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Multiple values of beekeeping (with *A. mellifera*) as an element of diversified, agroecological coffee farms in Chiapas, Mexico

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Abstract

Honeybees (*Apis mellifera*) and native bee species have ecological, economic, social, and cultural importance to smallholder coffee farmers. While the ecological contributions of bees to the sustainability of coffee systems are well documented, particularly in relation to the coffee crop, fewer studies have examined socio-economic dimensions of beekeeping for honey as an agroecological diversification strategy for coffee producers. Yet, understanding the multiple values of different diversification strategies is important as many coffee farmers in different parts of the world are finding it increasingly difficult to make a living on coffee alone and are adopting alternative strategies, such as on-farm diversification. In this Participatory Action Research (PAR) study, we examined the opportunities, limitations, and trade-offs of beekeeping (with *A. mellifera)* as an agroecological diversification option for smallholder coffee farmers in Chiapas, Mexico. We applied a mixed-methods approach, which consisted of monthly surveys with 25 beekeepers of *Campesinos Ecológicos de la Sierra Madre de Chiapas (CESMACH)/Apicultores Miel Real del Triunfo (ART)* producer cooperatives for 12 months and five focus groups between 2018 and 2019. We found that beekeeping is less labor-intensive than coffee, and there are opportunities to integrate beekeeping into the annual farming cycle of coffee and maize production without causing competing labor demands or additional time pressures. We also found that beekeeping could generate economic gains for peasant families; however, profitability hinged on various factors, such as the price for honey, yield per hive, and the number of beehives. Our results further show that beekeeping yielded multiple non-monetary benefits by contributing to the nutrition and health of farmer families and their communities, serving as a vehicle for horizontal learning and relationship building, and contributing to the emotional well-being of beekeepers. Finally, producers who hoped to gain economically from beekeeping were generally interested in growing their apiaries but expressed concerns about limited technical knowledge and the impacts of climate change. Given the multiple social, economic, and ecological benefits of beekeeping, it has great promise as a part of agroecological food and farming systems. We argue that efforts to promote beekeeping as a diversification strategy should take a holistic approach, underscoring the potential of apiculture to enhance the well-being and resilience of beekeeping families and strengthen food sovereignty and local economies (including solidarity economies) in peasant communities. These findings can be useful in supporting beekeepers and their organizations in strategic planning for enhancing the long-term sustainability of beekeeping.

Introduction

Bees have ecological, economic, social, and cultural importance to smallholder coffee farmers. Both honeybees (*Apis mellifera*) and native bee species contribute to the pollination of various plant species in shade-coffee agroecosystems, including important food crops and coffee (Vandame et al., 2012; Perfecto and Vandermeer 2015; Imbach et al., 2017; Martínez-Salinas et al., 2022). Beekeeping can reduce dependency on coffee income and decrease smallholder farmers' vulnerability to persistent disturbances, such as fluctuating coffee prices and climate change (Bathfield et al., 2013; Anderzén et al., 2020). While the ecological contributions of bees to the sustainability of coffee systems are well documented, particularly in relation to the coffee crop (e.g., Ricketts et al., 2004; Perfecto and Vandermeer, 2015; Martínez-Salinas et al., 2022), fewer studies have examined socio-economic dimensions of beekeeping as a

diversification strategy for coffee producers (Bathfield et al., 2013; Anderzén et al., 2020; Guzmán Luna et al., 2022; Bacon et al., 2023).

This Participatory Action Research (PAR) study presents novel findings about beekeeping as an element of diversified, smallholder coffee systems in Chiapas, Mexico. This study is a part of a broader PAR process with *Campesinos Ecológicos de la Sierra Madre de Chiapas* (CESMACH) coffee cooperative, its sister organization for beekeepers, *Apicultores Miel Real del Triunfo* (ART), and other partners. In this article, we examine the opportunities, limitations, and trade-offs of beekeeping as an agroecological diversification alternative for smallholder coffee farmers of CESMACH/ART. The article draws on a mixed-methods study to address the following research questions:

(1) How does beekeeping align with other activities within the annual agricultural calendar of the farmer families, and how do beekeeper-coffee farmers allocate their labor?
(2) Under what conditions can beekeeping be an economically viable diversification alternative for smallholder coffee farmers?
(3) What non-monetary values do farmers associate with beekeeping?
(4) How do farmers perceive the future of beekeeping in the context of climate change and other risks?

The first question draws our attention to time use and seasonality, important dimensions for understanding synergies and trade-offs among different agricultural activities (Niehof, 2004; Lentz et al., 2019). Coffee farming is time and labor-intensive, and in addition to coffee, smallholder farmer families often grow various other crops and animals (Fernandez and Méndez, 2018; Guzmán Luna et al., 2022; Bacon et al., 2023). For these families, adding new agricultural activities can be integrated into the seasonal rhythms of the farm or, conversely, may cause time-use conflicts (Niehof, 2004). In section '"Beekeeping is easy": combining beekeeping with coffee and maize production', we discuss the labor demands for beekeeping and how various tasks related to beekeeping align with those of other agricultural activities that peasant families carry out over the annual production cycle.

For the second question, we explore baseline factors that contribute to the economic outcomes of beekeeping. Prior studies on small-scale beekeeping have shown that economic benefits from managing honeybees are associated with several factors, including the number of hives, production costs, volume of honey, price of honey, or combinations of these (Vandame, 2008; Magaña Magaña et al., 2016; Schouten, 2020). In section 'Is beekeeping economically lucrative?', we explore the costs and income from beekeeping for the beekeepers of ART and use this information to discuss the short- and long-term economic sustainability of beekeeping in the context of diversified smallholder farming in Chiapas.

The third question examines the non-monetary values of beekeeping. Agricultural processes are embedded in a broader system that 'includes the social, cultural, and environmental processes of society' (Ament et al., 2022). Hence, farmers' decisions and actions are rarely based on economic rationality alone but are affected by various other factors, including social dynamics and relational values. The latter refers to non-economic values that shape agriculture and the relationship humans experience with land and nature (Himes and Muraca, 2018; Caswell et al., 2021; Bezner Kerr et al., 2022). In section 'It's also about nutrition, relationships, and joy', we explore how ART farmers described the extra-economic ways beekeeping benefits them, their families, and communities.

