2023

“no Solamente Del Café Puede Vivir Uno...”: Participatory Action Research On Agricultural Diversification In Smallholder Coffee Systems Of Chiapas, Mexico

Janica Mia-Maaria Anderzén
University of Vermont

"NO SOLAMENTE DEL CAFÉ PUEDE VIVIR UNO...": PARTICIPATORY ACTION RESEARCH ON AGRICULTURAL DIVERSIFICATION IN SMALLHOLDER COFFEE SYSTEMS OF CHIAPAS, MEXICO

A Dissertation Presented

by

Janica Anderzén

to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
Specializing in Plant & Soil Science

May, 2023

Defense Date: March 28, 2023
Dissertation Examination Committee:

V. Ernesto Méndez, Ph.D., Advisor
Joshua Farley, Ph.D., Chairperson
Scott Merrill, Ph.D.
Colin Anderson, Ph.D.
Cynthia J. Forehand, Ph.D., Dean of the Graduate College

ABSTRACT

Diversity and diversification are foundational principles of agroecology. Growing scientific and experiential evidence from different parts of the world shows that diversified, agroecologically managed agricultural systems generate multiple ecological, social, and economic benefits, and can be more resilient to risks and stressors. However, while ecological benefits of these systems are well documented, less is known about socio-economic dimensions of agricultural diversification. This dissertation explores characteristics and outcomes of agricultural diversification in smallholder coffee systems in Chiapas, Mexico, with special emphasis on beekeeping. In this region, beekeeping is seen as an alternative with potential to build household resilience in the face of increasing precariousness of coffee production. Conducted within the context of a broader Participatory Action Research (PAR) process, this study encompasses over three years of participatory, mixed-methods research with farmers from *Campesinos Ecológicos de la Sierra Madre de Chiapas* (CESMACH), a coffee cooperative and its sister organization for beekeepers, *Apicultores Real del Triunfo* (ART).

In Chapter 2, I integrate data from a household survey (n=167) and focus groups to examine how and why smallholder coffee farmers diversify their farms, and the effects that different diversification approaches have on farmer families' livelihoods and food security. I find that beekeeping for honey, especially when combined with basic grain production (in *milpa* systems), proves to be a promising strategy for supporting economic wellbeing and reducing the impacts of seasonal food insecurity. Chapter 3 builds on this finding and uses quantitative and qualitative methods to gain a deeper understanding of beekeeping as a diversification alternative for coffee farmers. Data from two years of knowledge co-creation with 25 beekeepers, who are members of ART, demonstrate that beekeeping: 1) contributes to the nutrition and health of farmer families and their communities; 2) serves as a vehicle for horizontal learning and relationship building; and 3) supports emotional wellbeing. This study also shows that 4) beekeeping can generate economic gains, but that profitability hinges on various factors, such as price for honey, yield per hive, and number of beehives. I argue that efforts to support beekeeping as a diversification strategy should take a holistic approach and highlight beekeeping as an activity that can build food sovereignty and autonomy in peasant communities.

Chapter 4 emerges from participatory reflections and uses findings from the case study with beekeepers to imagine agroecological transition pathways for ART. I apply 'Agroecological Principles for Beekeeping', a framework developed by *Equipo Abejas* at the *Colegio de la Frontera Sur* (ECOSUR) in Chiapas, to draw lessons from the case study and develop a set of context-specific applications for selected socio-economic principles. Finally, I adapt agroecological transition frameworks by Caswell et al. (2021) and Anderson et al. (2022) to propose a practical transition approach that integrates beekeeping-specific agroecology principles as well as experiences from the case study. By using a praxis-oriented approach, this chapter contributes to the growing literature on the application of agroecological principles and transitions in specific contexts.

CITATIONS

Material from this dissertation has been published in the following form:

Anderzén, J., Guzmán Luna, A., Luna-González, D. V., Merrill, S. C., Caswell, M., Méndez, V. E., Hernández Jonapá, R., and Mier-y-Terán, M.. (2020). Effects of on-farm diversification strategies on smallholder coffee farmer food security and income sufficiency in Chiapas, Mexico. *Journal of Rural Studies* 77:33-46.

DEDICATION

To my nephew, Ariel, the courageous little pirate.

ACKNOWLEDGEMENTS

There are many people to whom I want to express my deepest gratitude:

To my family in Finland: Thank you for your unconditional love and support, for always being there for me. Suuri kiitos.

A las familias campesinas de Campesinos Ecológicos de la Sierra Madre de Chiapas (CESMACH) y Apicultores Real del Triunfo (ART): Nunca olvidaré su generosidad al compartir sus conocimientos e invitarme a sus casas. Gracias de todo mi corazón. También deseo agradecer al personal y a la mesa directiva de CESMACH/ART por todo su apoyo durante este proceso de Investigación Acción Participativa (IAP). Cuando visité CESMACH por primera vez en 2004 me enamoré de las tierras cafetaleras y de su gente, y nunca hubiera imaginado que más de 10 años después tendría la oportunidad de regresar para colaborar con CESMACH y ART y las familias socias. Gracias por todo.

A todos/as los/as colaboradores/as de CESMACH, El Colegio de la Frontera Sur (ECOSUR), Red de Agroecología Comunitaria (CAN), Universidad de Santa Clara, PRODECOOP, Universidad Nacional Agraria (UNA), y Food 4 Farmers (F4F): nuestro proceso IAP ha sido una experiencia transformadora para mí, gracias por estos años de co-aprendizaje. Quiero dar un agradecimiento especial a mis amigos/as y colegas, Rigoberto Hernandez Jonapá y Alejandra Guzmán Luna, y al grupo de facilitadores comunitarios - Bernardo Roblero Perez, Williams Salomón Roblero López, Inés Lucia Perez, Alejandra Perez Lara, David Armando Anzueto Coutiño, y Caralampio López Garcia. ¡Esta aventura no habría sido lo mismo sin un equipo tan increíble!

To my advisor Ernesto Méndez: I am deeply grateful for your guidance, support, patience, empathy, and friendship during my time at UVM. Gracias.

To my committee, Scott Merrill, Joshua Farley, and Colin Anderson: thank you for all your encouragement, mentorship, and support. I'd also like to express my gratitude to Sarah Heiss who helped me organize my thoughts when I needed it the most.

I am also grateful for financial support from the E4A program, PSS, Gund Institute, Agropolis Foundation, Fondazione Cariplo, and Daniel & Nina Carasso Foundation.

To my friends and colleagues at the Agroecology Community of Practice: Your dedication, passion, creativity, and care are a continued source of inspiration for me, and

I feel so very lucky to be part of this community. Thank you for creating spaces to learn, grow, and laugh.

To Maryam Nouri-Aiin, Katie Horner, and Gabriela Bucini: I'm profoundly grateful and moved by your support, kindness, and humor during the last stretch of finishing my Ph.D. The snacks and little notes you left on my desk helped me get over the finish line!

To Martha Caswell, my partner in "Las Incompetentes": Who else would leave 'una bolsa de mareo' from a Bolivian airline filled with Big Reds (that fine Nicaraguan chewing gum) next to my computer at my defense? Thank you for your mentorship, for reminding me that laughing makes everything better, and for all the adventures we've shared. Maybe one day I'll be a "Presidenta" too.

To those at the Economics for the Anthropocene (E4A)/Leadership for the Ecozoic (L4E) program, the Department of Plant & Soil Science (PSS), and the Gund Institute: Thank you for allowing me to learn with and from you. A special thanks to my E4A buddies at UVM, Joe Ament and Ben Dube, for your friendship. Your wit inspires and terrifies me.

To my healthcare "team": Thank you for doing everything possible to help me recover from the long-Covid.

To my dear friends in Finland, Vermont, and other parts of this beautiful planet, and to my adoptive families: I would not be me without you. Thank you for everything.

To my partner Shawn: Your love and patience have carried me through this Ph.D. madness. Thank you for making me stop and listen to the sounds of birds.

To Samson, the dog: Thank you for being a Sam and for reminding me of the importance of naps and cuddling.

To everyone who is not (physically) with me anymore: You continue to accompany me wherever I go. Thank you for everything I've learned from you.

