

Review Article

The Potential and Transformation of Beekeeping for Natural Resource Conservation and Poverty Reduction in the Case of Ethiopia: A Review

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Abstract

Beekeeping is widely recognized as a valuable farming practice with the potential to enhance both natural resource conservation and rural livelihoods. It benefits the environment by promoting ecological balance and preserving natural resources. The purpose of this paper is to review the potential of beekeeping in fostering natural resource conservation and poverty alleviation, along with its transformative impact in these areas. The success of beekeeping is closely linked to the availability of untapped forests and low population density, as both factors create an ideal conditions for successful beekeeping. Beekeeping plays a vital role in preserving and enhancing the value of forests, while also promoting active involvement in their protection, conservation, and sustainable management. Honeybees are highly valued for their critical role in pollination, which greatly influences the global food system. They pollinate different agricultural crops, including fruits, vegetables, and nuts, leading to improved crop yields. Furthermore, honeybee pollination enhances the quality, nutritional content, and shelf life of many fruits and vegetables. In this regard, beekeeping serves as an important tool for fostering long-term development in numerous developing countries. Promoting beekeeping is a key to achieving sustainable development goals, such as poverty reduction, food security, and biodiversity conservation. In Ethiopia, beekeeping is a vital component of the agricultural sector and plays a significant role in the nation's economy. Recognizing its potential to reduce poverty and promote rural development, the Ethiopian government has introduced various programs to support and advance beekeeping activities across the country.

Keywords

Beekeeping, Natural Resource Conservation, Honeybee, Pollination, Sustainable Development, Livelihood

1. Introduction

Beekeeping is a vital part of agricultural and rural growth initiatives worldwide, particularly in Sub-Saharan African countries [1-3]. It contributes to economic stability, food security, and ecological sustainability while actively involving communities nearby in promoting environmental conser-

vation [4-6]. The link between beekeeping development and its contributions to local communities may not appear observable at first glance; rather, it exists and is based on the natural resource conservation, livelihood improvement, and pollination services provided by honeybees [7-9]. Accord-

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Received: 12 December 2024; **Accepted:** 24 December 2024; **Published:** 14 January 2025



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ingly, honeybees from managed apiaries and the wild, like all pollinators, play an essential role in contesting soil deterioration by improving the renewal life cycle, providing additional vegetation, maintaining the genetic composition of numerous plant and agricultural crops via pollination, and providing additional biomass to the soil [10], resulting in less soil grief, less flooding, and an environment that is healthier for living sustainably. Beekeeping has long been recognized as a farming practice with the potential to improve both natural resource conservation and rural livelihoods [11]. Beekeeping is an effective way to strengthen and create people's livelihoods by generating a variety of capital assets [12]. Rural livelihoods are based on access to natural assets like water, land, and biological resources [13]. The availability of these natural resources plays a crucial role in determining the well-being of rural societies. It is therefore critical to ensure that these natural resources are preserved and managed sustainably to support the livelihoods of rural communities. Biotic resources, such as plants and animals, provide food and other necessities for daily life in rural societies. Therefore, the survival of these communities is dependent on the responsible use of these resources, so it is everyone's responsibility to act now to protect them for future generations. Thus, beekeeping accomplishes this by helping to preserve the natural resource base [14]. The beekeeping landscape consists of adequate honeybee plants that are designed to promote sustainable beekeeping and support the enhancement of natural resource conservation [15]. Thus, every stakeholder who has participated in beekeeping activities has been concerned with ensuring the responsible handling of natural assets, improving incomes, and assuring adequate nourishment in rural areas at the regional and international levels [16].

The natural environment can only be kept in good condition with the curiosity and lively participation of local people in the area [17]. Keeping bees is an excellent way for people to generate money without affecting the environment, and pollinating honeybees and other pollinators helps conserve plant resources [10]. Moreover, beekeeping activities encourage the planting of various honeybee plants to maintain honeybee colony populations and harvest honey during different seasons, as opposed to other conventional farming systems that increase agricultural yield by diminishing the existing forest [18]. As a result, establishing and managing multipurpose honeybee plant species, as well as conserving natural resources in the system, can lead to sustainable beekeeping and sufficient honey production in most African countries, including Ethiopia. Therefore, beekeeping may not only increase rural communities' income but also help to restore and protect ecological resources [1, 19].