The fourth research question centers on farmers' perceptions of the future of beekeeping. Existing research shows that changing climate, pests, and diseases, as well as pesticide use are among critical challenges that have implications for the well-being of bees and the quantity and quality of honey (IPBES, 2016; Carrera Palí, 2018; Vercelli et al., 2021; Baena-Díaz et al., 2022). In section 'The future of beekeeping', we discuss how farmers of ART described the potential risks related to managing honeybees and how they perceive their future in beekeeping.

This study adds new insight into agricultural diversification in smallholder coffee systems by providing a more nuanced understanding of socio-economic and temporal aspects of beekeeping. This research is also timely, as many coffee farmers in different parts of the world are finding it increasingly difficult to make a living on coffee alone and are adopting alternative strategies, such as on-farm diversification, to cope with socio-economic and ecological challenges (Harvey et al., 2021; Anderzén et al., 2021; Bacon et al., 2023). The results from this study can support coffee farmers and their organizations in evaluating if beekeeping is a sustainable alternative for on-farm diversification. While our data emerge from a specific context in Southern Mexico, we believe these findings and our methodology are relevant specifically in contexts where small- and medium-scale coffee farmers make decisions about if and how to diversify their farms.

Beekeeping as an agroecological diversification alternative for coffee farmers

Diversity and diversification are foundational principles in agroecology, a holistic approach that strives for sustainable transitions and transformations within our farming and food systems (CIDSE, 2018; HLPE, 2019; Anderson et al., 2021). Mounting scientific and experiential evidence shows that diversified, agroecologically managed systems tend to be more resilient to various risks and disturbances (Gliessman, 2015; de Roest, IPES-Food, 2016; Ferrari, and Knickel, 2018; McCune et al., 2019). Importantly, they can contribute to food security and sovereignty, as people produce culturally and seasonally appropriate nutritious food, rely less on purchased products, and gain greater autonomy from extractive economies that accumulate wealth for corporate actors with negative consequences and few benefits for small-scale producers and local communities (Jones, 2017; Luna-González and Sørensen, 2018; Guzmán Luna et al., 2022). Diversified systems can also generate multiple sources of income, thus helping manage economic risks (Niehof, 2004). Additionally, they can contribute to social and solidarity economies in farming communities as families exchange or sell agricultural products locally (CIDSE, 2018).

Managing bees for honey is an agricultural activity that peasant farmers have integrated into their farming systems for centuries. Archeological evidence shows that people in different geographies have been collecting honey and beeswax by various methods for thousands of years. The 'modern' commercial forms of beekeeping are rooted in the 19th century when the movable comb hive for managing the western honeybee (*A. mellifera*) was developed (Crane, 1999). Over time, management of *A. mellifera* has become an attractive option for agricultural diversification. Compared to many other agricultural activities, the time and input requirements are relatively low, and beekeeping can generate returns on investment rapidly (Schouten, 2020).

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Additionally, bees produce honey and other medicinal beehive products that contribute to the health and well-being of farmer families and communities. These products can also be stored and sold to generate additional income streams throughout the year (Bathfield et al., 2016; Dolores-Mijangos et al., 2017; Gerlicz et al., 2018; Anderzén et al., 2020).

Beekeeping and coffee production can make a good match. While exact data on the prevalence of beekeeping in coffee landscapes are lacking, we know from our long experience of working with different honey and coffee producer groups in Southern Mexico and Central America that it is common for smallholder coffee farmers in the tropics to manage honeybees and/or native bees on their farms. As apiaries do not require much space, they can often be integrated within coffee farms with limited land (Bathfield et al., 2016). Agroecological shade-coffee systems, common in smallholder coffee landscapes, provide suitable conditions for bees to thrive, as these biodiverse systems provide habitat and forage (Perfecto and Vandermeer, 2015). Bees also benefit these systems and their stewards. Both native bees and honeybees help pollinate many important food and cash crops such as coffee, thus contributing to farmers' and their communities' food and livelihood security (Klein et al., 2007; Cely-Santos and Lu, 2018; Martínez-Salinas et al., 2022; see Figs. 1 and 2). A recent study shows that bees' pollination services positively impact fruit set, fruit weight, and fruit uniformity of coffee (Martínez-Salinas et al., 2022). In another study, members from *Equipo Abejas* ('Bee team') at El Colegio de la Frontera Sur (ECOSUR) and the UVM Institute for Agroecology (formerly called the UVM Agroecology and Livelihoods Collaborative) at the University of Vermont worked with farmers from CESMACH to calculate the contributions of pollinators to food crops produced in coffee plantations. They found that approximately 24% of the food harvested from coffee plots could be attributed to bees and other animal pollinators (Equipo Abejas, CESMACH and ALC, 2022; see Fig. 2).

While the beneficial contributions of bees to coffee production are relatively well established, less is known about the direct socio-economic impacts of beekeeping for farmers and their communities. We conducted a baseline study with CESMACH farmers, finding that coffee farmer households who managed bees and grew basic grains in addition to coffee experienced fewer months of seasonal food insecurity and were generally more satisfied with their annual income (Anderzén et al., 2020). Similar results were reported from coffee regions in Nicaragua (Guzmán Luna et al., 2022; Bacon et al., 2023). These findings prompted us to continue exploring the opportunities and challenges of beekeeping as a diversification strategy. In this article, we describe our findings on four socio-economic dimensions—time use/seasonality, economic benefits, non-monetary values, and the future.

Approach and methods

Participatory Action Research (PAR) approach

PAR is a research approach that seeks to co-create knowledge (Utter et al., 2021) where research teams made up of actors with different knowledge and ways of knowing (e.g., scientists with local farmers) engage in horizontal research processes through iterative cycles of research, action, and reflection (Caswell et al., 2021; Maughan and Anderson, 2023). This study emerged in the context of a broader PAR process that was launched in 2017 with two smallholder coffee cooperatives, CESMACH in Mexico and PRODECOOP in Nicaragua, and other partners. The PAR process aimed to co-create actionable knowledge of the characteristics, benefits, and limitations of different types of agricultural diversification approaches in smallholder coffee communities (see Anderzén et al., 2020; Bacon et al., 2021; Guzmán Luna et al., 2022; Bacon et al., 2023; Anderzén, 2023).