TABLE OF CONTENTS

Page

CHAPTER 1. INTRODUCTION

1.1 Setting the context

Diversity and diversification are foundational principles of agroecology (CIDSE, 2018; FAO, 2019; HLPE, 2019), used to describe and understand different kinds of diversity present in socio-ecological systems (e.g., agrobiodiversity), or processes (e.g., agricultural or livelihoods diversification). While industrial agriculture pushes the agenda of intensification and specialization, many peasant farmers in different parts of the world continue to manage diversified agricultural systems. Growing scientific and experiential evidence shows that these diversified systems, especially when agroecologically managed, generate multiple benefits for people and ecosystems and can build resilience to various risks and stressors (e.g., Gliessman 2015; Perfecto & Vandermeer, 2015; de Roest et al., 2018). They also tend to be flexible and dynamic, as farmers "shift along balances including social and natural demands, production and reproduction, the scale and intensity of farming, internal and external resources, and autonomy and dependence" (van der Ploeg, 2013, in McCune, 2019).

Smallholder coffee systems in the tropics constitute an ideal context for studying diversity and diversification. Coffee is typically grown in shade agroforestry systems with multipurpose trees and a variety of other species that are used for food and other purposes (Soto-Pinto et al., 2000; Toledo and Moguel, 2012; see Figure 1-1). Beside coffee plantations, farmers raise animals and grow fruit and vegetables in home gardens, *milpas*[1], pastures, and apiaries to feed their families, create additional sources of income, or engage in *trueque* (exchange of products) with community members (Jaffee, 2014; Guzmán Luna et al., 2022; see Figure 1-2). Many studies have explored the ecological dimensions of smallholder coffee systems (e.g., Méndez, 2007; Perfecto & Vandermeer, 2015). Yet, less is known about the socio-economic characteristics of agricultural diversification in coffee landscapes and how different forms of diversification affect food security and sovereignty or economic wellbeing of families and their communities (some examples include Morris et al., 2013; Bacon et al., 2017, Fernandez & Méndez, 2018; Gerlicz et al., 2019).

Figure 1-1: A biodiverse shade coffee plantation in the community of Llano Grande, Chiapas, Mexico (image: Janica Anderzén)**.**

---

[1] Traditional intercropping system originated in Mesoamerica with corn, beans and squash and other regional plant.s

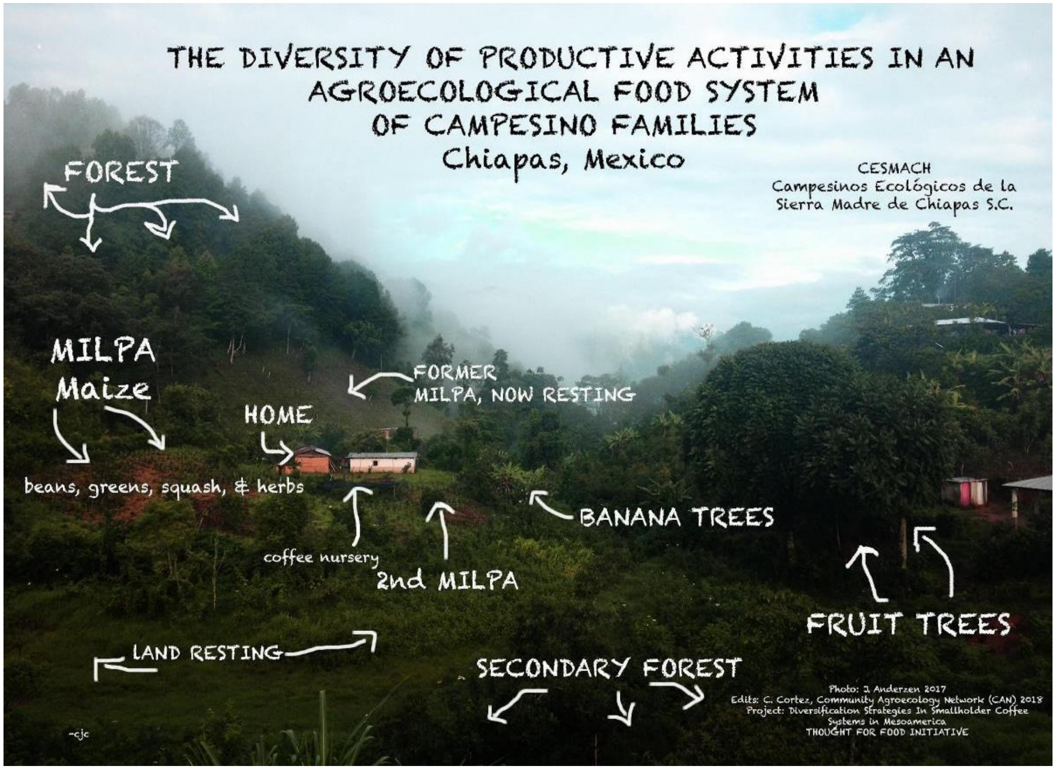


Figure 1-2: A diversified coffee farm in Sierra Madre de Chiapas, Mexico (image: Janica Anderzén)

Why does it matter? Why do we need more context-specific case studies on agricultural diversification in coffee landscapes? Because *"no solamente del café puede vivir uno ya"* ('one cannot live solely off coffee anymore'), as one coffee farmer of CESMACH said to summarize his situation. While coffee is a relatively new crop in Chiapas, it has come to dominate the landscape in many parts of the state, often leading to specialization and reducing other land uses (like the production of corn and beans in milpas) (Guzmán Luna et al., 2022). Now, the future of coffee farming is becoming more precarious. Climate change is bringing warmer and drier conditions and is one major factor threatening coffee-dependent livelihoods, causing disruptions in coffee production, and reducing the land suitability for growing *Arabica* coffee (Läderach et al. 2017; Hannah et al., 2017). Additionally, as an agricultural commodity, coffee is susceptible to price fluctuations, which in recent years has coincided with increasing costs of production and food prices (SCA, 2019; Anderzén et al., 2021). These compounding challenges are pushing many people to migrate, abandon coffee, or simply operate at a loss (see Harvey et al., 2021). It is within this context that an increased understanding of sustainable alternatives becomes relevant.

1.2 Participatory Action Research (PAR) approach

This dissertation explores characteristics, outcomes, opportunities, and challenges of agricultural diversification in smallholder coffee systems of Sierra Madre de Chiapas, Mexico. It was conducted as part of an ongoing Participatory Action Research (PAR) process with farmers from *Campesinos Ecológicos de la Sierra Madre de Chiapas* (CESMACH) coffee cooperative and its sister organization for beekeepers *Apicultores Mield Real del Triunfo* (ART). Since 2017, a transdisciplinary and international team of practitioners and researchers[2] has been collaborating with these two organizations to co-create actionable knowledge about on-farm diversification in coffee landscapes.

[2] The PAR process was funded through *Assessment of Diversification Strategies in Smallholder Coffee Systems of Mesoamerica* project, taking place in Mexico and Nicaragua. In Mexico, the PAR partners included CESMACH, Agroecology and Livelihoods Collaborative (ALC) at the University of Vermont

This dissertation contributes to the collective goals and accumulating knowledge and learning of the larger PAR process. In Chapter 2, we use findings from a household survey (n=167) and focus groups to examine how and why smallholder coffee farmers diversify their farms, and to assess the effects that various diversification approaches may have on farmer families' livelihoods and food security. In particular, the chapter examines the potential effects of combining coffee with two other important agricultural activities in the region, *milpa* production, and beekeeping.

