacco, and coconut.

In Bangladesh, the production of a number of home garden crops that produce nectar and pollen has gradually increased. Growing yields of crops like tomatoes, cucumbers, onions, and pumpkins may help sustain honey bee populations and improve apicultural practices. Among the chosen crops in Figure 6, onions demonstrated the maximum output, according to BBS (2025). Its steady rise suggests that onion blossoms are becoming more accessible as a possible supply of nectar and pollen during the flowering season.

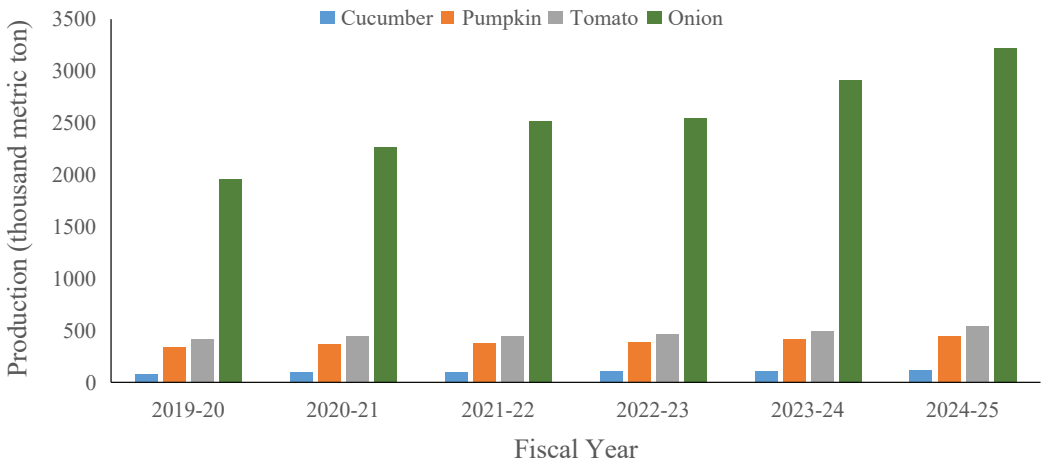


Figure 6. Production trends of nectar- and pollen-producing home garden plants in Bangladesh, 2019-2020 to 2024-2025.

Beekeeping and land restoration

Land degradation destroys floral diversity and reduces forage and water sources for bees, causing poor colony health and lower honey yields. Conversely, integrating sustainable apiculture into land restoration projects helps revive degraded ecosystems by improving plant pollination and boosting biodiversity.

Figure 7 illustrates the cultivated areas of nectar and pollen-producing crops from 2018-19 to 2024-25, expressed in thousand acres. According to The Agriculture Wing of BBS (2025), lentil and mango occupied the largest cultivated areas, whereas sunflower, linseed, and black cumin were grown on comparatively smaller areas. Lentil was the predominant crop during the earlier years; however, mango became the leading crop during the final two years. Lime and lemon covered approximately 155-160 thousand acres during the first three years, followed by a substantial decline in cultivated area in subsequent years. Sesame cultivation remained relatively stable at approximately 75-85 thousand acres, while guava showed an overall decline and litchi and other crops occupied smaller areas. Strategic movement of bee colonies among mango, lentil, sesame, litchi, citrus, sunflower, linseed, and black cumin-growing areas according to flowering periods could extend forage availability and reduce seasonal shortages.

Biodiversity conservation through beekeeping

Beekeeping contributes to environmental sustainability by supporting ecosystem health and promoting biodiversity. Bees are vital pollinators that are useful in the reproduction of both wild plants and domesticated crops, supporting the maintenance of varied and healthy ecosystems. Because healthy bee numbers are a sign of a balanced ecosystem, encouraging beekeeping motivates rural communities to take part in environmental conservation. Additionally, it encourages sustainable farming methods, especially the use of less pesticides, which protects bees and enhances environmental health in general.

Nectar and pollen producing wild plants

Nectar- and pollen-producing wild plants are flowering plants that provide two major floral resources for pollinating insects, especially bees. Bangladesh has substantial potential for bee-forage resources, as diverse flowering plants are distributed across agricultural lands, wetlands, forest margins, roadsides, homesteads, grasslands, and mangrove ecosystems.