Reflections on the first phase of the PAR process, described more fully by Anderzén et al. (2020) and Guzmán Luna et al. (2022), resulted in the development of this study. The results of the first phase pointed to many beneficial outcomes from beekeeping, which raised an interest among the staff and board members of CESMACH and ART. Additionally, members of the *Equipo Abejas* had previously developed and applied a methodology to assess the costs and benefits of beekeeping (Vandame, 2008) and were interested in replicating a similar study with coffee farmer-beekeepers in the Sierra Madre de Chiapas. As a result, a team consisting of farmers, practitioners, and researchers from CESMACH/ART, *Equipo Abejas*, the UVM Institute for Agroecology, and a supporting NGO called Food 4 Farmers collaborated to articulate the goals of the study, co-design a

Figure 1. Western honeybee (*A. mellifera*) on a coffee flower (photo: Janica Anderzén); and beekeepers of ART at a training (photo: Food 4 Farmers).

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Figure 2. A poster illustrating the contributions of animal pollinators to food production in coffee plantations in Sierra Madre de Chiapas. The poster was co-created with farmers from CESMACH/ART (Equipo Abejas, CESMACH and ALC, 2022; design by Daniela Gallardo Olimón; high-resolution version available at https://bit.ly/3lh4ylN).

methodology, and conduct the study. In between the activities, the team communicated regularly via Zoom and WhatsApp, and whenever possible, met in person. A beekeeping specialist from *Equipo Abajas* visited CESMACH/ART on several occasions.

The study site

In Mexico, beekeeping dates to prehispanic times. The ancient Mayas and other Indigenous groups, like the Nahua, Totonaca, and Chontal, were experts in stingless beekeeping (meliponiculture), a practice that continues today in many parts of Mexico (Quezada-Euán, May-Itzá, and González-Acereto, 2001). Management of *A. mellifera* is a more recent activity that has steadily grown in importance nationwide. In 2019, Mexico ranked as the ninth biggest honey producer globally, having approximately 43,000 beekeepers (Secretaría de Agricultura y Desarrollo Rural, 2020).

Chiapas is among Mexico's most significant honey producer states (Secretaría de Agricultura y Desarrollo Rural, 2020). In contrast to other producing states like Jalisco, many producers in Chiapas operate on a small scale—a study from 2016 found that the average number of hives in Chiapas was 21, while in Jalisco beekeepers managed an average of 335 hives (Magaña Magaña et al., 2016). ART is one of several honey producer organizations representing and supporting small honey producers in Chiapas. Officially founded in 2018, ART maintains close ties with its sister cooperative, CESMACH, that focuses on the commercialization of coffee. Most members of ART belong to CESMACH as well. The two organizations have their facilities in the small town of Jaltenango de la Paz, with most producers living in the municipalities located in the mountains of the Sierra Madre de Chiapas. In 2019, ART's 85 member beekeepers produced 31 tons of honey that was sold to one buyer in bulk. Some producers also traded honey on a small scale in their communities. The cooperative does not hold any sustainability certificates, but due to their management practices that align with many of the requirements for certified organic honey, ART calls its honey 'agroecological'.

Member farmers of CESMACH typically manage diversified farms to support and feed their families, with honey being one of the few agricultural products that have an established infrastructure to facilitate commercialization in addition to coffee (Anderzén et al., 2020; Guzmán Luna et al., 2022). Management of honeybees (*A. mellifera*) is a relatively recent activity among the farmers, which has been supported by nonprofits like Food 4 Farmers (F4F) and governmental programs over the past decade. The region provides suitable conditions for beekeeping—it is home to *El Triunfo Biosphere Reserve*, a biodiversity hotspot with abundant floral resources (Vandame et al., 2012). Membership in ART can lower barriers to becoming a beekeeper, as the organization provides technical and material support and commercial connections to its members.

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Methods and analysis

Mixed-methods approach

We used various participatory research methods, all co-designed among the team members and approved by the Institutional Review Board of the University of Vermont (UVM). For 12 months between 2018 and 2019, we worked closely with 25 beekeepers (six women and 19 men) from 13 rural communities. Twenty beekeepers had participated in the baseline survey of the PAR project (see section 'Participatory Action Research (PAR) approach'), and we invited five additional beekeepers from ART to increase the size and diversity of the group. The participating beekeepers represented producers of different sizes, geographies, and experience levels. Two beekeepers were members of CESMACH but not ART and thus did not sell their honey to the organization.

One of the key data collection methods was a household survey, adapted from a method that members from Equipo Abejas had designed and used in the past with other groups (Vandame, 2008; see Supplementary materials for more details). The survey consisted of seven sections with questions on production costs, family labor, honey sales, bee ecology, nutrition, and other benefits of beekeeping. After piloting the survey, the local team—consisting of five community promoters from the cooperative, the local coordinator, and on some occasions, a PhD student from UVM (Anderzén)—visited each participating beekeeper monthly for a year, using tablets to record the responses. The questions on the costs of production and family labor were repeated every month, while other questions were asked once.

Our PAR team facilitated five focus groups between 2018 and 2020. Focus group as a research method offers the opportunity to gain insights into the experiences of individuals and groups, and collect in-depth data on complex topics (Morgan, 1997; Creswell, 2013). Two focus groups were centered on the future of beekeeping and the impacts of climate change. Additionally, we conducted three focus groups in which CESMACH farmers worked in small groups to create an agricultural calendar showing all tasks that go into coffee farming, beekeeping, and maize production annually (see Fig. 3).

One of the principles of PAR is sharing results with the people and communities participating in the study, which also represents essential moments of reflection (Méndez et al., 2017). After a year of data collection, team members from UVM, F4F, and ECOSUR systematized the data, prepared a summary of the costs of production and earnings for each participant, and validated the summaries with everyone individually. The team also hosted sessions with CESMACH and ART staff, board members, and a group of beekeepers to discuss the results, which prompted much discussion around the implications and applicability of the findings.