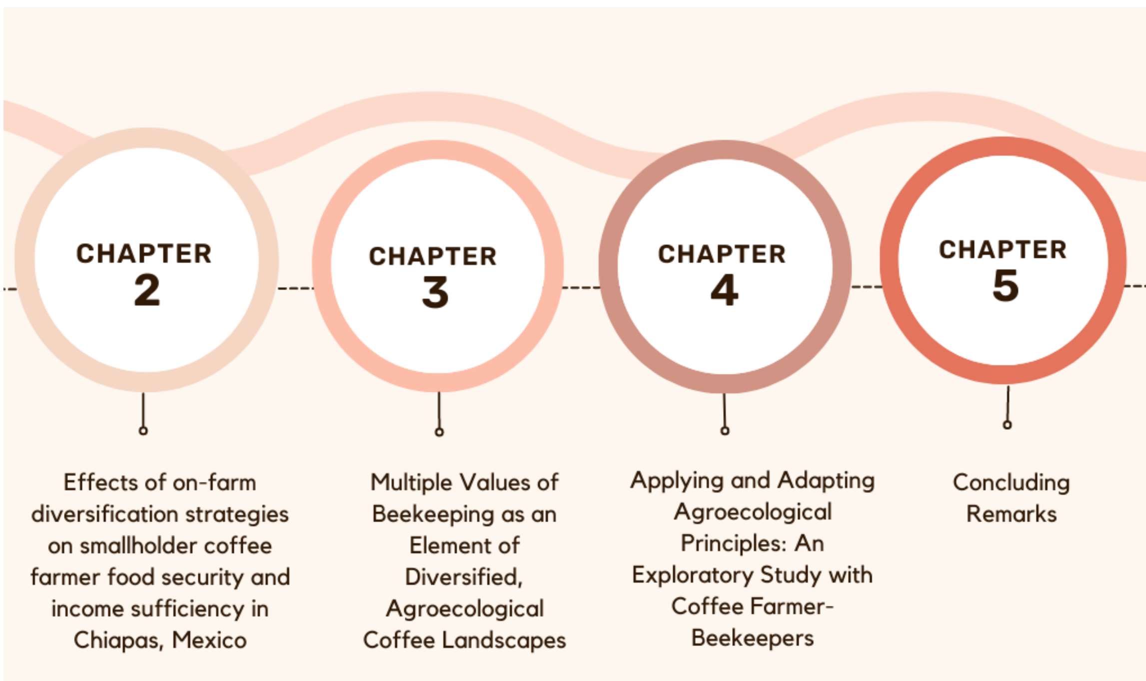


Figure 1-3: Chapters of this dissertation.

(UVM), El Colegio de la Frontera Sur (ECOSUR), and Community Agroecology Network (CAN). In Nicaragua, the team consisted of participants from PRODECOOP cooperative, Santa Clara University, Universidad Nacional Agraria (UNA), and CAN. Since the project ended, members from ALC and ECOSUR have continued collaborating with CESMACH.

Chapter 3 centers on beekeeping as an alternative for smallholder coffee farmers to diversify and reduce dependency on coffee. We used qualitative and quantitative methods to better understand the social and economic benefits associated with beekeeping and coffee farmer-beekeepers' perceptions of their future in beekeeping. Several previous studies have discussed the economic outcomes of beekeeping (e.g., Magaña Magaña, 2016), its social or cultural meanings (e.g., Ellis, 2022), or ecological contributions of bees in ecosystems (Martínez-Salinas et al., 2022). However, this is the first study to our knowledge that examines socio-economic aspects of beekeeping as an element of diversified coffee systems.

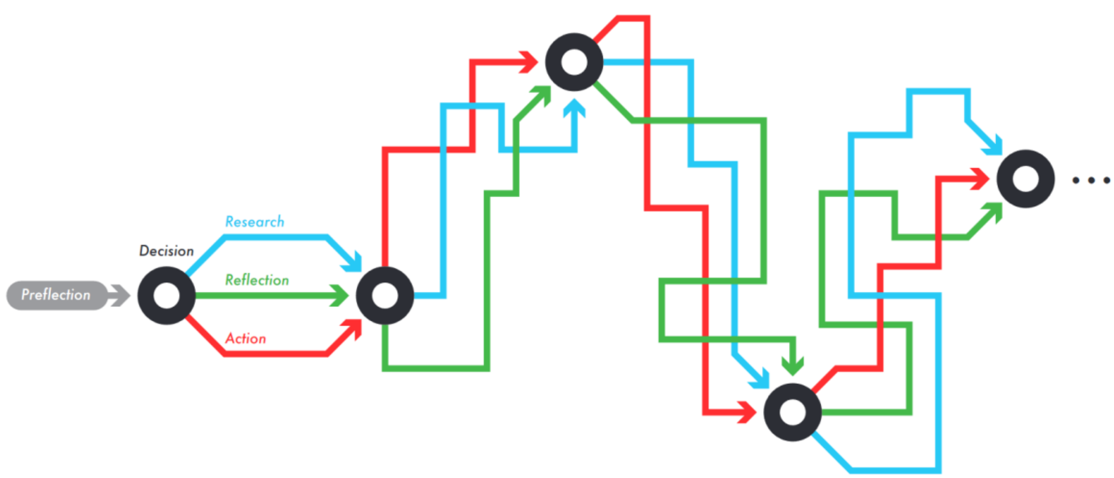


Figure 1-4: PAR processes typically start with a 'preflection' phase and then move through cycles of research, reflection, and action. Throughout the process, there are distinctive moments when the research team makes decisions e.g., about the next steps (Caswell et al., 2021).

PAR processes tend to follow cycles of research, action, and reflection (see Figure 1-4). Chapter 4 emerges from collective reflections on the findings from the study presented in Chapter 3. It explores opportunities for applying agroecological principles to the case study in order to enhance the ‘actionability’ or impact of the research results in the long term. We use a less well-known framework, *Agroecological Principles for Beekeeping* developed by *Equipo Abejas* at ECOSUR university, to draw lessons from our research findings and experiences with beekeepers of ART, explore how the framework can be adapted to the local context, and share ideas for an agroecological transitions approach for coffee farmer-beekeepers.

As a critical research approach, PAR seeks to integrate multiple ways of knowing and promotes processes of horizontal learning and knowledge co-creation (Cuéllar-Padilla and Calle-Collado 2011). The work presented in the following chapters results from the collaborative efforts of multiple people at different stages of the process – peasant families, a group of community facilitators and their coordinator, academics, NGO partners, and other collaborators (see Figure 1-4). To honor this collective knowledge production and the contributions of many people, I use “we” instead of “I” when sharing results in Chapters 2-4. At the same time, I acknowledge that my own background and past experiences affect in many ways how the findings from this study are framed and presented. I humbly recognize my biases as I continue to learn and unlearn.

Figure 1-5: PAR team after a *Feria de la milpa* in the community of Matazano: Bernardo Roblero Perez, Inés Lucia Perez, Janica Anderzén, Williams Salomón Roblero López, Rigoberto Hernandez Jonapá, Caralampio López Garcia, Alejandra Guzmán Luna, and David Armando Anzueto Coutiño. (Photo: Janica Anderzén)

1.3 References

Anderzén, J., Méndez, V.E., Griffeth, M., McHugh, C., Gilman, C., Barahona, C. and Peyser, R. (2021). *State of the Smallholder Coffee Farmer: An Initiative Towards a More Equitable and Democratic Information Landscape*. Research Report. Agroecology and Livelihoods Collaborative (ALC), University of

Vermont/Statistics for Sustainable Development (Stats4SD)/Heifer International/Lutheran World Relief (LWR). Burlington, Vermont, U.S.A.

Bacon, C. M., Sundstrom, W. A., Stewart, I. T., Maurer, E., and Kelley, L. C. (2021). Towards smallholder food and water security: Climate variability in the context of multiple livelihood hazards in Nicaragua, *World Development* 143: 105468. https://doi.org/10.1016/j.worlddev.2021.105468.

Caswell, M., Méndez, V. E., Juncos-Gautier, M. A., Hurley, S. E., Gould, R. K., Márquez Sánchez, D., and Lewis, S. (2021). Agroecological transformations in urban contexts: transdisciplinary research frameworks and participatory approaches in Burlington, Vermont. In M. Egerer and H. Cohen (Eds), *Urban agroecology: interdisciplinary research and future directions* (pp. 299-319). CRC Press, Taylor and Francis Group.

[CIDSE] Coopération Internationale pour le Développement et la Solidarité (2018). *The principles of agroecology: Towards just, resilient and sustainable food aystems.* CIDSE, Belgium. https://www.cidse.org/2018/04/03/the-principles-of-agroecology/.