Palash: Palash (*Butea monosperma* (Lam.) Taub.) is an important wild flowering tree belonging to the family Fabaceae and represents a significant floral resource for pollinators. Nectar seeking insects like honeybees, butterflies and birds transfer the pollens from anthers to

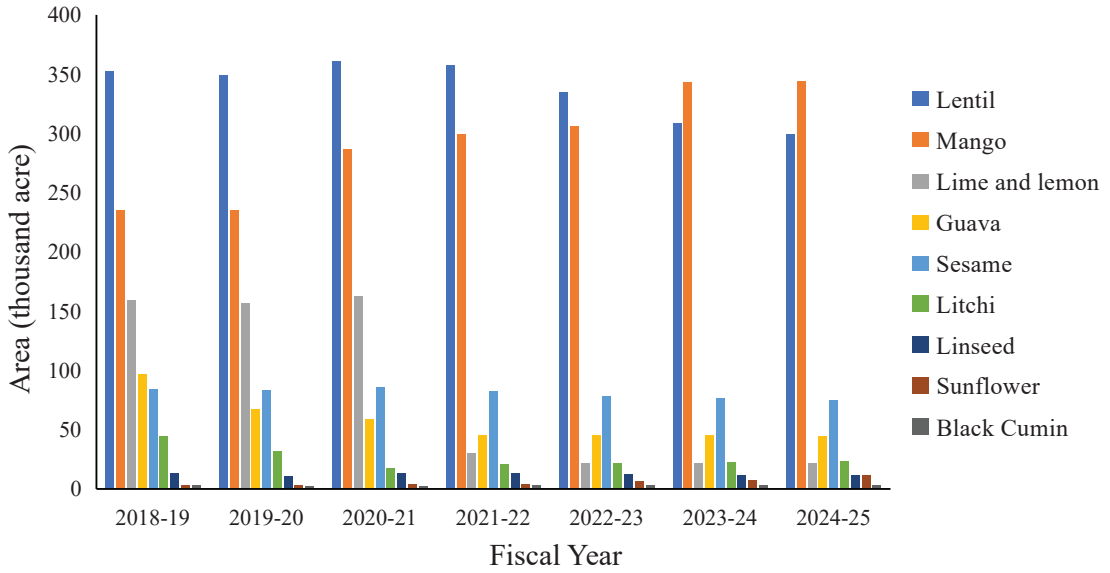


Figure 7. Trend in the cultivated area of major bee-forage crops in Bangladesh, 2018-2019 to 2024-2025.

stigma. However, honey bees act as major pollinators as they have high frequency and duration of visit and pollen load (Anuragi *et al.* 2023).

Wild jujube: Indian jujube (*Ziziphus mauritiana*) represents an important nectar- and pollen-producing plant for insect pollinators in Bangladesh. Pollen analysis of honey from South Asian melliferous vegetation indicates that *Z. mauritiana* can serve as a dominant pollen source, highlighting its potential importance as a forage plant for honeybees (Khan *et al.* 2024).

Ruku (2022) documented 16 insect species visiting the flowers of *Z. mauritiana*, with Hymenoptera being the predominant order throughout the flowering period, followed by Diptera. The Asian honeybee (*Apis cerana*) was the most frequent floral visitor, followed by other honeybee species. The substantial contribution of these insect visitors to fruit set and yield further highlights the ecological significance of *Z. mauritiana* as a pollinator-supporting plant.

Albizia lebbeck: *A. lebbeck* is an important flowering tree that supports a diverse assemblage of insect visitors. Latif *et al.* (2019) recorded eight bee species, two wasp species, two fly species, and two butterfly species visiting its flowers. Among the major visitors were *Apis dorsata*, *Apis florea*, and *Amegilla cingulata*, with bees carrying substantial pollen loads. Open-pollinated flowers also showed significantly improved fruit and seed characteristics compared with caged flowers, highlighting the ecological importance of insect-mediated pollination.

Leucas aspera: It commonly occurs in open areas, grasslands, roadsides, and disturbed habitats. Its importance as a bee-forage plant is supported by quantitative assessments of both pollen and nectar production. Studies have reported approximately 3,500 pollen grains per flower, while the nectar contains sucrose, glucose, and fructose, with a sugar concentration of approximately 25-30%. The flowers are visited by honeybees, including *Apis cerana* and *Apis florea*, as well as other bee species (Solomon *et al.* 2021).