Analysis

We used Excel to systematize the survey data and calculate descriptive statistics, and for statistical tests, we used R software (R Core Team, 2022). For data that were non-normal and included some exceptionally high values, we used the median to represent average values instead of the mean in the data tables (in the text, we use 'average' to refer to median values). We used a linear regression analysis to assess the association between three independent variables (number of beehives, yield per hive, and production costs) and a dependent variable (net income from beekeeping) to identify which factors had the most considerable effect on economic profitability. As for the qualitative data, we recorded and transcribed all focus groups and coded the transcriptions using NVivo 12 (QSR International Pty Ltd., 2018). We used thematic analysis to identify, analyze, and report themes within the data (Nowell et al. 2017 2006). We included representative quotations from the beekeepers to honor their voices. In our analysis and reporting, we triangulated findings from all our data sources.

Results

Characteristics of beekeepers

The characteristics of participating beekeepers mirrored the different types of producers in the organization, ranging from small operations with less than ten hives to beekeepers with more than 50 hives (see Table 1). On average, producers managed 26 hives and had one apiary. Four beekeepers produced honey in two

Figure 3. Early versions of the agricultural calendar created in a focus group (photos: Janica Anderzén).

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Table 1. General characteristics of beekeepers

Characteristics	Mean (s.d.)	Min.	Max.
Age of the beekeeper	43 (12.3)	21	66
Years of experience in beekeeping	6 (3)	2	17
# of hives	26 (16)	6	75
# family members working regularly in beekeeping	2.2 (1)	1	4

apiaries, and the group's largest producer (75 hives) managed four apiaries. Most apiaries were stationary, while three producers practiced mobile beekeeping and moved their hives once a year to lower elevations. The annual production volumes varied from 80 to 4463 kg per beekeeper, and the yield per hive ranged from 4 to 59.5 kg. Table 2 shows differences in honey production among small (<20 hives), medium (21–40 hives), and large (41 > hives) producers. Compared to other beekeepers in Chiapas, the number of hives that the beekeepers of ART managed and the honey the bees produced per hive were close to the state average (21 hives and 25.4 kg per hive, according to the study by Magaña Magaña et al. [2016]).

Beekeeping was often a family-run activity, with an average of two family members dedicating time to apiculture throughout the year. During the honey harvest, it was typical for more family members to join the efforts and help with different harvest-related tasks. When considering all workdays invested in beekeeping annually (including both family and hired labor), 88.4% of the labor for beekeeping was done by family members, as contrasted with 50% for coffee production. In addition to family participation, six beekeepers (24%) reported working with other beekeepers in their communities with varying degrees of collaboration. As managing honeybees was still a relatively new activity in communities with CESMACH/ART members, most beekeepers (52%) had five years or less of experience in beekeeping. In the families participating in the study, it was more common for men to be involved in beekeeping, although some apiaries were run mainly by women.

'Beekeeping is easy': combining beekeeping with coffee and maize production

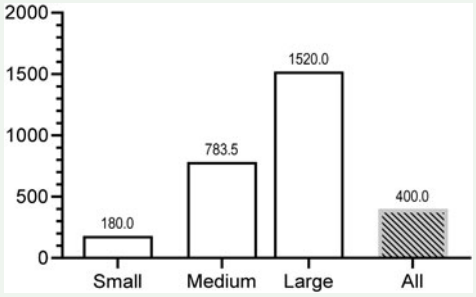
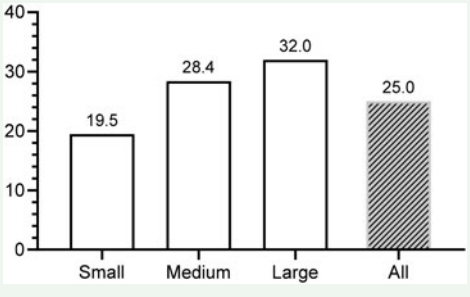
Beekeepers of ART manage their bees in diversified coffee farms where they often grow maize and/or other crops (Anderzén et al., 2020; Guzmán Luna et al., 2022). We found that there are opportunities to integrate beekeeping into the annual farming cycle of coffee and maize production without causing competing labor demands or additional time pressures. An agricultural calendar, created in focus groups with CESMACH/ART producers, shows that some of the most time and labor-intensive tasks related to beekeeping, coffee, and maize do not generally overlap (see Fig. 4). In the higher altitudes, where most producers manage their apiaries, honey harvest occurs in March–May, when the coffee harvest is winding down. Subsequently, farmers finish harvesting honey before the rainy season, a time of the year when they are busy in their coffee plots with tasks like weeding the coffee plantation. Those producers who also grow maize, plant it in May when honey harvest is ending. During the months when it is time to harvest maize (between September and December), beekeepers visit apiaries to feed the bees and make sure the colonies are healthy, tasks that do not necessarily require a significant time investment. However, depending on the year and the location of the apiary, coffee and honey harvests can overlap. The field technicians of ART explained to us that on these occasions farmers often give preference to coffee and dedicate less time to beekeeping, which can negatively affect bees and the honey yield.

Beekeeping is less time-intensive than coffee production. The survey results show that producers worked in their apiaries, on average, 6.5 times a month and invested 69 days of family labor in beekeeping in a year (Table 3). This includes the contributions from all family members who helped with beekeeping-related activities at any point during the year. In comparison, the same beekeepers worked an average of 23 days a month in their coffee plots, with days of family labor averaging 261 days a year. While we didn't ask producers to estimate the daily hours dedicated to beekeeping or coffee production, many told us that they typically spent less time per day working on their hives than on coffee. The visits to the apiary commonly lasted less than half a day, with the exception of honey harvest when beekeepers worked full days. One farmer described:

> [*In beekeeping*] *you only need to know what each hive needs, as they are all different. If a hive doesn't need work, I don't work on it. So, for me, beekeeping isn't something I do daily* [—] *sometimes it takes me just two days a week… or one day.*

Additionally, as the apiaries are often located close to the coffee plots or *milpas*, farmers visited their apiaries on the same day as they worked on coffee or maize. It is also important to note that beekeepers generated employment in their communities. In total,

Table 2. Median honey yield and yield per hive in kilograms, distributed by the size of the beekeeping operation (small <20 hives, medium 21–40 hives, large >41hives)

Honey produced (total, kg)	Yield per hive (kg)
	

Small producers not only had smaller total production, but on average they produced less honey per hive than medium and large producers.