Cuéllar-Padilla, M., and Calle-Collado, A. (2011). Can we find solutions with people? Participatory action research with small organic producers in Andalusia. *Journal of Rural Studies* 27(4), pp. 372-383.

de Roest, K., Ferrari, P., and Knickel, K. (2018). Specialisation and economies of scale or diversification and economies of scope? Assessing different agricultural development pathways. *Journal of Rural Studies* 59, pp. 222–231. https://doi.org/10.1016/j.jrurstud.2017.04.013.

Ellis, R. (2022). Social reproduction, playful work, and bee-centred beekeeping. *Agriculture and Human Values* 39, pp. 1329–1340. https://doi.org/10.1007/s10460-022-10319-0.

[FAO] The Food and Agriculture Organization of the United Nations (2018). *The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems.* FAO, Rome. http://www.fao.org/documents/card/en/c/I9037EN/.

Fernandez, M., and Méndez, V. E. (2018). Subsistence under the Canopy: Agrobiodiversity's Contributions to Food and Nutrition Security amongst Coffee Communities in Chiapas, Mexico. *Agroecology and Sustainable Food Systems* 43(5), pp. 1–23. https://doi.org/10.1080/21683565.2018.1530326.

Gerlicz, A., Méndez, V. E., Conner, D., Baker, D., and Christel, D. (2018). Use and Perceptions of Alternative Economic Activities among Smallholder Coffee Farmers in Huehuetenango and El Quiché Departments in Guatemala. *Agroecology and Sustainable Food Systems* 43(3), pp. 310–28. https://doi.org/10.1080/21683565.2018.1532480.

Gliessman [JA1] S.R. (2015). *Agroecology: the ecology of sustainable food systems*. 3rd Edition. CRC Press/Taylor & Francis, Boca Raton, Florida.

Guzmán Luna, A., Bacon, C. M., Méndez, V. E., Flores Gómez, M. E., Anderzén, J., Mier y Terán Giménez Cacho, M., Hernández Jonapá, R., Rivas, M., Duarte Canales, H. A., and Benavides González, Á. N. (2022). Toward Food Sovereignty: Transformative Agroecology and Participatory Action Research With Coffee Smallholder Cooperatives in Mexico and Nicaragua. *Frontiers in Sustainable Food Systems*, 6(August). https://doi.org/10.3389/fsufs.2022.810840.

Hannah, L., Donatti, C.I., Harvey, C.A., Alfaro, E., Rodriguez, D. A., Bouroncle, C., Castellanos, E., Diaz, F., Fung, E., Hidalgo, H. G., Imbach, P., Läderach, P., Landrum, J. P., and Solano, A. L. (2017). Regional modeling of climate change impacts on smallholder agriculture and ecosystems in Central America. *Climatic Change* 141, 29–45. https://doi.org/10.1007/s10584-016-1867-y

Harvey, C.A., Pritts, A.A., Zwetsloot, M.J., Jansen, K., Pulleman, M. M., Armbrecht, I., Avelino, J., Barrera, J.F., Bunn, C., Hoyos Garcia, J., Isaza, C., Muñoz-Ucros, J., Pérez-Alemán, J.C., Rahn, E., Robiglio, V., Somarriba, E., and Valencia, V. (2021). Transformation of coffee-growing landscapes across Latin America. A review. *Agronomy for Sustainable Development* 41(62). https://doi.org/10.1007/s13593-021-00712-0.

[HLPE] High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and* *nutrition*. (HLPE Report 14). HLPE, Rome. https://www.fao.org/agroecology/database/detail/en/c/1242141/.

Jaffee, D. (2014). *Brewing justice: Fair trade coffee, sustainability, and survival.* Updated edition. University of California Press, Berkeley, California.

Läderach, P., Ramirez-Villegas, J., Navarro-Racines, C., Zelaya, C., Martinez-Valle, A., and Jarvis, A. (2017). Climate change adaptation of coffee production in space and time. *Climatic Change* 141(1), pp. 47-62. https://doi.org/10.1007/s10584-016-1788-9

Magaña, M. A., Tavera, M. E., Salazar, L. L., and Sanginés, J. R. (2016). Productividad de la apicultura en México y su impacto sobre la rentabilidad. *Revista Mexicana de Ciencias Agrícolas* 7(February), pp. 1103–1115.

Martinez-Salinas, A., Chain-Guadarrama, A., Aristizabal, N., Vilchez-Mendoza, S., Cerda, R., and Ricketts, T. H. (2022). Interacting pest control and pollination services in coffee systems. *Proceedings of the National Academy of Sciences of the United States of America*119(15), pp. 1–7. https://doi.org/10.1073/pnas.2119959119.

McCune, N., Perfecto, I., Avilés-Vázquez, K., Vázquez-Negrón, J., & Vandermeer, J. (2019). Peasant balances and agroecological scaling in Puerto Rican coffee farming. *Agroecology and Sustainable Food Systems 43*(7–8), pp. 810–826. https://doi.org/10.1080/21683565.2019.1608348

Morris, K. S., Mendez, V. E., and Olson, M. B. (2013). 'Los Meses Flacos': Seasonal Food Insecurity in a Salvadoran Organic Coffee Cooperative. Journal of Peasant Studies 40(2), pp. 423–446. DOI: 10.1080/03066150.2013.777708.

Perfecto, I., and Vandermeer, J. (2015). *Coffee Agroecology: A New Approach to Understanding Agricultural Biodiversity, Ecosystem Services and Sustainable Development*. Routledge, Abingdon, UK.

[SCA] Specialty Coffee Association. (2019, December). *Price Crisis Response Initiative Summary of Work.* https://sca.coffee/availableresearch.

Soto-Pinto, L., Perfecto, I., Castillo-Hernandez, J., and Caballero-Nieto, J. (2000). Shade effect on coffee production at the northern Tzeltal zone of the state of Chiapas, Mexico. *Agriculture, Ecosystems and Environment* 80, pp. 61–69.

Toledo, V. M., and Moguel, P. (2012). Coffee and Sustainability: The Multiple Values of Traditional Shaded Coffee. *Journal of Sustainable Agriculture* 36(3), pp. 353–77.

CHAPTER 2: EFFECTS OF ON-FARM DIVERSIFICATION STRATEGIES ON SMALLHOLDER COFFEE FARMER FOOD SECURITY AND INCOME SUFFICIENCY IN CHIAPAS, MEXICO

Authors: Janica Anderzén, Alejandra Guzmán Luna, Diana V. Luna-González, Scott C. Merrill, Martha Caswell, V. Ernesto Méndez, Rigoberto Hernández Jonapá, R., and Mateo Mier-y-Terán

2.1 Abstract

Diversification has been recognized as an important agroecological strategy for rural development. Smallholder coffee agroecosystems are an illustrative example of diversified farming systems that provide an array of ecological, social, and economic benefits for farmer households, including food and income. Few studies have examined connections between farmer households' resource-base, livelihood activities, and food and/or livelihood security. This paper presents findings from a household survey conducted with member farmers of Campesinos Ecológicos de la Sierra Madre de Chiapas (CESMACH) coffee cooperative in Chiapas, Mexico, in 2017. We applied a Sustainable Livelihoods Framework to study selected household assets and livelihood strategies, and how these are associated with food security and income sufficiency. Here we show that farmer households combining coffee with beekeeping and staple food production reported fewer thin months and perceived themselves more income sufficient than other households. Additionally, we found that farm size and household composition

were connected with the level of on-farm diversification, an example of the complexity in these communities. Many factors affect diversification decisions and outcomes, and it is difficult to determine causal relationships. Here we suggest the need for nuanced and situational policy recommendations instead of generic ones. Further context-specific, empirical studies are needed to identify groups that may be amenable to strategy switching, livelihood strategies that could enhance coffee farmers' food and livelihood security, and to find leverage-points for interventions.