Mangrove species: The Sundarbans are especially important because they contain a large and distinctive assemblage of naturally occurring flowering plants. The Sundarbans produces distinctive polyfloral honey derived from the nectar of several mangrove species, including *Avicennia*, *Sonneratia*, *Ceriops*, *Heritiera*, *Aegiceras*, and *Excoecaria* (Salam *et al.* 2000; Ghosh *et al.* 2015). Among the dominant mangrove species, Sundori (*Heritiera fomes*) accounts for approximately 73% of the total landmass, while Gewa (*Excoecaria agallocha*) represents about 16% of the forest area (Rahman & Asaduzzaman 2010).

Honey-producing forests of Bangladesh

Sundarbans mangrove forest: About 75% of Bangladesh's natural honey production comes from the Sundarbans, one of the country's most important honey-producing locations. *Apis dorsata,* the giant honeybee, is the main collector of this honey from the forest ecosystem (Moniruzzaman and Rahman, 2009). Furthermore, 35 of the 50 real mangrove species known to exist in the globe are found in the Sundarbans, which has a remarkably high mangrove biodiversity (Rahman and Asaduzzaman 2010).

According to the Bangladesh Forest Department, honey collection in the Sundarbans declined from 4,463 quintals in 2021 to 3,008 and 2,825 quintals in 2022 and 2023, respectively. Although collection increased slightly to 3,183 quintals in 2024, it decreased markedly to 2,076 quintals in 2025. During the same period, the number of honey collectors also declined substantially, from approximately 8,000 in 2024 to 5,000 in 2025 (The Dhaka Tribune 2026).

Chattogram Hill Tracts: The Chattogram Hill Tracts, which include Rangamati, Khagrachari, and Bandarban, are well-known for producing both wild and commercial honey locally using *Apis cerana* beekeeping techniques. The region's humid climate and nearby to the Bay of Bengal create a unique apicultural environment.

Madhupur Tract (Sal forest): Significantly vital for commercial and regulated beekeeping with *Apis mellifera* and *Apis cerana*, notably during the seasonal nectar flows from crops like mustard.

Forests of northern region: The northwestern districts including Dinajpur, Rangpur and Natore are famous for commercial litchi and mustard honey. In this region, beekeeping is predominantly conducted by smallholder farmers who depend on honey production as an additional

source of income. The northeastern regions, including Sylhet, Moulvibazar, and Habiganj are characterized by tea plantations, citrus plantings, and forested terrains. Beekeeping is prevalent among tea plantation laborers who employ it to improve their earnings.

Figure 8 illustrates the percentage contribution of forest honey to the total honey production in Bangladesh from 2019 to 2025. Forest honey production remained relatively stable during the first two years, accounting for 11% and 12%, respectively, but declined to 8% in 2021-22 and 7% in 2022–23. In contrast, the highest contribution was recorded in 2024-25, reaching 54%. These fluctuations may be related to variations in climatic conditions, flowering patterns of forest plants, bee colony availability, and honey-collection activities.

Major challenges affecting apiculture in Bangladesh

The honeybee population has declined considerably due to the inappropriate use of pesticides and herbicides, deforestation, water pollution, and the burning of bushes and vegetation. These environmental pressures negatively affect bee habitats, forage availability, and colony health, thereby posing significant challenges to the development of apiculture in Bangladesh.

Impacts of climate change on apiculture: Climate change poses a significant threat to honey bees and the sustainability of apiculture. Crowley *et al.* (2021) reported that elevated atmospheric CO_2 may induce earlier flowering, disrupting the synchrony between flowering periods and bee activity and consequently affecting bee-plant interactions and pollination. Thermal stress can also deplete fat body reserves in honey bees, which are essential for energy metabolism, immune function, and hormonal regulation (Skowronek *et al.* 2021). High temperatures may further alter fat-body function and associated detoxification processes. In pumpkin, increased temperatures can produce more numerous but smaller flowers (Hoover *et al.* 2012), potentially affecting bee foraging because honey bees generally prefer larger flowers.