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Figure 4. Agricultural calendar showing activities related to diversified farming systems incorporating coffee, honey, and staple crop production (design: Daniela Gallardo Olimón).

72% of the study participants hired workforce at least once a year, providing 349 days of employment in total.

Beekeeping requires specialized skills, which can take years to acquire. Yet, many producers perceived beekeeping as easy, especially when compared to coffee. One producer noted that '[*beekeeping*] *is not difficult and it's less tiring for the body than coffee*'. To emphasize the point, he added jokingly, '*you can go to the apiary like a "licenciado" (a university graduate), in a suit*

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Table 3. Time beekeepers invest in beekeeping and coffee annually

Time use—beekeeping	*N*	MD	Min.	Max.
Days of family labor in beekeeping	25	69	16	272
Days of paid labor in beekeeping	25	7	0	143
% of family labor in beekeeping (days of family labor/total days of labor in beekeeping)	25	88.4	37.8	100
Time use—coffee production	*N*1	MD	Min.	Max.
Days of family labor in coffee	19	261	50	767
Days of paid labor in coffee	19	203	23	880
% of family labor in coffee (days of family labor/total days of labor in coffee)	19	50.0	15	92

1Only 19 out of 25 beekeepers participated in a parallel study where this information was collected.

and a tie'. These kinds of views were voiced by established beekeepers with more years of experience. Others pointed out that beekeeping is knowledge-intensive, and hives need to be checked regularly to ensure the colonies are healthy and have a good bee population. Neglecting regular visits to the apiary can lead to colony losses, which is one of the primary reasons why beekeepers drop the activity.

Is beekeeping economically lucrative?

Costs and returns

'*Here we depend on coffee, and now the coffee price is low… producing honey helps us a lot, it helps us not depend on coffee only.*' This account by a producer's daughter appears to capture the feelings of many beekeepers of ART. Over the past decade or so, income diversification has become an important motivator for farmers to manage honeybees in addition to coffee. Our data show that while all beekeepers saved a small portion of honey for consumption or gifting, they sold an average of 92% of their honey either to ART or locally. During the time of the study, the price paid by the buyer of ART hit an all-time low (US $1.25 kg^{-1}), which meant that the honey sold locally had a higher value (US$3.22 kg^{-1} on average). This finding was discussed widely in the session where we shared results from this study with member farmers and staff of CESMACH and ART. The participants reflected on how the development of local markets can make beekeeping economically viable even when prices are low.

Variable costs were the principal category of expenses for many beekeepers (Table 4). On average, transportation, inputs, and labor costs represented 69% of all expenses, while asset depreciation constituted 31% of the production costs. When dividing all production costs by the number of beehives and kilograms of honey produced, the costs averaged US$32.9 per hive and US $1.27 per kg of honey. Other studies from Mexico have found similar results. For example, in a study assessing the profitability of beekeeping in seven states of Mexico, the proportion of variable costs was 67%, whereas in a study from Yucatan, the percentage was a little higher (77.9%) (Magaña Magaña et al., 2016; Contreras Uc and Magaña Magaña, 2017). Another study from the state of Aguascalientes found that the production costs for beekeepers with 20–50 hives were $2.4 per kg of honey, while the production costs per kg of honey went down for larger producers (Zavala Beltrán et al., 2021).

Table 4. Summary of costs of production and gross returns in US dollars

	N	MD	Min.	Max.
Returns (gross, $US)				
Honey sold to ART (US $1.25 kg^{-1})	23	525.0	62.4	4990.0
Honey sold in local markets (US$3.22 kg^{-1} on average)	14	88.6	8.3	1299.6
Other beehive products1	1	52.0	52.0	52.0
Total gross income	25	524	106.0	6290.0
Production costs ($US)				
Variable costs				
Hired labor	25	39.5	0	1622.0
Inputs	25	230.8	23.6	489.0
Transportation	25	159.1	0	1723.0
Fixed costs (asset depreciation)				
Field equipment	25	150.2	41.0	520.0
Processing equipment and vehicle(s)	25	56.2	1.9	477.0
Total costs of production	25	441.34	138.1	4341.7
Costs of production per kg of honey	25	1.27	0.25	3.48

1In addition to honey, only one person sold other beehive products (shampoo and propolis) on a small scale.

Factors affecting economic outcomes

Honey price is a critical factor affecting the profitability of beekeeping. We found that with the price paid to the beekeepers during the time of the study (US$1.25 kg^{-1}), only a little over half (52%) of the producers were breaking even or making a profit. With this exceptionally low price, the income per kilogram of honey ranged from a loss of US$3.1 to a profit of US$0.6 (see Table 5 and Fig. 5a). We used two alternative price points, US $2.24 and US$3.12, to see how an increase in the price would affect the outcomes. The former represents the price paid by ART in 2018 when we were starting the study, while the latter is a price that the organization was able to negotiate with their buyer in 2020. Using the price point of US$2.24, 72% of the beekeepers participating in the study would break even, while with the highest price approximately 80% of the producers would make a profit.

Regarding how the scale influenced profitability, our calculations suggest that with the lowest price, beekeepers would need a minimum of 23 hives to break even, while with the alternative price points approximately 15 hives (US$2.24) or 13 hives (US $3.12) would allow producers to gain profit. As shown in Table 1, the average number of hives among the study participants was 26. However, these hive number estimates represent trends as the profitability per hive is influenced by many factors. As one focus group participant noted when asked about the minimum amount of hives to make a profit: 'It all depends on the zone, but you'll need 20 or more hives.'