2.2 Introduction

Diversification has been identified as an important agroecological strategy for rural development (Scoones, 1998; Ellis, 2000; Amekawa, 2011; Gliessman, 2015; FAO, 2018; HLPE, 2019). A growing body of evidence suggests that diversification is important for enhancing food and livelihood security, adapting to climate change, and conserving and protecting natural resources (Altieri, 2009; Amekawa, 2011; FAO, 2018; HLPE, 2019). In this paper, we describe strategies used by smallholder coffee farmers in Chiapas, Mexico, to diversify their agricultural production and earnings. We also explore some of the potential outcomes of these strategies in terms of food security and income sufficiency.

Small-scale shade-grown coffee agroecosystems represent an illustrative example of diversified farming systems that provide an array of ecological, economic, and social benefits (Vandermeer and Perfecto, 2015). In Mesoamerica, coffee systems constitute a central livelihood activity for a large number of smallholder farmers (Jha et al., 2011). Smallholder farmers typically grow their coffee in shade agroforestry systems (Toledo and Moguel, 2012), which are home to a diversity of species that farmer households can sell or use for food, medicine, and timber/firewood (Soto-Pinto et al., 2000; Jha et al., 2011). Although coffee remains the main source of income for many households, farmers often complement their livelihood portfolios with other on-farm production, off-farm labor, and non-farm sources of income (Jaffee, 2014; Fernandez and Méndez, 2018; Gerlicz et al., 2018). Some farmers engage in vertical diversification within coffee (Rodríguez Padrón and Burger, 2015). Despite the diversity of food- and income-generating activities, many smallholder households experience seasonal food insecurity (Morris et al., 2013; Bacon et al., 2014; Fernandez and Méndez, 2018), and face challenges in earning a 'livable' income, even when participating in sustainable certification schemes (Robles Berlanga, 2011; Jaffee, 2014; Caswell et al., 2016; Sherfey, 2017). In addition, a changing climate poses further challenges to coffee producers (Imbach et al., 2017).

Many studies have explored aspects of livelihood diversification in smallholder coffee systems (e.g., Jha et al., 2011; Jaffee, 2014; Vellema, 2015; Gerlicz et al., 2018). However, few studies have examined connections between farmer households' resource-base, livelihood activities, and food and/or livelihood security (Eakin et al., 2012; Baca et al., 2014; Donovan and Poole, 2014; Caswell et al., 2016; Fernandez and Méndez, 2018). This study analyzed characteristics and outcomes of livelihood diversification among coffee farmers of the Campesinos Ecológicos de la Sierra Madre de Chiapas (CESMACH), and constitutes the first phase of a 3-year research project on livelihood diversification in the coffee lands of Mexico and Nicaragua. The results of this survey established a baseline for subsequent research that included monthly data collection with a selected cohort of CESMACH members for over a year. We believe that this type of place-based research is important for (1) gaining a deeper understanding of the complex, and dynamic, livelihood diversification strategies used by rural smallholder coffee farming communities; (2) understanding what kind of diversification (if any) may be the most optimal for the smallholder producers, in terms of food security and the household economy; and (3) creating actionable knowledge for decision-making at different levels (household, cooperative, and coffee industry).

We applied an adapted version of the Sustainable Livelihoods Framework (Scoones, 2009) to study on-farm diversification strategies, households' livelihood resources (assets), and how these are associated with seasonal food insecurity and income insufficiency. Previous studies and our field experience, pointed toward four diversification strategies (combinations of the activities of coffee production, beekeeping and milpa) that appeared to be particularly relevant for the provision of food and income. Maize and beans are staple crops that form an essential part of Mexican diets, identity and culture (Eakin et al., 2015; Appendini and Quijada, 2016; Guzmán Luna et al., 2019), while beekeeping provides an additional, relatively stable source of on-farm income for coffee farmers (Magaña Magaña and Leyva Morales, 2011; Bathfield et al., 2013). In recent years, CESMACH has been actively promoting beekeeping among its member farmers with support from NGOs.

To understand the connections between smallholder coffee farmer household livelihood assets, strategies, and outcomes, we posed the following research questions: (1) What livelihood diversification strategies are currently in use by smallholder farmers of the CESMACH coffee cooperative?; (2) What characteristics vary among the smallholder coffee farmer households having different livelihood strategies?; and (3) How are such characteristics and livelihood strategies associated with interacting outcomes of seasonal food insecurity and perceived income sufficiency?

This paper is divided into six sections including the introduction. In section 2.3, we explore theoretical and empirical perspectives on livelihood diversification in smallholder coffee systems, and describe the socio-economic context of our case study. In section 2.4, we describe the methods for data collection and analysis, our research approach, and the conceptual framework. In section 2.5, we present the study results starting with the characteristics of the participants and their livelihood strategies, followed by the outcomes related to income and food security. Finally, we conclude the paper with a discussion of the findings as well as policy implications in sections 2.6 and 2.7.

2.3 Livelihood diversification in coffee agroecosystems: theoretical and empirical perspectives

2.3.1 Dimensions of livelihood diversification

Livelihood diversification is a dynamic process that is influenced by a range of contextual and interconnected factors (Ellis, 2000). Ellis (2000, p. 15) defines diversification as "…the process by which rural families construct an increasingly diverse portfolio of activities and assets in order to survive and improve their standards of living." Activities refer to a range of on-farm, off-farm, and non-farm pursuits that individuals or households engage in to generate cash income, produce food for household consumption, or gain other benefits, such as personal contentment (Ellis, 2000; Scoones, 2009). Assets, on the other hand, are different resource categories, including natural, financial, human, physical, or social, that are owned or controlled by households (Ellis, 2000; Scoones, 2009).

Households' access to assets and choice of activities is mediated by a variety of factors, and entangled in power dynamics often outside the reach of individual households (Ellis, 2000; Ribot and Peluso, 2003; Scoones, 2009). In the Theory of Access, Ribot and Peluso (2003, p. 153) define access as "the *ability* to derive benefits from things", bringing attention to relational and structural mechanisms that create differing opportunities to gain, control, and maintain access to resources. For example, land ownership does not necessarily imply the access to resources that enable the owner to make use of the land. The access to these resources could be limited by absence of credits or other factors. Moreover, access is not static but a process, and access patterns can change over time (Ribot and Peluso, 2003).

2.3.2 Coffee farmers as exponents of livelihood diversification

Smallholder coffee production provides ample opportunities for livelihood diversification. Similar to other coffee producing regions in Mesoamerica, smallholder coffee farmers in Mexico typically grow Arabica[3] coffee in diversified shade agroecosystems along with multipurpose trees (Soto-Pinto et al., 2000; CEDRSSA, 2018). These agroecosystems generate many vital ecosystem services that provide "agroecological resistance" to climate change (Perfecto and Vandermeer 2015, p. 230; Altieri, 2009), and contribute to farmer households' food and livelihood security (Toledo and Moguel, 2012). For instance, fruit trees not only provide shade to coffee but also contribute to household nutrition through the production of fruits that are rich in vitamins and minerals (Albertin and Nair, 2004; Morris et al. 2013). Likewise, several species of plants, insects and mushrooms that inhabit the understory of shade coffee plantations are important to traditional cuisine and are used to complement diets (Luna-Gonzalez and Sørensen, 2018; Fernandez and Méndez, 2018). In addition to nutritional benefits, coffee agroecosystems produce economic value beyond coffee (Albertin and Nair, 2004; Westphal, 2008). In Guatemala, 'shade products' from coffee plots, such as fuelwood,

[3] Arabica coffee (*Coffea Arabica*), the species of coffee dominating specialty markets, is an understory shrub that grows best at moderate temperatures and middle to high elevations (600–2000 meters) (Jha et al., 2011).

food and lumber, accounted for approximately one fifth of the value of the coffee agroforestry system (Rice, 2008).

In conjunction with coffee agroecosystems, coffee farmers often manage other agricultural activities for food and income, such as raising animals or growing fruit and vegetables in home gardens (Jha et al., 2011; Jaffee, 2014). Corn and beans, grown in milpas (corn-bean-squash polyculture), are traditionally an important part of people's diet and food security in Mexico (Appendini and Quijada, 2016). Although some producers have converted milpas into coffee parcels, many households continue to plant corn and beans for subsistence (Jaffee, 2014; Appendini and Quijada, 2016). *Milpa* production can also serve as a coping strategy that some coffee farmers revert to in times of crisis (Eakin et al., 2012; Jaffee, 2014). In terms of agricultural income diversification, beekeeping for honey has shown to be a promising alternative for some smallholder coffee farmers (Bathfield et al., 2013). Beekeeping does not require much land, and can be economically viable even in relatively small operations (Magaña Magaña and Leyva Morales, 2011). It can also contribute to the health and nutrition of the households, as beehive products have high nutritional and medicinal values (Pasupuleti et al., 2017). Moreover, beekeeping offers pollination services for coffee agroecosystems (Imbach et al., 2017).