Ethiopia is one of Africa's honey production hotspots. Ethiopia boasts a diversified flora and Africa's largest honeybee population as a result of its unique environmental and geographical characteristics [20]. The country's abundant and diverse honey plant resources combined with suitable meteorological conditions render it an attractive area for beekeep-

ing. As a result, Ethiopia honors beekeeping's contribution to livelihoods, natural resource preservation and water shade management. Therefore, beekeeping is an indispensable part of Ethiopia's agricultural and rural development venture. This approach is popular among smallholder farmers and landless people in the country because beekeeping does not utilize farmland, demands little expenditure and can be held almost anywhere in rural or peri-urban areas, less labor intensive and less time-consuming, and provides immediate financial returns [21, 22]. In addition to financial advantages, beekeeping has social benefits, like ensuring nutritional stability [23], improving quality of life in rural communities [22], promoting social cohesion, and reducing rural-urban migration [23, 24]. Moreover, this sector has the potential to provide prospects for small-scale agricultural enterprises in both urban and rural areas of the country. Thus, the promotion of beekeeping practices is now largely regarded as being one of the most effective ways to improve the livelihoods of local communities. Furthermore, beekeeping is incredibly good to the environment as it promotes ecological balance and natural resource conservation in the country [25-27]. This review aims to provide an in-depth analysis of beekeeping practices in Ethiopia, emphasizing their significant contributions to natural resource conservation and poverty reduction. It highlights the crucial role of beekeeping in forest preservation, pollination, sustainable development, and as an effective livelihood strategy. The review also emphasizes the significant impact of beekeeping on household-level welfare and its broader socio-economic benefits.

2. Impression of Beekeeping in Natural Resource Conservation and Poverty Reduction

2.1. Beekeeping for Forest Conservation

The beekeeping potential of these plants is directly related to the availability of intact forests with a low human population intensity, both of which offer favorable environments for beekeeping [28]. Forests provide an ideal environment for bees and beekeepers, and bees have a vital part in forest ecosystems. As a result, local honeybee subspecies are naturally occurring forest assets, and beekeeping allows humans to exploit them for valuable products while avoiding harming honeybee populations [29]. Once societies are recognized for the valuable contributions that bees make to humanity, they will honor them and endeavor to take care of them, their surroundings, and their foraging area because beekeeping helps to sustain plant biodiversity in natural settings through pollination. Thus, beekeeping projects are excellent tools for increasing forest value and engaging people in mindful protection, preservation, and sustainable use of resources [30]. Thus, the rural areas that share borders with unexplored forests that have substantial diversity in flowers might be no-

ticed to promote organic honey production [31]. Beekeeping also offers vulnerable individuals with additional economic benefits from forest resources, as they have a great interest in maintaining the trees that provide the honey [32, 33]. Keeping bees can help to address the problems of ownership property in natural forest areas, which is crucial for sustainable resource management [30]. Beekeeping can also be used in rehabilitation initiatives, with a focus on native and melliferous vegetation that produce a variety of nectar and pollen. Rehabilitation programs can provide alternative activities for communities living near forests, especially when access to the forest is limited. Moreover, beehive products like honey and pollen offer a wide range of substantial health benefits, including boosting immunity, providing essential vitamins and minerals, and promoting digestive health. These natural substances are rich in antioxidants, anti-inflammatory compounds, and antimicrobial properties that can support overall well-being. Given their nutritional value and therapeutic effects, honey and pollen could serve as viable alternatives to traditional foods that communities typically gather from forests, such as wild fruits, herbs, and nuts. Once beekeepers receive assistance and access to a viable market for what they produce, they are far more inclined to contribute to conservation initiatives in their area. In this context, a research carried out central Ethiopia showed the significance of beekeeping in agricultural forestry and vegetation preservation. As a result, the majorities of beekeepers grow and conserve bee forage plants for their honeybees, resulting in greater plant diversity than that of non-beekeepers [34]. Another study conducted in Menegasha Sub Forest found that integrating beekeeping technology with forest conservation will increase household income and promote the growing of honeybee plants, both of which substantially contribute to the management of forests sustainably. Furthermore, by combining beekeeping technologies with the preservation of forests, beekeepers at Menegasha Sub forest boosted their honey production fourfold (411%) and revenue by 5.76 times (576%) [8].

2.2. The Beneficial Role of Beekeeping in Pollination

Honeybees are interesting social insects that play an important part in our natural environment. Honeybees are highly regarded for their outstanding ability to generate hive products (honey, beeswax, pollen, propolis, royal jelly, and bee venom) and their critical pollination activities, which provide greatly to the global food chain [35, 36]. They pollinate a number of agricultural commodities, for instance fruits, vegetables, and nuts [37]. This produces higher crop yields and enhances genetic diversity [38]. Their role in cross-pollination is especially important because they increase genetic variation among multiple plants and guarantee the existence of many plant species in ecosystems [28].

