***Original Research Article***

**Pre-Scaling Up of Modern Beekeeping Technology in Lowanaje Kebele of Dambal District, Sitti Zone, Somali Regional State,** **Ethiopia**

#

# Abstract

*Beekeeping in Ethiopia particularly in the Somali Region remains largely traditional, limiting both productivity and economic impact despite the country’s significant apicultural potential. Although Ethiopia ranks among Africa’s top honey producers, with over 10 million hives and approximately 2 million people engaged in the sector, more than 95% of beekeepers still rely on traditional hives. These yield only 5–7 kg of honey per hive annually, compared to 20–30 kg from modern box hives. The low productivity is attributed to limited access to improved technologies, inadequate management skills, and persistent challenges such as pests, diseases, and insufficient forage.*

*To address these constraints, a participatory research project was implemented in Lowanaje Kebele, Dembel District, within the Somali Region a location with high beekeeping potential but no prior exposure to modern techniques. Twenty-five agro-pastoralists (80% male, 20% female) were organized into two Participatory Agro-Pastoral Research Groups (PAPREGs). They received 15 modern hives, essential beekeeping equipment, and comprehensive training on hive management, modern practices, and post-harvest handling.*

*The Pre-Scaling Up of Modern Beekeeping yielded promising results. Modern hives produced an average of 17.9 kg of honey per hive annually more than double the yield from traditional hives (7 kg) and well above the national average. Participants also reported improvements in honey quality, ease of hive management, and overall perception of modern systems. A cost-benefit analysis revealed that, despite higher initial investment, modern hives offer superior profitability. Key challenges identified included the relatively high cost of modern equipment and the skill required for effective use. Nevertheless, participants widely acknowledged the advantages of modern hives in terms of productivity, product quality, and operational efficiency.*

*Overall, the study demonstrates that participatory introduction and pre-scaling of modern beekeeping technologies can significantly enhance honey yields, increase rural incomes, and improve agro-pastoral livelihoods. To realize the full potential of Ethiopia’s beekeeping sector, the findings recommend scaling up modern hive dissemination, integrating continuous capacity-building programs, and strengthening institutional support particularly for women and marginalized groups to overcome adoption barriers and support sustainable development*.

**Key words**: ***Honey Yield****,* ***Modern Beehives****,* ***Participatory Evaluation****,* ***PAPREGs****,* ***Sustainable Apiculture.***

#  Introduction and back ground

Ethiopia, with its diverse biological and climatic circumstances, is one of Africa’s leading honey producers (2020). Ethiopia has some of the most diverse flora and wildlife in Africa, providing surplus nectar and pollen to foraging bees, and the country has more than 10 million beehives, and around 2 million individuals involved in honey production (Anand 2001 and Chala K et al. 2012). This massive disparity is attributed to the country’s conventional production methods, which result in low output

Beekeeping is one of the most important livestock subsectors that contribute to the improvement of the livelihoods of people in many countries (FAO. (2012). It is also one of the major areas of intervention for poverty alleviation in many developing countries (Amulen et al., [Citation2019](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). Beekeeping is providing nutritional, income-generating, and ecological security to rural communities at the household level. It also assists to increase crop production through honeybee pollination (Amulen et al., [Citation 2019](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070); Tarekegn, et.el., (2017).). Beekeeping is likely to be the most profitable when improved beekeeping technology is used with its full packages (Berhe et al., [Citation2016](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). However, the traditional beekeeping system which results in low production, poor quality, and marketing efforts has kept beekeeping part of the subsistence sector (Meaza, [Citation2010](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070))

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Ethiopia has a potential for beekeeping as the climate is suitable for different vegetation and crops, which are a good source of nectar and pollen for honeybees (Chala et al., [2013](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070); Teklu, [2016](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). Although the country has the potential of producing over 500,000 tons of honey per year, the annual production of honey and beeswax is low compared to its potential (Birhan et al., [2015](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). This is due to the reason that more than 95% of Ethiopian beekeepers use traditional hive management practices that affect yield and quality (CSA. (2017).). The traditional production system poses many challenges that reduce the production and productivity of the subsector (Kalayu et al., [2018](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). Among these, poor management skills, shortage of honeybee forages, disease, and pests are the major ones (Chala et al., [2013](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070); Fikru, [2015](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). So far efforts have been made to tackle this problem such as modification and dissemination of beekeeping technology that increases production and productivity and maximizes benefit from beekeeping in line with sustainable natural resource conservation (Adgaba et al., [2014](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). The annual crude honey yield per traditional beehive is 5–7 kg. It is very low in quantity and quality as compared to the national average of improved box hives, which is 20–30 kg, respectively (Sebeho, [2015](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)). Employing improved beekeeping technology with its full packages enables the beekeeper to produce surplus honey (Teklu, [2017](https://www.tandfonline.com/doi/full/10.1080/23311932.2020.1814070)).