Climatic variability can also influence foraging activity and honey production**.** Changes in summer conditions may reduce pollen and nectar availability, thereby limiting bee foraging and honey collection (Delgado *et al.* 2012). Dry summers and excessive rainfall may further reduce floral resources and bee activity, potentially increasing colony-loss risks. Because honey bees depend on nectar and pollen for growth and colony maintenance, climate-induced changes may affect their distribution and population sustainability. In addition, hive humidity influences nectar dehydration, pollen preservation, and honey production

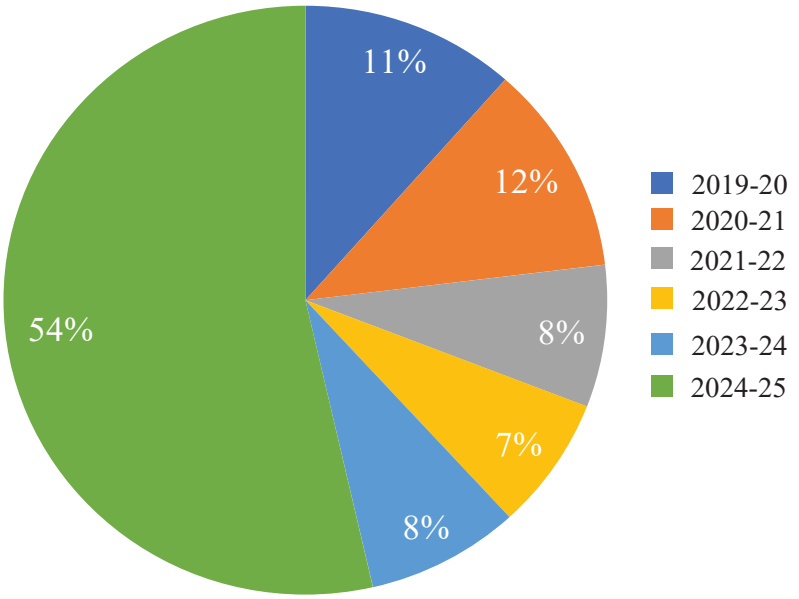


Figure 8. Contribution of forests to annual honey production in Bangladesh during 2019-20 to 2024-25.

(Erdoğan 2019), indicating that both temperature and humidity are important environmental factors affecting colony performance and honey production.

Major pests and diseases affecting honey bees: Foulbrood diseases, including European foulbrood and American foulbrood, and chalkbrood are important brood diseases that can cause mortality in honey bee larvae and pupae. Nosema disease is widespread and can reduce the lifespan of adult workers, cause premature queen replacement (supersedure), and decrease honey production. Chronic bee paralysis may affect all three honey bee castes- workers, drones, and queens.

In addition to diseases, insect pests and parasitic mites pose major biotic threats to honey bees. The parasitic mite *Varroa destructor* is among the most important, feeding on immature bees and potentially causing developmental abnormalities, weakening colonies, and brood mortality. Boecking and Genersch (2008) reported that *V. destructor* causes varroosis and can facilitate the transmission of several viral pathogens, including Kashmir bee virus (KBV), black queen cell virus (BQCV), acute bee paralysis virus (ABPV), chronic bee paralysis virus (CBPV), and deformed wing virus (DWV). Moreover, changing climatic conditions may influence the distribution and spread of *V. destructor*, potentially increasing its impact on honey bee health and beekeeping (Giliba *et al.* 2020, Muli *et al.* 2014).

Pesticide exposure and its effects on pollinators: One of the main causes of the worldwide decrease in pollinator populations is thought to be the use of biologically active ingredients in plant protection products, or pesticides. Insect pollinators may be exposed to pesticide residues during feeding activities since they frequently feed on the nectar and pollen of various crops. Foraging habits, floral morphology, and pesticide application techniques all influence the degree of exposure. The health, behavior, and general survival of honeybees and other pollinators may all be negatively impacted by such exposure. The adverse effects of acaricides, categorized according to their respective active ingredients, are presented in table 3. The listed compounds belong to different chemical groups, including the formamidine amitraz, synthetic pyrethroids such as tau-fluvalinate and flumethrin, the organophosphorothioate coumaphos, and alternative compounds such as thymol and oxalic acid. Although all of these acaricides target *V. destructor*, their chemical properties and potential effects on honey bee colonies may differ (Tihelka 2018). Therefore, careful selection and appropriate use of these compounds are important for effective mite management while minimizing potential risks to honey bee health and colony performance.