Honeybee pollination not only boosts crop productivity

[39-41], but also improves the quality, nutritional content, and shelf life of fruits and vegetables. Research has demonstrated that bee pollination increases the flavor, aroma, and color of fruits and vegetables, making them more appealing to consumers [42]. It also enhances the nutritional content of crops, making them healthier and more beneficial for human consumption. Moreover, bee pollination can help reduce food waste by preventing losses in yield due to aesthetic defects. This is because, with better pollination, fruits and vegetables are less likely to be misshapen, discolored, or blemished, which can lead to rejection by consumers or grocery stores. This, in turn, reduces the amount of food that is wasted and improves the overall efficiency of the food system [43].

Honeybees are irreplaceable assets for the worldwide food system and essential components of the ecosystem. In addition to honeybees, numerous animals, including bats, birds, moths, hoverflies, thrips flies, wasps, butterflies, beetles, and other insects, play crucial roles in pollinating crops and are among the many creatures that aid in the pollination process [44]. Thus, both wild and managed pollinator populations are responsible for providing pollination services to a variety of crops and wild plant species [45]. This process is necessary for plant growth because it enables them to produce seeds and fruits, which are vital for survival and food production [46]. Pollination is a natural and resource-efficient way to boost crop yields without requiring additional land or resources. Studies conducted by [39] have demonstrated that bee pollination can substantially enhance agricultural crop production, leading to yield increases of up to 50%. In a similar way the Food and Agriculture Organization (FAO) estimates that pollination is worth an alarming 100 times more than extracted honey in Africa and around 30-50 times more in Western Europe, depending on the crops [29]. This emphasizes the economic relevance of honeybees as insect pollinators globally [38, 47, 48]. One of the main reasons behind honeybees' effectiveness as pollinators is their ability to pollinate a various array of flowers, which enables them to contribute to the fertilization of various crops. In addition, they can move huge amounts of pollen particles via their sticky spines, which aids in the process of pollination. Another factor that contributes to their effectiveness is their dependence on flowering plants for food sources. Furthermore, the eusociality of honeybees, which is their social organization, also plays a significant role in their success as pollinators [49].

Pollination is essential for the survival of both wildflowers and cultivated crops, with insects playing a crucial role in this process. Among these insects, honeybees are particularly important due to their significant contribution to pollination. In addition to this, honeybees produce various valuable by-products, such as honey, beeswax, pollen, propolis, royal jelly, and bee venom, all of which have numerous applications across different industries [50]. Honeybees are vital to pollination, contributing to the fertilization of about one-third

of the plants and plant-based products humans rely on, both directly and indirectly [29]. However, their contribution goes beyond human consumption, as bees perform an astonishing 80% of all pollinations worldwide, ensuring that ecosystems around the globe grow and thrive [27]. Thus, bees pollinate seventy of the top hundred food crops grown by humans, accounting for approximately 90% of the global nutritional status [51]. This includes many of the foods we eat, such as fruits, nuts, and vegetables. Without bees, we would have a severely limited ability to feed humanity [27]. According to various reports, honeybees can increase the productivity of various fruit yields by thirty to forty percent and most crops by 5-50% through pollination [39]. Approximately, Ethiopia produces about fifty-three key crops each year. Of Ethiopia's fifty-three important crops, 33 (62.2%) rely on biotic pollinators, with honeybees providing 80% of pollination services [52]. Honeybees are highly efficient pollinators and can greatly increase agricultural yields on farmlands, according to previous study findings. Thus, Crane [53] found that honeybee pollination can boost citrus *sinensis* yield by 30%, watermelon output by 100% and tomato yield by 25%. This suggests that honeybees perform a vital role in pollinating a number of commodities and contributing to the overall agricultural productivity. Moreover, various research carried out in Ethiopia have demonstrated that pollination by honeybees can boost the seed yield of various crops. For instance, a study by [54] revealed that the Niger seed yield increased by 43% due to honeybee pollination. Similarly, a study by [55] found that honeybee pollination increased onion yield by twofold. In addition to yielding, honeybees also contribute significantly to the quality of crop seeds. Topical research have demonstrated that honeybee pollination can considerably improve the nutritional content of various crops, including onions, apples, and sunflower kernels. For instance [56] found that honeybee pollination improved the quality of onion seeds, resulting in higher yields and faster seed germination rates. Similarly, [7] reported that apple fruits pollinated by honeybees exhibit improved color, firmness, and sugar content, resulting in higher-quality fruits. In another study by [57], honeybee pollination increased the size and oil content of sunflower seeds, leading to higher-quality seeds. Furthermore, in Sub-Saharan Africa, honeybees play a vital role in cotton production, which is a major economic crop. According to [41], bee pollination can boost cotton output by up to 62%, compared to 37% without pollination. Given the importance of cotton in many African countries' economies, the impact of honeybees in enhancing cotton yields cannot be emphasized. Moreover, bee pollination improves crop yield in small-scale agricultural systems in Kakamega, in the southwest of Kenya. Several researchers have recently conducted studies on various crops and have reported interesting findings. Among the crops that have been found to possess noteworthy properties are green gram (*Vigna radiata*), beans, cowpea (*Vigna unguiculata* L. Walp), sunflower, tomato (*Solanum lycopersicum* linn), Bambara groundnut (*Voan-*