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Table 5. Median gross revenue, net revenue, the income per kg of honey, and the income per day of family labor shown for all beekeepers and broken down by the size of the operation (small, medium, large), using three different price points

Income	Size of apiary	Price per kg of honey		
		$1.25	$2.24	$3.12
Total income (gross)	Small	215.4	374.4	522.4
	Medium	933.7	1669.4	2327.8
	Large	1497.0	2682.3	3742.8
	All	524.00	854.1	1181.1
Total income (net)	Small	−141.5	−14	117.1
	Medium	109.6	724.9	1350.2
	Large	184.2	1449.8	2687
	All	32.8	285.6	511.9
Income per kg of honey	Small	−0.9	−0.2	0.6
	Medium	0.2	1.0	1.7
	Large	0.2	1.1	1.8
	All	0.04	0.9	1.4
Income per day of family labor	Small	−2.7	0.2	2
	Medium	1.84	11.9	22.2
	Large	2.14	13.4	23.5
	All	0.4	6.2	10.3

We found that the number of hives, yield per hive, and production costs per hive were other key factors contributing to the profitability of beekeeping. Our model showed that these three indicators could explain approximately 75% of the variability in the data on economic returns (adjusted $R^2 = 0.75$, $P < 0.001$). The yield per hive and the number of hives appeared to have the strongest effect on the economic outcomes ($P < 0.001$ and $P = 0.001$, respectively), while the impact of production costs was less clear.

Family labor is often not accounted for in research assessing the economic outcomes from farming activities. In this study, we wanted to understand what the returns from beekeeping would look like when considering family contributions. In other words, if the net revenue was divided by days of family labor, how much would a beekeeper or their family members earn per day of work? We found that with the lowest price (US$1.25 kg^{-1}), the income per day of family labor varied from a loss of US$13.4 to a gain of US$18 (see Fig. 5b). As a point of reference, the minimum salary per day in Chiapas was $4.59 in 2018 (STSP, 2018). The income per day grew with the two alternative price points, with the effect being particularly considerable for medium and large producers. However, these values are based on a small sample of beekeepers, and it is important to remember that many factors affect the economic outcomes, such as the frequency in which beekeeper families visit their apiaries. Additionally, it represents an oversimplification of the value of one's labor, which in the case of beekeeping contributes to producing honey and many other benefits that extend beyond the beekeeping families, as we will see in the next section.

It's also about nutrition, relationships, and joy

In a focus group, a farmer shared his feelings about beekeeping as follows:

> *… it almost makes you want to sell the coffee plantation and continue with the beehives, because sometimes you fall in love with beekeeping… it is very easy and very healthy, and it is something that benefits the family and other people as well.*

This quote illustrates that, while economic aspects are important, many other factors motivated and brought joy to the beekeepers. One of these was the nutritional and medicinal benefits of honey and other beehive products. All beekeepers participating

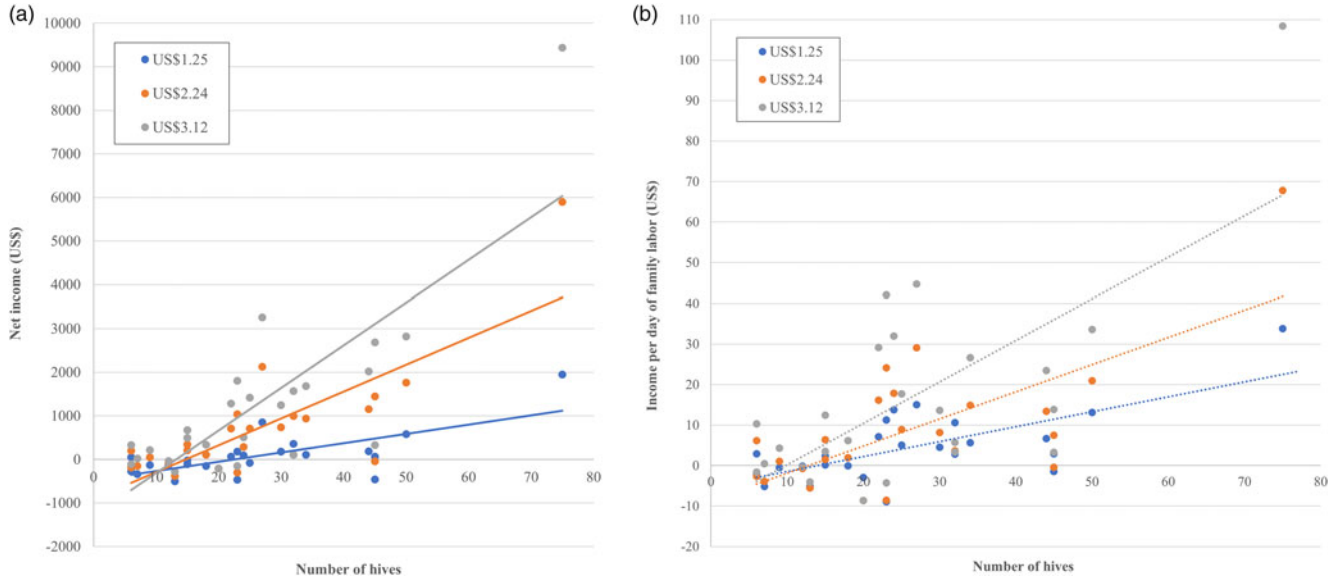

Figure 5. (a) Impact of price and the number of hives on the income (net revenue) from beekeeping. (b) Impact of price and the number of hives on the income per day of family labor. Each color and line represent one of the three price points.

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in the study kept some honey for family consumption, enjoying it plain or with bread, fruit, tortillas, pancakes, coffee, tea, *pozol* (maize beverage), and/or fruit juices. Just under half of the producers (44%) said they also consumed other beehive products, such as pollen and propolis, which they used mainly for medicinal purposes. As we saw in section 'Costs and returns', only one beekeeper was selling other products besides honey, suggesting that the beekeepers collect pollen and propolis mainly for family consumption or buy them from other producers.

Another theme that emerged during the study was beekeeping as a vehicle for building and strengthening relationships, which occurred in different ways. First, many participants mentioned how beekeeping was an activity that brought the family together, as everyone could participate in different ways. Beekeepers also enjoyed going to the apiary with their children, which served as a space to share knowledge about beekeeping and the environment. Second, beekeeping was seen as a way of cultivating relationships within the communities. Many beekeepers kept honey not only for their own consumption or local markets but also to give away or exchange with family or community members. In many communities, beekeepers were respected for their specialized skills, and occasionally community members asked them to share their knowledge about beekeeping. However, in some communities, the opposite was true—people would express their mistrust about beekeeping and not want beehives near their farms or houses. Beekeepers commented that people need to be educated more about the multiple advantages of beekeeping.