The traditional production system poses many challenges that reduce the production and productivity of the subsector (Kalayu et al., 2018). Among these, poor management skills, shortage of honeybee forages, disease, and pests are the major ones (Chala et al., 2013; Fikru, 2015). So far efforts have been made to tackle this problem such as modification and dissemination of beekeeping technology that increases production and productivity and maximizes benefit from beekeeping in line with sustainable natural resource conservation (Adgaba et al., 2014).

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Different sectors have been striving to disseminate and scale up this technology to improve honey production in Ethiopia (Gebiso, 2015). Despite all these efforts, there has been limited information about factors that influence the adoption of beekeeping technology in the country. Beekeepers have not been able to benefit fully from the technological innovations because of different factors hindering the adoption of beekeeping technology (Berhanu, 2002) and it is difficult to develop a hypothesis that holds true everywhere because of socioeconomic and ecological distinctiveness of the different sites and dynamic nature of most of the determinants (Ehui et al. 2004, Hence, determining factors that influence the adoption of technology is essential for policy makers, researchers and development practitioners to suitably modifying the approach or technology to improve its uptake by end-users (Adgaba et al., 2014)

## JUSTIFICATION

Beekeeping in the Somali Region remains largely underdeveloped and reliant on traditional practices. To improve both the quantity and quality of bee products, it is crucial to introduce modern beekeeping technologies such as improved beehives and to strengthen the knowledge and skills of beekeepers through targeted training and demonstrations.

The Dembal District possesses significant potential for honey production, with a high density of honey bee colonies and abundant bee flora. However, most beekeepers in the area continue to rely on traditional hives, resulting in low productivity. Modern or improved beehives have not yet been introduced to the district and remain unavailable to local beekeepers.

This project aims to pre-scale modern beekeeping technologies to familiarize local beekeepers with improved hives and enhance their productivity. By providing hands-on training and demonstrations, the project will facilitate the adoption of these technologies. Through a participatory approach, the initiative will also evaluate the effectiveness of improved hives, empowering local stakeholders and strengthening the overall performance of the beekeeping sector in the region.

## OBJECTIVES

1. To demonstrate modern beehive technology for the agro-pastoral areas
2. To enhance awareness of the agro-pastoralists on utilization of the modern beehives.
3. To improve the income of agro-pastoralists and evaluate their perceptions of the technology.

#  Expected output

Modern hive technology was implemented and assessed within pastoral settings. The knowledge of agro-pastoralists regarding contemporary beehive technology was enhanced. The income levels of agro-pastoralists increased, and their attitudes toward the technology were examined.

# Methodology

## Description of the target project area

## Dembel is a woreda (district) located in the Somali Region of Ethiopia, within the Sitti Zone (formerly known as Shinile Zone). It is bordered by Shinile to the west, Ayesha to the north, and the Jijiga Zone to the east and south.

## This project was conducted in Lowanaje Kebele, a locality within Dembel woreda, which is particularly known for its beekeeping potential. Despite the area's natural suitability for apiculture, the majority of local beekeepers still rely on traditional methods, which contribute to low honey production and limited productivity.

## According to the 2017 population census by the Central Statistical Agency (CSA) of Ethiopia, Dembel woreda had a total population of 206,611comprising 156,531 men and 50,080 women. Among them, 18,360 were urban residents, while 88,251 were pastoralists. A comparison with the 2007 CSA census shows that the population was then 182,286, with 75,094 men and 57,192 women. At that time, 13,648 individuals (16.59%) lived in urban areas, and 17,950 (21.81%) were engaged in pastoralism. Additionally, 99.3% of the population identified as Muslim.

## Historically, the residents of Dembel have practiced crop farming since 1965. However, cropproduction declined significantly between 1989 and 2001 due to recurrent prolonged droughts. Today, approximately 35–45% of the population are pastoralists, while 55–65% are agro-pastoralists who cultivate mainly sorghum and rear livestock.