dzeia subterranean L.), passion fruit, and capsicum, all of these crops showed substantial improvements in their yield and overall production rates when bee pollination was involved. The increased pollination efficiency provided by bees played a crucial role in boosting the productivity of these crops, demonstrating the vital relationship between pollinators and agricultural success. According to research conducted by [58], bee pollination contributes to approximately 40% of the annual crop yield in this region. This study further highlights the significance of pollination by honeybees in increasing agricultural output and enhancing the economic returns of smallholder farmers in the region. These findings have significant implications for agricultural practices in other areas of the world where bee pollination could play an essential role in crop production.

2.3. Role of Beekeeping in Watershed Management

Watersheds are intricate, interconnected ecosystems that demand a holistic management approach, taking into account biodiversity, soil health, water quality, and the needs of the local communities [59]. Beekeeping contributes significantly to watershed management by promoting biodiversity, improving pollination, and preserving the delicate balance of local ecosystems [60, 61]. Honeybees are crucial pollinators for many plants, including those that are integral to the health of watersheds, such as native vegetation and cultivated crops [62]. By promoting plant reproduction and growth, beekeeping plays a vital role in enhancing water quality, soil health, and the overall resilience of ecosystems. In addition, the presence of healthy honeybee populations can improve agricultural yields and contribute to more sustainable land use practices, which ultimately protect water resources and promote the well-being of the entire watershed. Incorporating beekeeping alongside other sustainable land and water management practices can significantly enhance the long-term health and resilience of watersheds by fostering biodiversity, improving soil fertility, and supporting healthy water cycles [63, 64]. Furthermore, when beekeeping is integrated with other sustainable practices such as organic farming, agroforestry, and water conservation, it creates a synergistic effect that significantly enhances ecological health [65]. Moreover, healthy watersheds play an important role in sustaining the environment, as they help maintain biodiversity, regulate the integrity of water, and support various plant and animal species [66-68]. Through preserving these natural systems, watersheds contribute to the resilience of ecosystems, preventing soil erosion, mitigating flooding, and enhancing water filtration. In addition to its environmental advantages, beekeeping can offer valuable economic opportunities for local communities [65]. It provides a source of income through honey production and other bee products such as beeswax and propolis. Moreover, beekeepers often adopt regenerative farming practices that play a crucial role in im-

proving soil health and water quality. Through methods like crop rotation, cover cropping, and reduced tillage, they help rebuild and preserve soil structure, which enhances water retention and minimizes erosion. These practices also foster greater biodiversity, promoting a more resilient ecosystem that supports pollinators and other beneficial species. As a result, healthier soils and water systems contribute to long-term sustainability, reducing the adverse effects of traditional farming techniques and ensuring the land remains productive for future generations. This approach not only benefits the environment but also enhances the quality of crops, leading to more sustainable and responsible land management practices.