2.3.3 Multiple motives driving diversification among coffee farmers

Multiple motives can drive coffee farmer households to diversify their livelihood portfolios. For example, farmers may pursue diversification in order to manage risk, meet the basic needs of their household, or to respond to shocks or stressors that threaten livelihood assets or activities (Niehof, 2004; Westphal, 2008; Jaffee, 2014; Gerlicz et al., 2018). Examples of these livelihood shocks include natural disasters (Eakin et al., 2012) and declines in global coffee prices (Jaffee, 2014; Hausermann 2014; Rodríguez Padrón and Burger, 2015). Diversification can also serve as a means of dealing with persistent livelihood stressors, such as seasonal food insecurity (Baca et al., 2014; Morris et al., 2013) or changing climatic patterns (Ruiz Meza, 2015). Regardless of what pushes or pulls farmers to diversify, the decision of what activity to pursue also hinges on whether the household seeks a temporary coping mechanism or a long-term strategy (Westphal, 2008; Jaffee, 2014; Gerlicz et al., 2018).

2.3.4 Enabling and limiting factors for livelihood diversification among coffee farmers

Access to assets can either enable or limit coffee farmers' adoption of alternative livelihood activities. First, land availability (natural asset) is essential to rural livelihood diversification. Small landholdings and lack of access to additional land can constrain coffee farmers' opportunities to diversify their production (Eakin et al. 2012), or entail trade-offs between cash crops and subsistence production (Ponette-González, 2007). Second, household size and composition (human assets) are important determinants of diversification, as the availability and type of household labor have implications on the allocation of human resources (Vellema et al., 2015). For example, labor demands for coffee production may overlap with other activities, driving farmers to consider trade-offs in labor allocation (Westphal, 2008; Jaffee, 2014).

Third, changes in land-use or crop mix often implies investments (financial assets) that can deter resource-poor farmers, especially if access to financial capital is limited (Westphal, 2008; Ribot and Peluso, 2003). Moreover, farmers may be hesitant to take financial risks and pursue diversification, if market access is uncertain or technical assistance to support new activities is lacking (Tucker et al., 2010). Finally, diversification decisions and access to assets is mediated by various structural factors or processes at different levels, such as shifts in agricultural or trade policies (Ribot and Peluso, 2003). In our analysis, we considered land ownership, agrobiodiversity, household size and composition, sources of income and volume of coffee production as the limiting and/or enabling assets/conditions of livelihood diversification (see Figure 2).

2.3.5 Case study background

Chiapas is the principal coffee producing state in Mexico and among the first states to produce coffee over 200 years ago (CEDRSSA, 2018). Initially, coffee production was largely controlled by foreign estate owners who constituted a class of coffee elites (Jaffee, 2014). Following the post-revolutionary agrarian reforms in the early 20^{th} century, smallholder farmers and cooperatives were able to replace some of these large landowners as important actors in Mexican coffee production (Jaffee, 2014). Today, the vast majority (95.4%) of approximately 500,000 producers in Mexico are smallholders (<5 ha), and around 90% of them grow coffee in shade agroforestry systems

(CEDRSSA, 2018). The creation of the National Mexican Coffee Institute (INMECAFE) in 1958, encouraged smallholder farmers to specialize in coffee by offering credit, agricultural inputs, centralized coffee purchasing and technical assistance. Around that period, INMECAFE was the largest buyer of coffee in the country (Hausermann, 2014). Because of these supports and incentives, coffee production expanded rapidly, in many cases replacing other crops, such as maize (Tucker et al., 2010). The dismantling of INMECAFE in 1989 forced farmers to seek ways to cope with the new situation, leading to the creation of smallholder cooperatives, among other alternatives (Jaffee, 2014).

Campesinos Ecológicos de la Sierra Madre de Chiapas (CESMACH) were among the cooperatives that emerged from the post-INMECAFE context. In 1994, a group of farmers founded the organization to bypass intermediaries for the commercialization of their coffee and thus obtain better prices for their product. In addition to financial viability, conservation of the environment has also been an important principle for CESMACH since the beginning (CESMACH, 2019). The 663 members (211 women and 452 men) of CESMACH live in 46 communities (*ejidos*) in the Sierra Madre de Chiapas mountain range, and grow mainly *Arabica* coffee between 900 and 1700 msl. The communities are located in the buffer zone of the *El Triunfo* Biosphere Reserve, a biodiversity hotspot, which offers ideal conditions for coffee production (Cortina-Villar et al., 2012). The region was largely uninhabited before the 1950s, when, attracted by the possibilities to grow their own coffee and to acquire land through the agrarian reform, former coffee plantation workers, people from other regions of Chiapas, and indigenous people from Guatemala started migrating there (Cortina-Villar et al, 2012, CESMACH 2019). Today, coffee is the main livelihood activity for many people living in the region, with maize-bean cultivation and some livestock being other important land use systems (Fernandez and Méndez, 2018). The municipalities where CESMACH members live have been categorized as having 'high' levels of marginalization (CONAPO, 2015), due in part to the geographically remote location of the communities.

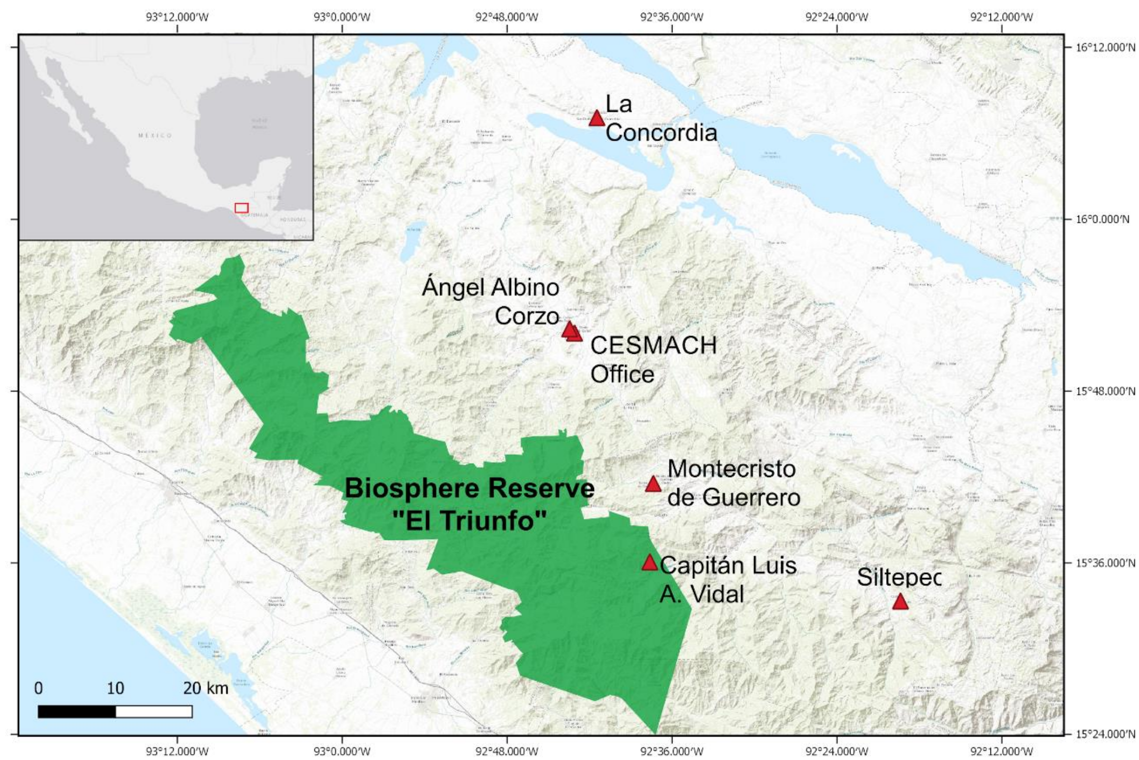


Figure 2-1: Map showing the 5 municipalities where the study was conducted, the Biosphere Reserve and the co-operative office (CONANP, 2018). Coffee-growing communities are located in higher elevations.