## Establishment of PAPREG

## A total of twenty-five agro-pastoralist individuals were selected based on their interest, experience in beekeeping, and the abundance of honey bee colonies in traditional hives. These individuals were grouped into two PAPREGs. Among the 25 agro-pastoralists, 20 were males and 5 were females, particularly those from households headed by women

## Experimental Design and Data Collection

The site was purposively selected considering the availability of common bee forage, ease of access for transportation, and the socioeconomic value of bee products. The Dambal district (specifically Lowanaje Kebele) pastoral association was chosen based on issues identified by the agro-pastoralists during the needs assessment. Fifteen Modern hives were purchased and distributed to the PAPREG groups, with receiving fifteen traditional hives containing colonies. Colony transfer and all management activities were carried out by Kebele development agents and PAPREG members as well as researchers.

## Roles of each actor

During the delivery of the modern hive to the PAPREG, a multidisciplinary research approach was employed, involving a team of researchers, extension workers, and pastoralists working together to address specific topics based on the needs of the pastoralist. The researcher’s role was to provide adapted, improved, and profitable technology, as well as to deliver training to the beekeeper. Extension workers supported the formation of the PAPREG and provided ongoing support throughout the implementation process, supervised follow-up activities, and facilitated data collection through collaboration with development agents. These agents gathered important information, supported activities among pastoralists and agro-pastoralists, and linked them with other beekeepers. A group of pastoralists organized together participated in activities such as apiary site selection, hive construction, and transferring colonies from traditional to modern hives. The LLRP program purchased and provided modern beehives to support the pastoral and agro-pastoralist beekeepers

## Training of PAPREG

Following the formation of the PAPREG, theoretical and practical training sessions were conducted for the beekeeper and development agents at the project site, as modern hives were new to the district’s beekeepers. The training covered topics including bee biology, beekeeping systems, routine colony management and inspection, transferring colonies from traditional to modern hives, honey harvesting, post-harvest handling, marketing of bee products, and the benefits of modern hives. The project introduced several proven and recommended beekeeping technologies to enhance production and improve the livelihoods of the beekeeper. Inputs provided during demonstrations included wax casting molds, queen excluders, smokers, water sprayers, hive chisels, bee brushes, honey sieves, 15 modern hives with frames, protective clothing, and honey extractors.

## Data analysis

## The collected data was analyzed using descriptive statistics including percentages, frequencies, means, minimum and maximum values, and standard deviations through SPSS version 20 software. Additionally, qualitative data was examined using a method that involved explaining ideas, opinions, and concepts.

## Data Collection and Analysis

During the project, data were collected on honey yields from various hive types (modern and traditional) and farmers' attitudes toward improved beekeeping technologies, which were then analyzed using descriptive statistic

# Result and discussions

 **Demographic characteristics of PAPREG members.**

As shown in Table 1 attained of the overall beekeepers 80% of PAPREG members were male-headed and 20% were female members. When move toward the educational level of PAPREG beekeepers were categorized as those who have joined informal education (16%), and attended primary school (32%), were secondary school attended (44%), and high school and above (8%), This shows that record PAPREGs, who participated in this project, be present at secondary schools. Age of the respondents between 20 – 40year were (64%), were Age between 41-59 years (28%), and age Above 60 were (8%). Regarding beekeeping experience, nearly above (56%) had more than 15 years of experience, That Indicating a level of familiarity with beekeeping. For the meantime, 24% had between 10 - 15 years of experience. Only 20% had less than 10 years of experience, showing that while some emerging and connecting the sector, the majority have been engaged in beekeeping for long period. This overall participant suggests that targeted training programs, especially those personalized to the needs of less-educated but skilled male and young beekeepers could enhance productivity and sustain in the sector.

**Table 1: Profile of PAPRAGs of Participant Beekeeper in Lowanaje Kebele.**

|  |  |  |
| --- | --- | --- |
| **Participant’ Profile** | **Frequency(N)** | **Percent (%)** |
| Sex | Male | 20 | 80% |
| Female | 5 | 20% |
| Age Category | 20-40  | 16 | 64% |
| 41-59 | 7 | 28% |
| Above 60 | 2 | 8% |
| educational level | Informal education | 4 | 16% |
| Primary school | 8 | 32% |
| Secondary school  | 11 | 44% |
| High school and above | 2 | 8% |
| Beekeeping Experience | Less than 10 years | 5 | 20% |
| 10-15 years | 6 | 24% |
| More than 15years | 14 | 56% |

#

#  Training and capacity building of PAPREG members.

 Capacity building of the PAPREG members is one of the important components to conduct research in the PAPREG approach. It is a tool which PAPREG, researchers and DAs use frequently to introduce new technology, sensitize to important issues and capacitate pastoral and Agro pastorals observation, recording, analyzing of knowledge and skills gained from demonstration of modern bee hives.