2.4. Beekeeping for Sustainable Development

Sustainability is a complex concept that is based on three main pillars: environmental, social, and economic [69]. The principle of environmental protection prioritizes protecting natural resources and ecosystems, which are indispensable for the survival of all living organisms. While, the social pillar addresses issues related to human well-being, including social justice, equity, and accessibility to necessary resources like medical care, educational opportunities, and food. The economic pillar aims to generate a sustainable economy that generates wealth and prosperity while preserving the environment and promoting social equity. The main goal of sustainability is to address significant social problems, such as poverty, inequality, and social exclusion, as well as the current ecological crisis, which includes global warming, deforestation, and loss of biodiversity. Through achieving sustainability, it is possible to build an improved future for ourselves and subsequent generations. According to Polačko [70] the concept of sustainability motivates people to prioritize the well-being of both humans and the environment. This approach encourages an extensive plan that recognizes the interdependent nature of social, economic, and environmental systems. This strategy involves the creation of unique solutions that balance between human, environmental, and economic needs. Thus, beekeeping is a key intervention for promoting sustainable growth in many developing countries. It is a sustainable approach that supports biodiversity while offering income and sufficient nutrition to people in rural communities. Therefore, enhancing beekeeping can contribute to accomplishing objectives related to sustainable development, such as decreasing poverty, ensuring adequate food supply, and conservation of biodiversity [71]. This sustainable development can be achieved by generating income opportunities, promoting crop diversity, and supporting environmental conservation. Honeybees play an important part in maintaining the Earth's life support systems by providing a variety of environmental benefits [72, 73]. These benefits include pollination which is crucial for blooming plant reproduction, as well as fruit, vegetable, and nut production. In addition, honeybees help to maintain ecological diversity by

pollinating plants that grow naturally and supporting the food web for other animal species. Honeybees also contribute significantly to nutrient cycling by facilitating the decomposition of dead plant and animal material [74]. As they forage and interact with various ecosystems, bees help break down organic matter, such as decaying plants and animal remains, through their activities. This process not only accelerates the decomposition of organic material but also promotes the release of essential nutrients like nitrogen, phosphorus, and potassium back into the soil. These nutrients are vital for soil health and fertility, supporting the growth of plants and sustaining the stability of the ecosystem. In this manner, bees indirectly contribute to the enrichment of the soil, enhancing its productivity and supporting sustainable agricultural practices. All of these ecosystem services that bees provide naturally help to achieve global sustainability by sustaining the balance of nature [75]. Without bees, many wild plants and agricultural crops would not reproduce properly, resulting in a decrease in food supply for people as well as animals. Additionally, the loss of bees can have a cascading effect on other species that depend on them for food and pollination. Therefore, it is essential to implement strategies to safeguard bees and their habitats to guarantee the ongoing provision of these essential ecosystem services.

Furthermore, beekeeping plays a crucial role in environmental conservation by fostering sustainability and supporting biodiversity [28]. In addition, it can be integrated with agricultural practices to enhance crop pollination, leading to improved yields. This mutual relationship between bees and agriculture not only boosts food production but also helps maintain healthy ecosystems, making beekeeping a key contributor to both environmental preservation and sustainable farming. In many developing countries, the role of bees in achieving the full spectrum of sustainable development goals has not been fully explored. However, recent studies have highlighted the critical importance of insects, particularly honeybees, in supporting numerous environmentally sustainable development goals. This can be achieved by carefully managing and optimizing natural ecological functions, such as pollination, biological pest control, seed dissemination, and bioinspiration. Through harnessing and regulating these natural systems, humans can improve environmental health, enhance biodiversity, and create more sustainable agricultural and ecological practices [72, 76, 77].

In recent years, the government of Ethiopia has increasingly recognized the vital role of beekeeping in fostering sustainable development [78]. Through promoting this sector, the government aims to enhance both economic growth and environmental sustainability. Thus, honeybees are vital insects that play a crucial role in sustaining ecosystems and supporting the overall health of the planet's environment [79]. They are responsible for pollinating approximately 80% of the crops essential for human food, including a wide variety of fruits and vegetables that would not thrive without their vital contribution. [80]. Therefore, it is important to recognize and appreci-

ate the crucial role honeybees play in shaping our ecosystem and safeguarding the sustainability of our planet.

2.5. Beekeeping as a Livelihood Strategy and Its Impact at the Household Level

Beekeeping may serve as a valuable agricultural business option for landless and small-scale farmers looking to sustain their livelihoods. It is a profitable business that pays well and encourages more people to pursue sustainable livelihoods [81]. Beekeeping is an attractive business, and many farmers around the world rely on beekeeping for a significant share of their annual income. It plays a key role in diversifying the income sources of rural communities, which helps reduce their reliance on traditional agricultural activities. Through providing alternative means of livelihood, such as through sustainable tourism, handicrafts, or agroforestry, it diminishes the demand for agricultural land expansion and forest pressure. It requires only a minimal financial commitment, making it a low-cost solution that does not put additional load on the existing agricultural system. As a result, it does not compete for limited resources like land, water, and capital, which are frequently in high demand in traditional farming [82]. This allows it to coexist with traditional agricultural practices without producing resource conflicts, creating opportunities for long-term growth without overburdening the present infrastructure [29]. Thus, beekeeping has become increasingly popular as a way to boost farm productivity in developing countries.