The Government of Bangladesh has promoted pesticide use to support agricultural intensification, expand crop

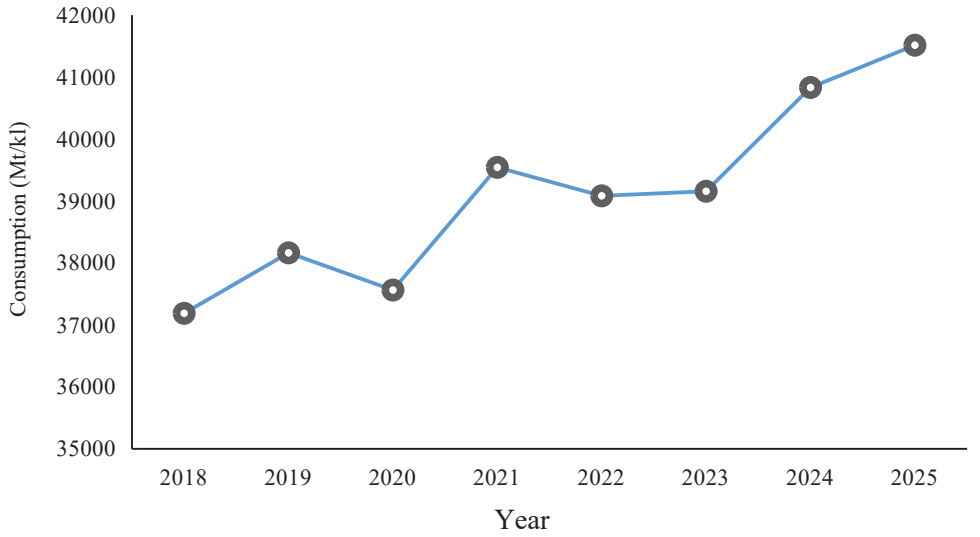


Figure 9. Trend in pesticide use in Bangladesh during 2018-2025.

production, and increase productivity per unit of land. According to the Bangladesh Crop Protection Association, pesticide consumption increased from 37187.3 metric tons in 2018 to 41514 metric tons in 2025, as illustrated in figure 9.

Honey adulteration and its potential health risks

Honey adulteration is a significant concern in the beekeeping and honey-processing industries. Commercial syrups and low-cost sweeteners, including cane and beet sugars, glucose, fructose, corn, invert, and high-fructose inulin syrups, may be used as adulterants (Morariu *et al.* 2024). Their addition can alter the chemical and biochemical characteristics of honey, including enzymatic activity, electrical conductivity, and the levels of bioactive compounds. Moreover, adulterated or contaminated honey may trigger allergic reactions in susceptible individuals, while prolonged consumption may pose potential acute and chronic health risks (Seraglio *et al.* 2021).

Strategies for addressing the challenges of apiculture

Minimizing pesticide exposure: To minimize detrimental exposure to honey bees and other pollinators, chemical pesticides should not be applied during flowering period. Biorational products, botanical pesticides, and microbial-based pest-control agents should be used wherever possible in place of conventional pesticides because they often represent less of a threat to pollinators.

Adoption of climate-smart apiculture: The development and promotion of climate-resilient and climate-smart technologies should be prioritized within the apiculture sector. Beekeepers and farmers should be supported in adopting innovative management practices that enhance colony resilience, productivity, and adaptive capacity under changing climatic conditions.

Strengthening climate-related research: Further research is needed to clarify the impacts of climate change on honey bees and beekeeping, particularly through long-term, location-specific studies. Despite its growing importance as a threat to honey bees, climate change remains relatively understudied. Decourtye *et al.* (2019) reported that it accounted for only 3.2% of global research on threats to honey bees. Therefore, future research should prioritize the interactions among climate change, honey bee health, colony performance, and beekeeping practices.

Improving hive management: Beekeepers can assist colonies adapt to adverse weather conditions by implementing very easy management changes. In order to improve colony resilience and sustain productivity under climate-related stress, Doha *et al.* (2025) suggested techniques like hive insulation and additional feeding.

Conclusion

Beekeeping holds considerable potential for Bangladesh by contributing to rural livelihoods, employment generation, honey and beeswax production, and agricultural crop pollination. At present, about 25000 beekeepers produce around 12000 metric tons of honey each year, while the national demand is about 30000 metric tons. Forest areas are also an important source of honey production. In the fiscal year 2024–25, about 2072 metric tons of honey was produced from different forest areas of Bangladesh. Despite this production potential, Bangladesh remains highly dependent on imported natural honey. In 2024, honey exports were valued at only US$118 thousand, compared with imports worth approximately US$2.619 million, indicating a substantial trade deficit. Therefore, systematic assessment of pollen and nectar sources is important for optimizing apiary management, authenticating honey, establishing geographical identity, enhancing product differentiation, and creating opportunities for the production and marketing of premium monofloral honey. Moreover, location-specific, long-term research on the impacts of climate change is essential for promoting sustainable and climate-resilient beekeeping in Bangladesh.

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