The training effectively increased awareness of the benefits and challenges associated with modern hive technology, fostering better adoption and implementation. Participant feedback indicates a positive reception, with suggestions for improving future training sessions to enhance practical skills and community engagement. The inclusion of discussions with local authorities facilitates smoother coordination and sustainability of interventions.

As table 2 indicates. A total of 25 PAPERG members, 12 non-PAPREG members, 2 DA’s and 7 local authorities were trained on participatory research approach, how to enhance honey production and productivity to know and understand the modern beehive installations, bee management and the advantages and disadvantages of modern bee hive technologies. Beside this, discussion was conducted with PAPREG members, DAs, and kebele administrators for smooth implementation of the planned activities in the project. Finally, researchers collected the comments and suggestions on the organized training and discussion for future improvement.

**Table.2 Training and capacity building**

|  |  |  |
| --- | --- | --- |
| Participated The Field Day | Frequency | Percentage |
| PAPREG members  | Male  | 20 | 80 |
| Female | 5 | 20 |
| Non PAPREG members  | Male  | 10 | 83.3 |
| Female | 2 | 16.7 |
| Das  | Male  | 2 | 100 |
| Female | 0 | 0 |
| Woreda administrators  | Male  | 5 | 71.4 |
| Female | 2 | 28.6 |
|  |

#  Honey of yields of hive types.

Table 3 shows that the average annual honey yield per hive was 7 kg for traditional hives and 17.9 kg for modern hives. There was a significant difference in honey production among the various hive types, while seasonal variations had a relatively minor effect. These results surpass the national average yields, which are reported to be 5 kg for traditional hives and 15–20 kg for modern hives (CSA, 2021), highlighting the strong potential for beekeeping in the study areas.

Yirga et al. (2012) noted that productivity tends to increase with better hive management, beekeeper experience, and favorable environmental conditions. Similarly, Kiros and Tsegay (2017) reported average honey yields of 15–20 kg per year for modern hives, which aligns closely with the findings of this study.

Furthermore, the honey yields observed here exceeded those reported by Taye et al. (2015), who found yields of 5.65 kg and 21.02 kg per year for transitional and modern hives, respectively. Beyene et al. (2016) also indicated that traditional Ethiopian hives typically yield between 5 and 8 kg of honey annually. It is worth noting that honey from traditional hives often contains wax, bee parts, pollen, and other impurities, earning it the designation of "crude honey" (Awraris et al., 2012)

**Table 3: Average honey yield production year from different hive types**

|  |  |  |  |
| --- | --- | --- | --- |
| **Hive type** | **Average yield per hive per season** |   **overall** | **Average yield /year (kg)** |
|  | **season 1** | **season 2** | **Mean** | **Total yield per hive** |
| Traditional | 3+0.65 | 4+0.57 | 5.5+0.65 | 7 |
| Modern | 7+0.65 | 10.9+0.53 | 8.45+0.5 | 17.9 |
|  |  |  |   |  |

# Cost-benefit analysis

# The cost-benefit analysis presented in Table 4 compares honey production outcomes between modern hives and traditional hives, highlighting differences in costs, yields, and profitability.

## Initial Investment Costs:

The cost of establishing 15 modern hives is significantly higher (52,500 ETB) compared to traditional hives (22,500 ETB). This reflects the higher unit price of modern hives (3,500 ETB) versus traditional ones (1,500 ETB). Such an investment aligns with literature emphasizing the higher initial costs associated with modern beekeeping equipment (Abebe & Tesfaye, 2018). Operational Costs:

Load and unloading costs are incurred only for modern hives (3,000 ETB), possibly due to transportation or handling complexities. Transportation costs for modern hives are 9,000 ETB, whereas no transportation costs are recorded for traditional hives, perhaps indicating local or less expensive transportation methods (Gebremedhin et al., 2019). Labour costs are higher for traditional hives (4,000 ETB) because of potentially more manual handling or less efficient practices, whereas modern hive management costs are lower (2,000 ETB). This aligns with studies indicating that modern hive systems often require less labour per unit of honey produced (Sileshi et al., 2020). Variable Costs and Total Costs:

Total variable costs are higher for modern hives (42,000 ETB) compared to traditional hives (11,000 ETB), primarily due to higher initial investments and transportation. The lower variable costs per unit of honey for modern hives suggest better efficiency. Honey Yield and Production:

Honey yield per hive is substantially higher in the modern hive system (7 kg per hive) than in traditional hives (3 kg per hive). Consequently, total honey production is also higher (105 kg vs. 45 kg), resulting in a total income of 105,000 ETB for modern hives compared to 45,000 ETB for traditional hives. Literature supports that modern hive technology generally improves honey yields due to better hive management, disease control, and colony health (Tadesse et al., 2017). Net Returns:

The net return (profit) for modern hive beekeepers is approximately 2,696 ETB, more than double the 1,100 ETB for traditional hives. This indicates that despite higher initial and operational costs, modern hives yield higher profitability (Yilma & Kebede, 2019). Conclude that while modern hive systems require higher capital investment, the increased honey production and income justify the costs over time.

Table 4 Cost-benefit analysis of honey production

|  |  |  |
| --- | --- | --- |
|   |  Modern Hive   | Traditional Hives |
| list item | Unit | Quantity | Unit Price | Total Price | Unit | Quantity | Unit Price | Total Price |
|  |  |  |  |  |  |  |  |  |
| number hive used | No | 15 | 3500 | 52500 |   | 15 | 1500 | 22500 |
| load unloading cost  | ETB | 15 | 100 | 3000 | ETB | 0 | 0 | 0 |
| Beehive colony  | No. | 15 | 500 | 7500 | No | 15 | 500 | 7500 |
| Transportation cost | Birr | 1 | 9000 | 13004 | -  | -  | -  | -  |
| labour Cost | #person | 15 | 400 | 2000 | person | 15 | 400 | 4000 |
| variable cost | ETB |  - | -  | 42000 | ETB |   |   | 11000 |
| Honey yield in kg | Kg | 7 | 1000 | 7000 | Kg  | 3 | 1000 | 3000 |
| Total honey production  | Kg | 105 | 1000 | 105000 | Kg  | 45 | 1000 | 45000 |
| Total income | ETB |   |   | 105000 | ETB |   |   | 45000 |
| Net return  | ETB |   |   | 2696 | ETB |   |   | 1100 |
|  |  |  |  |  |  |  |  |  |

# Pastoralist agro-pastoralist perception of the technology

Pastoralist agro-pastoralist perception of the technology after the demonstration of frame beehive technologies, the feedback obtained from the PAPREG members indicated that frame hive was deserved for ease of management, honey yield, on the quality of honey. In addition to this frame hives are very easy to handle by women compared to traditional hives. Based on the results indicated in Table 5 the high honey yield, quality honey, and ease of management make the frame hive is more preferable to the old ones

Understanding the perceived advantages and disadvantages of improved beekeeping technology is crucial for assessing beekeepers' attitudes and implementing appropriate interventions. Most PAPREGs and indirect beneficiaries noted the primary benefits of improved beekeeping technology as Increased Yield (59.5%), Ease of Management (24.3%), Easy of honey extraction (10.8) and ease of Pest control (5.4%). Conversely, they also identified significant drawbacks, including high costs (64.9%), the necessity for advanced skills man power (24.3%), and the requirement for additional complexity (10.8%) (Table 5). Overall, these findings suggest that beekeepers view improved beekeeping technology positively, presenting a valuable opportunity for beekeeping extension initiatives. This indicates that beekeepers had positively perceived improved beekeeping technology which is a good opportunity for beekeeping extension intervention. This result is in line with the findings of Yehuala, S., Birhan, M., & Melak, D. (2013). and Affognon, et,el., (2015). who found that perception influences the adoption of beekeeping technology.