CESMACH is committed to the wellbeing of its members, and offers them access to markets, financial resources and technical assistance (CESMACH, 2019). It holds Fair Trade and Organic certifications, among others, and participates actively with the Small Producers Symbol (SPP), a global network of small farmers' organizations. In recent years, CESMACH has diversified their own market for coffee sales – continuing to export green coffee , and by creating a commercial subsidiary; *Sierra Verde de Chiapas SC de RL de CV*, which manages two coffee shops in the state capital, and processes and distributes a line of coffee for national consumption. *Café Femenino México* is a registered trademark for coffee grown by female members of CESMACH. It was initiated by a group of female heads of households who, inspired by experiences of a group of Peruvian women, sought to get recognition and direct compensation for their work. Currently, 146 women benefit directly from *Café Femenino.*

In addition to their focus on coffee, CESMACH has partnered with several NGOs and governmental agencies to support its members to diversify their production beyond coffee. Past projects have included the introduction of fruit trees, small family gardens, and beekeeping. These initiatives have proven important partly due to the devastating coffee leaf rust epidemic that affected the region, and illustrated the vulnerability of CESMACH members as coffee producers. CESMACH has enjoyed special success with beekeeping, and in 2019, *Miel Real del Triunfo*, a parallel cooperative with 80 members, was created by CESMACH members to sell their honey. Management of honey bees (*Apis mellifera*) was first introduced in 2009 by the Heifer Foundation through a project that promoted the adoption of different on-farm activities. According to the project manager of the *Miel Real del Triunfo,* beekeeping was the most successful activity, as it generated income for the families and targeted any member of the cooperative who was truly motivated to become a beekeeper. Over the recent years, beekeepers have started to invest more in apiculture, partly through a partnership with Food 4 Farmers, a US-based organization that has provided financial and technical support.

Beekeeping aligns well with the expected benefits of productive diversification. In the words of the CESMACH general manager: "[CESMACH] should be focused on satisfying the dietary needs of families, the conservation of resources *in situ* and (supporting) the role played by the flora and fauna in the *milpa* agroecosystem and surrounding local environments". Although there is support for diversification activities from CESMACH members, the cooperative is aware of the difficulties for diversifying and recognizes previous failures, such as not recognizing the conditions and needs of the member families, at a given time. These contextual factors, and a desire to find solutions, motivated CESMACH to participate in the PAR process, which forms the basis for this paper.

2.4. Methods and analysis

2.4.1 Research project and the PAR approach

This paper presents results of a household survey that constitutes the first phase of the 3-year, transdisciplinary research project "Assessment of Diversification Strategies in

Smallholder Coffee Systems of Mesoamerica". The project was launched in 2017 and aimed to generate scientific and actionable knowledge on livelihood diversification in coffee-growing communities of Mexico and Nicaragua. We used a participatory action research (PAR) approach to frame and guide our research. PAR is better described as a process (rather than project), and usually combines mixed methods research with knowledge co-creation through the engagement of scholar and non-scholar partners. It seeks to generate scientific evidence on a topic of interest to all parties and build capacity for strategic decisions (Méndez et al., 2017). This is commonly done through an iterative process that includes a 'preflection' phase, and cycles of research, reflection and action (Mendez et al., 2017). In this process, members of the Agroecology and Livelihoods Collaborative (ALC) of the University of Vermont (UVM) led the preflection with all partners to define research objectives and roles. The participants of the PAR process in the Mexico site[4] include the leadership of CESMACH, a group of community facilitators[5], professors/researchers from El Colegio de la Frontera Sur (ECOSUR) in Chiapas, the Community Agroecology Network (CAN, a U.S.-based non-profit), and the ALC. Due to pre-existing relationships between project partners, there was already a certain level of trust among the team members, which facilitated open dialogue from the very start of the process.

[4] In Nicaragua, the project partners include the coffee cooperative PRODECOOP, Santa Clara University, Universidad Nacional Agraria (UNA), and CAN.

[5] Community facilitators are young farmers who are CESMACH members or children of members. They participate actively in all phases of the PAR process.

The preflection phase was followed by survey data collection that sought to generate a baseline and, subsequently, steer phases of deep reflection and action (see Lewin, 1946; Bacon et al., 2005). Once research was initiated, the team sought to maintain the PAR principles of transparency, communication, and collective action in the generation of methodologies, data collection, its analysis and interpretation (Mendez et al., 2017). In advance of, and parallel to the preparation of this paper, the team has engaged in ongoing dialogue with stakeholders, produced tools and facilitated activities that fulfil the reflection and action components of the PAR cycle. These include sharing preliminary data among farmers and other audiences and designing popular educational tools for farmers.

2.4.2 Participants and data collection

Data was collected through surveys of 167 households, which represent approximately 25 % of CESMACH's total membership. Within this sample, 28.7 % of the interviewees were women (see Table 2-1). Households were randomly selected from five groups (30 participants from each group): 1) beekeepers, 2) farmers with *milpa* (selected from a list that was generated in a previous, related study; Fernandez and Méndez, 2018), 3) farmers who had participated in diversification projects, 4) farmers participating in specialty coffee initiatives, and 5) farmers who had not participated in any projects. These groups were chosen with the assistance of the cooperative leadership as potentially representing the range of engagement with diversification present in the cooperative, based on previous data that CESMACH had gathered from all of its members. We added several beekeeper households to the survey in order to obtain a sample size large enough for statistical inference, resulting in an overrepresentation of the beekeeper group in the sample (50.7 % of all beekeepers in the cooperative). The selection sought to maintain a gender representation proportional to the cooperative's membership and include participants from all the municipalities in which CESMACH has members. Due to a policy of CESMACH, participants did not receive a monetary compensation.

The Phase 1 survey included an initial design by the core research team, followed by a round of revisions and edits from the participating field team. The survey was then vetted by the cooperative partners and underwent several rounds of piloting and testing. The instrument consisted mostly of closed ended questions, and was administered on tablets using Kobo Toolbox (https://www.kobotoolbox.org/), a free open-source tool. The application of the survey took between 40-60 minutes. The survey team consisted of six enumerators, the local field coordinator, two doctoral students and an undergraduate student, who visited 30 communities during June and July 2017. Survey team members held reflection sessions after each workday, both to enhance data quality and also to include the survey team in initial data analysis.

The survey included 79 questions organized in eight sections, as follows: household demographic information, land use, diversification activities, financial capital, shocks and stressors experienced by farmers, food security, social capital and community, as well as a specific section only for beekeepers. The list of on-farm activities was compiled in collaboration with CESMACH and represents the most common activities in the communities. The option “other” was given to ensure identification of other possible activities. The survey sought to obtain information about farmer households’ livelihood activities, their resource base as well as indications of the possible economic and food security outcomes of their livelihood decisions.

We used various sources of qualitative data to triangulate survey data, and to engage CESMACH members and staff in the data analysis and reflection. These included key informant interviews with the CESMACH leadership, agricultural calendars developed in three focus groups, and two data-interpretation workshops with the local research team. In addition, we drew information from participant observation and several informal conversations with farmers during the visits to communities. Interviews, workshops and focus groups were recorded, and the recordings from the latter were transcribed; field observations were documented in notebooks. Research instruments were approved by UVM’s Committee on Human Research in the Behavioral and Social Sciences (CHRBSS) Institutional Review Board (IRB).