A third theme we observed was beekeepers' unique connection with the bees, representing a source of joy, peace, and respect. We often heard how relaxing it was to visit the apiary and observe how bees work ('*they work for us, and we work for them*'). Beekeepers perceived that the bees recognized them and acted more calmly in their presence, which created a sense of kinship. Some participants referred to their bees as family members, and one producer told us that his affection and fascination for bees kept him practicing beekeeping even when he knew it was not economically profitable for him. Beekeepers also appreciated bees for the role they play in nature. Many were aware of the pollination services that bees provide and could name several native bee species that existed locally. There was also awareness of beekeepers' responsibility for the bees' well-being, and how conservation practices and good management of their coffee plantations could support it. As summarized by a producer when addressing other beekeepers in a focus group:

> [*beekeeping*] *is not just something that produces honey and then I am going to sell it and get rich, but the work that you have as beekeepers is very important… you are not only taking care of the bees to produce honey, but also to conserve the shade that is required for coffee and logically to take care of the environment, right?*

Finally, bees were considered as teachers who were guiding beekeeper-coffee farmers to observe nature and its interactions more deeply. One producer explained:

> *we share almost the same language with the bees… they make us work, they make us understand new ideas, they make us observe the weather a lot, the type of flowering.*

Some farmers had learned by observing the bees that it was important to avoid pruning the shade trees in their coffee plantations too soon or too much, as this interfered with floral resources for the bees. The farmers expressed that this realization had helped them become both better beekeepers and coffee farmers.

The future of beekeeping

Many beekeepers were hoping to grow their apiaries, although they were aware of its challenges and risks. In a focus group about the future and challenges of beekeeping, the participants were asked to write down the number of beehives they were managing at the time and the number of hives they were hoping to have in five years. This was followed by a reflection on what this growth would imply regarding resources and skills, and if there was a threshold for the number of hives they could manage without compromising other farm activities. While some beekeepers hoped to see significant growth in their operation, most participants set cautious plans for growth. One of the biggest obstacles they identified was the lack of credits or savings to grow. As one beekeeper noted:

> *In my case, I could grow a little… but to double or triple the number of hives in a year, that would be difficult* [—] *I think we'd have time and all, but it would be complicated because of the* [*lack of economic*] *resources.*

This concern became more pronounced in 2019, when the low honey prices led many farmers to temporarily put beekeeping on hold or invest less in it. Another common theme was the need for more technical training. Many participants said they didn't feel confident in their current skills to scale up and hoped to deepen their knowledge.

Farmers were concerned with the adverse effects of climate change when considering the future. Many beekeepers had noticed changes in the timing and amount of flowering, which in some years led to a situation where there is, '*no food for the bees, and no harvest*', as one beekeeper noted. Some beekeepers had experimented with adaptive strategies, such as planting trees or shrubs in their coffee plots and apiaries to diversify the forage supply. Still, there was uncertainty about how to best adapt to climate change. Another more recent challenge that the beekeepers mentioned was aerial sprayings of pesticides to combat fruit flies in the region. According to several producers, these sprayings—authorized by the municipalities and deemed harmless for humans and other insects—were causing colony losses in apiaries and harming farmers' livelihoods. They noted that collective action and conscientization of people in the communities about the risks related to the spraying would likely be the most effective ways of dealing with the issue. The poster on the contributions of pollinators (Fig. 2) is an example of a popular educational tool for raising awareness.

Discussion

This research elaborates on the growing body of research from different parts of the world that have found beekeeping to be an economically, ecologically, and socially beneficial agricultural activity that can be easily integrated into different types of small-scale farming systems (Wolff and Costa Gomes, 2015; Schouten, 2020). Our findings point to multiple socio-economic values of beekeeping both to the family unit and the wider community. In the following sections, we use these findings to discuss how conditions and operational scales for beekeeping influence the feasibility, sustainability, and desirability of beekeeping as an alternative for diversified coffee farmers.

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On the optimal operational scale

Economic considerations

The economic sustainability and resilience of a system builds on the stability of income over time, in addition to the income itself (FAO, 2018). This study shows that the honey price strongly affects the stability of beekeeping as a livelihood diversification alternative. As honey and coffee are subject to price fluctuations (Contreras Uc and Magaña Magaña, 2017; SCA, 2019), any estimate about the 'ideal' number of hives should consider the possibility of both unfavorable honey and coffee prices. According to our calculations, ART beekeepers would need to manage approximately 23 hives to endure years of low honey prices and break even. Yet, we argue that the estimates of an optimal number of hives should not have 'scraping by' as a goal but should be based on a living income for all family members participating in beekeeping activities. Ideally, this would mean making over a minimum wage salary per day of work in beekeeping, even under conditions of low honey prices. We found that the price for honey in local markets was higher and more stable, implying that strong local markets for honey could increase the stability of beekeeping as a part of diversified livelihoods.

While apiary size and issues of economies of scale are important components, we further suggest that management practices play a significant role in beekeeping's economic sustainability. We found that the yield per hive is another critical contributor to income from beekeeping, pointing to the importance of technical skills and careful management of apiaries. This aligns with findings from other studies assessing factors contributing to the profitability of beekeeping (Hinton et al., 2020; Schouten, 2020).

Finally, another aspect that merits attention when thinking about the economic sustainability of beekeeping is the timing of the payment for honey. Our baseline study with CESMACH members indicated that the beekeepers get paid for their honey at a time of the year when money from coffee is running low and the prices for staple foods spike. This suggests that even a modest income from beekeeping can be critical for supporting household expenditure or investing back in agriculture (Anderzén et al., 2020). Additionally, beekeeping not only benefits farmer households—it generates paid jobs in communities, which can be crucial in remote areas with limited employment opportunities and high emigration rates, as other studies have shown (e.g., Yusuf, Lategan, and Ayinde 2014; Hinton et al., 2020).