In Ethiopia, where approximately 79.2% of the entire population resides in rural areas, agriculture is the main source of revenue [83]. Thus, beekeeping is a crucial component of Ethiopia's agricultural sector, supporting both the economy and the livelihoods of many rural communities. Ethiopia is Africa's largest producer of honey and ranks fifth globally, with an estimated annual production of 53,000 metric tons [2, 84]. The Ethiopian government has recognized the potential of beekeeping as a valuable tool for poverty reduction and rural development. As part of its efforts to support this sector, the government has introduced various initiatives, including training programs, extension services, credit facilities, and improved market access. In many rural areas, the impoverished population depends heavily on crop production for their livelihood, either through personal farming or agricultural wage labor. This reliance on agriculture makes them highly vulnerable to adverse weather conditions and climate-related challenges. While agriculture plays a crucial role in their financial and nutritional well-being, the rural poor also engage in non-agricultural work like beekeeping to supplement their income. So, beekeeping has increasingly gained recognition as a sustainable and profitable activity, offering local beekeepers an excellent opportunity to generate extra revenue through non timber forest products. As the demand for natural honey, beeswax, and other bee-derived products grows, many communities are turning to beekeeping as a

way to diversify their income streams. This practice not only helps preserve and enhance biodiversity by supporting pollination, but it also provides a way for beekeepers to engage with nature while promoting environmentally friendly, low-impact agricultural practices. As a result, beekeeping is becoming a key economic activity for rural and forest-dependent communities, contributing to both their livelihoods and the conservation of natural resources [7, 86].

Moreover, beekeeping is regarded as a sustainable livelihood diversification strategy by farmers and development organizations in developing countries, as it offers supplementary income, food, and medicinal resources [29, 87, 88]. It is not only serves as a significant economic resource for rural communities but also plays an important role in fostering environmental sustainability. Furthermore, beekeeping also offers a valuable opportunity for women and young people in rural communities, empowering them by enabling their participation in economic activities and the acquisition of new skills. Women, in particular, can benefit from beekeeping, as it is a flexible activity that can be performed alongside other household responsibilities [89]. Beekeeping also brings considerable advantages to rural farmers by offering them consistent and reliable financial security throughout the year [90, 91]. Studies conducted in northwestern Ethiopia show that farmers engaged in beekeeping tend to have higher per capita incomes, greater household assets, and more livestock compared to those who do not practice beekeeping. On average, beekeepers make about ETB 7,433 per year, whereas non-beekeepers make around ETB 4,736 annually. This finding indicates that beekeepers earn, on average, 2,697 ETB more per capita compared to non-beekeepers [12]. Additionally, beekeeping can provide a safety net for households by generating an additional source of income through the sale of honey and other bee-related products. These products are not only valuable for their economic potential but also offer nutritious foods that can help meet the energy and nutrient needs of rural communities. Honeybees are essential to agriculture as they pollinate a wide range of crops, enhancing seed and fruit production. This boost in crop production directly translates into higher income for rural farmers, who can sell their surplus yields in local and global markets, thereby supporting their livelihoods and driving rural economic growth [7]. Moreover, beekeeping offers valuable self-employment and income-generating opportunities for individuals in rural areas. Through beekeeping, people can produce a variety of hive products, including honey, beeswax, and propolis, all of which are in high market demand [65]. Thus, the revenue generated from this sector could be a crucial source of funding for a wide range of social services like education, healthcare, electricity, transportation, and the development of improved housing that are essential to improving the quality of life for vulnerable populations [92]. Additionally, hive products, including honey, beeswax, pollen, propolis, royal jelly, and bee venom, are highly regarded worldwide for their considerable socioeconomic value [50].

These products play a key role in various industries, ranging from food and pharmaceuticals to cosmetics and natural health supplements. Honey, for instance, is not only a staple in many diets but also prized for its medicinal properties. Beeswax is widely used in the production of candles, cosmetics, and as a natural sealant in diverse applications. Pollen and propolis are sought after for their potential health benefits, including boosting immunity and promoting overall wellness. Royal jelly, known for its unique nutritional profile, is often used in dietary supplements, while bee venom is gaining attention in alternative medicine for its anti-inflammatory and therapeutic properties. Collectively, these hive products contribute significantly to local economies, especially in regions where beekeeping is a key agricultural practice, supporting livelihoods, boosting trade, and promoting sustainable agricultural practices.