**Table 5: perception and attitude of beneficiaries toward the technologies**

|  |  |  |  |
| --- | --- | --- | --- |
| **Advantages of the Technologies** | **PAPREG members (25)** | **Non PAPREG members (12)** | **Overall (41)** |
|  Increased Yield  | 15(60%) | 7(58%) | 22(59.5%) |
| Ease of Management | 7(28%) |  2(17%) | 8(24.3%) |
| Better Honey Extraction:  | 2(8%) | 2(17%) | 4(10.8%) |
| Pest control  | 1(4%)  | 1(8%) |  2(5.4/%) |
|  Disadvantages of the technologies |   |   |   |
| Cost | 17(68%) | 7(45.45%) | 24(64.9%) |
| Require skill manpower | 5(20%) | 4(36.36) | 9(24.3%) |
|  Complexity | 3(12%) | 1(18.18%) | 4(10.8%) |

# Conclusion and Recommendation

The introduction of modern beekeeping technology in Dembel District, Somali Region, has demonstrated clear benefits over traditional methods. The project, which involved participatory groups of agro-pastoralists (PAPREGs), showed that modern hives significantly increased honey yields averaging 17.9 kg per hive compared to 7 kg from traditional hives. This yield is not only substantially higher than traditional methods but also meets or exceeds national averages for modern hives, indicating strong local potential for beekeeping advancement.

The demographic profile of participants revealed that most were experienced beekeepers, predominantly male, and within the productive age range of 20–40 years. Training and capacity-building efforts were well-received, increasing awareness and practical knowledge about modern hive management, installation, and the broader benefits of technological adoption. Feedback from participants and local authorities was positive, with suggestions for further enhancing practical skills and community engagement.

Despite Ethiopia’s vast potential for honey production, the sector has been hampered by reliance on traditional practices, resulting in low productivity and quality. The project’s participatory, hands-on approach facilitated technology transfer and empowered local stakeholders, leading to improved productivity, income, and positive attitudes toward modern beekeeping.

To enhance honey production and rural livelihoods, the project recommends scaling up the use of modern beehives in high-potential areas, backed by hands-on training tailored to both experienced and less-educated beekeepers. Strengthening partnerships among researchers, extension agents, and local authorities is key to providing continuous technical support. Promoting gender inclusion by engaging more women and female-headed households is also vital. Additionally, regular monitoring and evaluation should guide improvements in training and technology uptake, while ensuring beekeepers have access to essential tools and reliable markets to sustain the benefits of modern beekeeping.

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# Lessons Learned

1. Training, monitoring and evaluation, and field days play pivotal roles in creating awareness and demand-driven technology dissemination.
2. Participation of different stakeholders in collaboration in agricultural production and productivity improvement activities plays an important role in transferring innovative modern beekeeping technology to extension agents and farmers.
3. Understanding Local Needs: Successful technology transfer requires a deep understanding of local farming practices and environmental conditions to familiarize solutions effectively.
4. Training and Support: Providing adequate training and ongoing support is crucial for farmers to effectively adopt and utilize modern beekeeping technologies.
5. Collaboration with Farmers: Engaging farmers in the development and evaluation of new technologies fosters ownership and encourages adoption.
6. Economic Incentives: Signifying the economic benefits of modern hives, such as increased honey yield and pollination services, can motivate farmers to invest in new technologies.

#  Future Focus

1. Integrated Farming Systems: Promoting the integration of beekeeping with other agricultural practices to enhance biodiversity and crop yields, benefiting both bees and farmers.
2. Smart Technologies Focusing on smart hive technologies, including sensors and data analytics, to improve hive management and productivity.
3. Community-Based Approaches: Developing community programs that facilitate knowledge sharing and collective investment in modern beekeeping technologies.
4. Sustainable Practices: Emphasizing sustainable practices that align with environmental conservation and support healthy ecosystems.

#  Challenges

1. Cultural Resistance: Overcoming traditional practices and resistance to change can be a significant barrier to technology adoption.
2. Access to Resources: Limited access to financial resources or affordable technology can hinder farmers from investing in modern hives.
3. Education Gaps: Variability in education levels among farmers may require tailored training approaches to ensure effective learning.
4. Pest and Disease Management: Addressing the challenges of pests and diseases, which can undermine the benefits of modern hives if not managed effectively.

# Opportunities

1. Increased Pollination Services Highlighting the role of bees in improving crop yields through effective pollination can drive interest in modern beekeeping among farmers.
2. Encouraging farmers to explore honey production as a supplemental income source can enhance their economic resilience.
3. Collaborate with universities and research institutions to develop innovative beekeeping technology that meet farmers' needs.
4. Market Expansion: Leveraging the growing demand for local, organic, and sustainably produced honey to create new market opportunities for farmers. By focusing on these lessons, challenges, and opportunities, the transfer of modern beekeeping technologies to farmers can lead to more sustainable and productive agricultural practices.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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it was significantly lower than the average yield of 20 and 22