Temporal and seasonal considerations

From the temporal and seasonal perspective, beekeeping's feasibility and optimal scale are associated with available (human) resources and 'competing' labor demands. Diversified farms tend to be labor intensive, and small family farms relying mainly on family labor need to constantly make decisions on allocating time and organizing their labor (Tacconi et al., 2022). This study demonstrates that the time requirements for beekeeping were relatively low—especially compared to coffee—and farmers found synergies between the two activities. We also found that the activity appeared to be mainly managed by male family members, which begs the question about the possible barriers to the participation of women. It is unclear whether these are related primarily to socio-cultural factors, time use conflicts, or both (see Bezner Kerr et al., 2019; Austin et al., 2020). This issue merits further attention in future research.

Additionally, the agricultural calendar showed that beekeeping does not generally add significantly to farmers' workload during times when coffee and/or corn production require the most attention. However, overlaps occasionally occur, creating conflict or trade-offs in time use. These high work-intensity overlaps could become more permanent with changes in climate (Vercelli et al., 2021). Other factors, such as increased emigration from coffee communities and reduced flows of temporary workers during the coffee harvest (see Harvey et al., 2021), can add to the time pressures many families experience and limit beekeepers' willingness to expand their apiaries. Popular educational and managerial tools, like the agricultural calendar used in this study, could help farmer families with planning. The calendar can also serve as a decision-making tool for farmers considering becoming beekeepers.

Embracing the non-monetary values of beekeeping

Our findings highlight the importance of non-monetary values when considering beekeeping as an agroecological diversification alternative for coffee farmers. One theme that emerged strongly during this study was beekeeping as a vehicle for cultivating reciprocal relationships with bees and nature, a manifestation of relational values associated with beekeeping (Himes and Muraca, 2018). We observed that the special connection beekeepers experienced with their bees sparked feelings of joy and calmness and helped relieve stress. Working with bees also guided farmers to observe their environment in new ways and learn about synergies. Luna et al. (2022) describe similar experiences from their work with Nicaraguan farmers practicing meliponiculture (management of native bees). They found that meliponiculture served as 'pedagogical mediator' ('mediador pedagógico') that allowed beekeepers to be more observant and deepen their feelings of love and care toward nature (Luna et al., 2022, p. 18). In another study conducted with hobbyist beekeepers in Canada, Ellis (2022) observed that the beekeepers developed 'a sensuous and embodied relationship with honeybees that typifies playful work' and projected an 'expression of delight, enchantment, and curiosity'. While members of ART rely on the income from beekeeping more than hobbyist beekeepers in Canada, it can be argued that for many participants in this study, the relational values were equally important as the 'instrumental' values (i.e., income generation) of beekeeping. Perhaps for this reason, many beekeepers described beekeeping as 'easy'.

Our study provided several examples of how benefits from beekeeping trickled beyond the beekeeping families. In some communities, beekeepers assumed the role of educators, thus promoting horizontal learning and knowledge exchange. Few studies thus far have reported these types of outcomes from beekeeping (but see Luna et al., 2022). Beekeepers also contributed to the nutrition and health of community members by producing honey and beehive products with high nutritional and medicinal values. During the time of the study, the consumption of beehive products was relatively low in communities with CESMACH/ART members. Yet, during the early months of the global COVID-19 pandemic, we heard from our local partners in Chiapas that the consumption of honey and other beehive products had surged. Amid lockdowns and in the absence of vaccines, many people were turning to beekeepers for home remedies against COVID-19. Finally, as many producers gave away honey or exchanged it in addition to selling it, they helped strengthen solidarity economies in their communities.

Conclusions

Agroecology promotes agricultural diversification as a means of supporting ecological balances and enhancing well-being of

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farmer families and their communities (de Roest, Ferrari, and Knickel, 2018).

This PAR study shows that there are opportunities to integrate beekeeping into the annual farming cycle of coffee and maize production without causing competing labor demands or additional time pressures. It also provides evidence of the multiple values of beekeeping as an element of diversified coffee landscapes. The results show that while beekeeping can generate economic gains for peasant families, the profitability hinges on various factors, such as the price, yield per hive, and the number of beehives. Our findings further demonstrate that beekeeping contributes to the nutrition and health of farmer families and their communities, serves as a vehicle for horizontal learning and relationship building, and supports the emotional well-being of beekeepers. Limited technical knowledge and financial resources, and the impacts of climate change can pose constraints to the sustainability of beekeeping.

We argue that efforts to promote beekeeping as a diversification strategy should take a holistic approach, underscoring the potential of apiculture to enhance the well-being and resilience of beekeeping families and strengthen food sovereignty and local economies (including solidarity economies) in peasant communities. Through participatory reflections, we identified the following approaches to support the sustainability of beekeeping: (1) Building capacity with a focus on agroecological approaches to provide beekeepers with the skills and tools to manage apiaries in a way that is bee-friendly, yields desired outcomes for the beekeepers and their communities, and promotes long-term adaptive planning (see Schouten and Lloyd, 2019; Hinton et al., 2020). For example, training programs like the ones offered by *Equipo Abejas* in Chiapas are examples of educational initiatives that provide a holistic approach to beekeeping. (2) Supporting the participation of young people and women in beekeeping, without generating a 'double burden' for women (Bacon et al., 2023). Acquiring new professional skills can also potentially reduce the emigration of young people and facilitate farm succession. (3) Creating financial mechanisms that provide loans/credits for farmers to have a better capacity to invest in the activity (see Hinton et al., 2020; Schouten 2020). (4) Strengthening local markets for honey, other beehive products, and beekeeping materials to reduce dependency on export markets and build stronger local economies. This could also encourage a higher consumption of beehive products that, in turn, could have important health implications. (5) Finding synergies between the commercialization of honey and coffee, for example, by identifying buyers for both products (ALC and Gund Institute for Environment, 2020).

Given the multiple social, economic, and ecological benefits of beekeeping, it has great promise to be integrated into agroecological food and farming systems. Further research is needed to understand better the synergies and trade-offs related to combining beekeeping with other agricultural activities, the gendered aspects of beekeeping, and the networks and support systems that can best facilitate the integration of beekeeping in the wider pursuit of agroecological transitions for more just and sustainable food systems.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1742170524000164.

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