3. Constraints and Opportunity of Beekeeping in Ethiopia

3.1. Constraints of Beekeeping

Ethiopia has significant beekeeping potential, owing to its ideal environment and abundant biodiversity [21, 93, 94]. The country's diverse ecosystems provide an extensive variety of flowering plants, which are crucial for maintaining healthy bee populations and generating high-quality honey. Furthermore, the broad range of native flora not only promotes bee health but also helps to produce unique honey variations that reflect the richness of Ethiopian farming. Despite these benefits, Ethiopia's beekeeping business confronts numerous important challenges that hinder its expansion [94-96]. Issues such as a lack of improved beekeeping practices, inadequate access to training for local beekeepers, high prices and limited supply of improved beekeeping technologies, honeybee pests, predators, and diseases, inappropriate agrochemical application, extension services, a shortage of financial services, and a lack of standardization and quality management systems can all limit the sector's productivity. Additionally, environmental concerns such as climate change and habitat loss endanger bee populations and honey production [97-99]. Addressing these issues is critical for realizing the full potential of Ethiopia's beekeeping sector, which has the potential to generate economic opportunities and contribute to the country's agricultural development.

3.2. Opportunities of Beekeeping

Ethiopia's distinct weather conditions and rich floral resources create an ideal environment for honey production, providing a great opportunity for the expansion of the beekeeping industry [93, 95, 100-102]. In line with this, the beekeeping industry provides numerous opportunities to improve the well-being of society by increasing honey produc-

tion. Meeting the demand from both domestic and international markets can boost incomes and stimulate economic growth [12, 103]. Beekeeping also allows farmers to diversify their income sources, reducing reliance on a single crop and boosting financial stability. This diversification strengthens resilience against market and environmental fluctuations. Additionally, beekeeping industry generates employment in beekeeping, honey processing, packaging, and distribution, providing job opportunities in rural areas with limited employment options. By producing value-added products like beeswax, propolis and royal jelly, beekeepers can tap into niche markets for additional income from beekeeping industry. Also, ecologically bees play a key role in pollinating crops and wild plants, which improves biodiversity and agricultural productivity [12, 65, 104-106]. So, supporting bee populations is crucial for maintaining a balanced ecosystem and ensuring food security by providing a sustainable source of nutrition. Moreover, beekeeping-related agro-tourism is gaining popularity, offering unique experiences that can boost local economies. With the right policy support and government initiatives, including resources and training, the beekeeping industry has the potential to thrive and contribute to both local and national economic development. Therefore, with strategic investments in training, infrastructure, and market access, Ethiopia has the opportunity to fully realize the potential of its beekeeping industry and position itself as a leading exporter of high-quality honey in the worldwide market.

4. Conclusion and Recommendations

Beekeeping plays a critical role in agricultural and rural development worldwide, especially in sub-Saharan Africa. It contributes to economic stability, strengthens food security, and promotes environmental sustainability, while involving local communities in the conservation of natural resources. Historically, beekeeping has been recognized as a farming practice that can enhance the livelihoods of rural communities, which depend heavily on access to natural resources such as land, water, and biological assets. The accessibility and long-term management of these resources is critical to the well-being of rural communities. The success of beekeeping is closely linked to the presence of intact forests and low human population density, which provide favorable conditions for honeybee habitats. Forests offer an ideal environment for bees, and in turn, bees are essential for maintaining the health of forest ecosystems through pollination, which supports biodiversity. Beekeeping also provides rural communities with additional economic opportunities from forest resources, offering them a strong incentive to protect trees that produce honey. Promoting this practice can contribute to achieving sustainable development goals, including poverty reduction, food security, and the preservation of biodiversity. Beekeeping also provides a valuable and accessible agricultural opportunity for landless farmers and those with

small-scale operations. As a result, beekeeping is a key part of Ethiopia's agricultural sector, significantly boosting the national economy. Acknowledging its potential to reduce poverty and promote rural development, the Ethiopian government has introduced several initiatives to support and enhance beekeeping practices nationwide.

5. Future Perspective

Beekeeping has been a vital part of Ethiopia's agricultural heritage, providing both economic and environmental benefits. This practice provides crucial economic opportunities by generating revenue through the sale of honey and other bee-derived products, while also contributing to the environment by facilitating pollination, which is essential for crop growth and biodiversity conservation. Looking ahead, there is significant potential to strengthen and expand beekeeping practices, transforming them into sustainable solutions that can contribute to natural resource conservation and poverty alleviation in rural areas. As Ethiopia faces challenges such as land degradation, deforestation, and widespread rural poverty, beekeeping offers a unique opportunity to protect ecosystems and improve the livelihoods of marginalized communities dependent on agriculture. To fully exploit this potential, Ethiopian beekeeping needs focus on the following critical areas:

5.1. Promotion of Sustainable Beekeeping Practices

Promoting sustainable beekeeping techniques involves supporting practices that prioritize the long-term health of both bee populations and the environment, while also ensuring the economic viability of the beekeeping industry. These practices aim to balance the demand for honey production with the necessity of protecting ecosystems, conserving biodiversity, and maintaining healthy pollinators. Thus, sustainable beekeeping offers significant benefits not only for bees and beekeepers but also for the environment as a whole. These benefits include increased agricultural productivity and the restoration of ecosystems.

5.2. Capacity Building and Training

Providing comprehensive training programs to farmers in modern beekeeping techniques, alongside strategies for environmental conservation, can significantly enhance productivity in the beekeeping sector. These training initiatives can provide farmers with the knowledge required to implement sustainable beekeeping practices, ensuring the long-term profitability of their operations. Moreover, focusing on the improvement of skills related to honey processing and marketing can open up new market opportunities. By learning advanced methods of extracting, refining, and packaging honey, as well as effective marketing strategies, farmers can

increase their product quality and appeal to a broader consumer base. This not only has the potential to boost their sales but also to increase overall income for rural households, contributing positively to their economic stability.

5.3. Integration of Beekeeping with Agroforestry and Ecosystem Restoration

The integration of beekeeping with agroforestry and ecosystem restoration offers a comprehensive and innovative approach to land management that addresses several critical environmental and agricultural challenges. This strategy aims to enhance biodiversity by creating diverse habitats for various plant and animal species, thus supporting a more resilient ecosystem. Agroforestry incorporates trees, shrubs, and crops in a single agricultural system, which improves soil quality, conserves water, and reduces erosion. When beekeeping is introduced into this system, it not only provides bees with an abundance of forage but also benefits farmers through increased pollination. This leads to improved crop yields and greater fruit and seed production, essential for both subsistence and commercial farming. Additionally, ecosystem restoration efforts focus on repairing damaged landscapes, restoring natural processes, and improving overall ecosystem health. Incorporating beekeeping into these restoration initiatives can boost local pollinator populations, which play a vital role in the reproduction of both wild plants and cultivated crops. This mutually beneficial interaction between beekeeping and tree conservation helps to mitigate the consequences of climate change while also providing farmers with extra sources of income.

5.4. Access to Finance and Market Linkages

To significantly enhance beekeeping opportunities for rural farmers, it is essential to improve their access to financing specifically designed for purchasing beekeeping equipment and building essential infrastructure. This could be achieved through low-interest loans and cooperative financing models, which would enable farmers to access quality beekeeping equipment. Additionally, fostering strong market linkages for honey and other bee products like beeswax and propolis is vital to increasing the profitability of beekeeping. Connecting farmers with local markets, retailers, and online platforms will help them sell their products at fair prices. So strengthening these market connections allows farmers to maximize their earnings, ensuring that the benefits of beekeeping are more widely shared within the community. This approach can ultimately lead to enhanced economic stability and sustainability for rural families.

5.5. Research and Policy Support

Research and policy support are essential for the growth and sustainability of the beekeeping industry, as well as for

the preservation of biodiversity and the stability of agricultural systems. Beekeeping plays an important role in crop pollination, honey production, and the creation of other hive-related products such as beeswax and propolis. However, beekeepers face numerous challenges, including environmental threats, disease management, climate change, and economic instability. Targeted research and effective policy interventions are vital for overcoming these challenges and ensuring the continued development of the sector.

5.6. Empowering Women and Youth Through Beekeeping

Beekeeping empowers women and youth and provides a transformative method for driving economic growth, promoting gender equality, and encouraging sustainable agricultural practices. By actively engaging these communities in beekeeping, they gain access to a wide range of opportunities that substantially enhance their livelihoods. Beekeeping not only provides individuals with the opportunity to become financially independent through the selling of honey and other bee-related products, but it also allows them to gain vital skills in agriculture, business management, and responsibility for the environment. Through gaining expertise in beekeeping, women and youth can create small enterprises, which further contribute to their communities' economies.

Abbreviations

FAO	Food and Agriculture Organization
CSA	Central Statistical Agency
CAAS	Chinese Academy of Agricultural Sciences
IZSLT	Istituto Zooprofilattico Sperimentale Lazio e Toscana

Acknowledgments

I would like to sincerely thank the reviewers for dedicating their time and effort to reading and evaluating my manuscript.

Author Contributions

Tadele Alemu Hunde is the sole author. The author read and approved the final manuscript.

Funding

This study did not receive any funding.

Conflicts of Interest

The author declares no conflicts of interest.

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