2.4.3 Analysis

2.4.3.1 Analytical framework

To guide our analysis, we used a modified version of the Sustainable Livelihood Framework (SLF; Scoones, 1998). The SLF, and similar livelihood frameworks (e.g., Ellis, 2000), view livelihoods as dynamic processes in which households’ assets and livelihood activities as well as contextual and structural factors influence livelihood outcomes. Amekawa (2011) notes that a Sustainable Livelihoods (SL) approach is useful for analyzing agroecological farming systems, as it allows placing "agroecologically based" and "pluriactive" smallholder livelihoods – such as those of smallholder coffee farmers – as the subject of research. The approach is also compatible with other theoretical frameworks, such as the Theory of Access, that draw attention to various structural factors and processes mediating access to resources (Myers and Pilegaard Hansen, 2019). In our study, we adapted the SLF (see Figure 2-2) to describe the characteristics of the farmer households and their livelihood portfolios, and to explore which assets and activities (and combinations of these) potentially yield the most beneficial outcomes in terms of food and livelihood security. We further sought to link our findings to some of the socio-economic processes that may influence diversification decisions and access to assets.

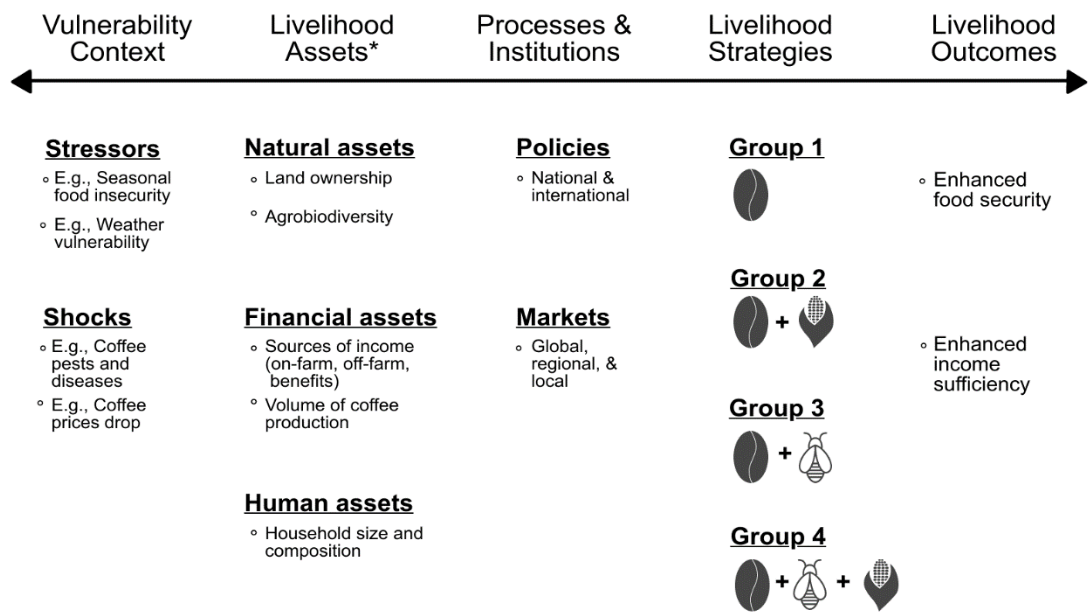
As illustrated in Figure 2-2, we analyzed three types of livelihood assets: natural (land and agrobiodiversity), human (household size and composition), and financial assets (sources of income and volume of coffee production). We selected these assets after a careful reading of prior, similar studies (e.g., Bacon et al., 2014; Donovan and Poole, 2014; Caswell et al., 2016; Fernandez and Méndez, 2018), and reflection sessions with the research team. We recognize that other types of resources, such as social, physical and political assets/capitals, can also be important determinants of diversification (see Ellis, 2000), and hope to include these factors in our analysis of the Phase 2 data from this study.

Each of the 167 farmer households in our study represents a unique combination of livelihood activities and assets. In order to reduce some of the variability among farmers and explore potential differences and similarities between the farmer households, we re-categorized farmers into four livelihood strategy groups. These groups reflect our increased understanding of livelihood diversification among CESMACH farmers, and thus depart from the original stratification criteria. Reclassification was based on an examination of existing literature (see section 2.2), our field research, and conversations with CESMACH staff and members. This examination pointed to the importance of staple food production and beekeeping for food and livelihood security. In addition, our PAR partner CESMACH had a particular interest in gaining a better understanding of the role of beekeeping and staple crop production in their members' livelihood portfolios. Therefore, our four livelihood strategy[6] groups represent all possible combinations of these two 'key' activities, beekeeping and staple crop production, plus coffee. The farmers in each group may have other on-farm activities in addition to the key activities.

In this study, we narrowed our focus to potential impacts of livelihood diversification on income sufficiency and food security, which are important determinants of households' wellbeing. These two variables are strongly interrelated (Dasgupta and Ray, 1986) and are affected by agricultural production, and therefore diversification (HLPE, 2019). We used an ordinal, self-reported variable, 'perceived sufficiency of income for basic needs' (levels: 'not sufficient', 'more or less sufficient',

[6] We recognize that the term 'strategy' may have the connotation of a carefully determined plan (Gerlicz et al., 2018); we do not assume that this is the case, and we use the term as an analytical category.

‘sufficient’) as a proxy for the economic success of the farmer households’ livelihood portfolio. We chose not to add questions about actual cash income for two main reasons: (1) our local partners informed us that farmers would not necessarily be comfortable talking about their income with strangers, (2) the answers would have provided information about the gross income which, without counting all the investments in coffee and other agricultural production, would have been an inaccurate indicator of the net income available for the households.



** Livelihood analysis may include other asset categories, such as physical and social assets.*

Figure 2-2: Adapted Sustainable livelihoods framework (Scoones, 1998; Ellis, 2000*).*

For learning about farmer households' level of food (in)security, we used FANTA's indicator (Bilinsky and Swindale, 2010) 'Months of Adequate Household Food Provisioning' (MAHFP). Participants were asked if in the previous 12 months they had experienced food shortages. If the answer was positive, we asked in which months they did not have enough food to meet their family's needs, and, in consequence, had to reduce their consumption or change their habitual/preferred diet. We then counted the number of food insecure months, or 'thin months', reported by farmers. This variable was treated as ordinal. Other studies with coffee farmers have also used the variable 'thin months', which allowed us to compare our findings (Bacon et al., 2014; Baca et al., 2014; Fernandez and Méndez, 2018).

2.4.3.2 Data analysis

The survey data were summarized and analyzed in R version 3.5.1 (R Development Core Team, 2018; Wickham et al., 2018). Mean, standard deviation, maximum and minimum, and/or percent were calculated for all variables (Tables 2-2, 2-3, 2-4, 2-5). Comparisons among groups (e.g., among the four livelihood strategies, and among the three levels of income-sufficiency) were analyzed using one-way ANOVA tests (followed by Tukey HSD tests) and Pearson Chi-squared tests (followed by the calculation of odds ratios). When comparing quantitative response variables among groups, such as total land area, number of on-farm activities, or number of thin months, we used the former; for comparing categorical response variables among groups, such as binomial variables about the practice of specific agricultural activities (Yes/No), we used the latter. Spearman correlations (r_s) were used to assess the association between some variables (e.g., number of edible crops and number of thin months). We held focus groups and data interpretation workshops, to triangulate with our preliminary findings from quantitative analysis. Focus groups that resulted in participants creating agricultural calendars were especially helpful in understanding seasonal patterns of food insecurity to compare with survey results. Insights from field notes, informal conversations with farmers and results interpretation workshops also helped us to interpret survey results.

2.5 Results

2.5.1 Household characteristics and on-farm diversification

2.5.1.1 Livelihood strategies groups and demographic characteristics

As shown in Table 2-1, farmers who reported having coffee and no other key activities (Group 1 - G1) constituted 25.1 % of all farmers in the sample, while farmer households combining coffee with staple crops made up the biggest group (Group 2 - G2), representing 53.3 % of all households. Respondents who reported practicing beekeeping in addition to coffee (Group 3 - G3) or having all key livelihood activities (Group 4 - G4) represented 11.4 % and 10.2 %, respectively, of all surveyed households. However, it is important to note that beekeepers were overrepresented in the sample, as mentioned above. In terms of demographic characteristics, we found some differences between the groups. For instance, farmers in G2 had the highest average age (48.7 years) and the least formal education (3.9 years), while the beekeeper groups (G3 and G4) had the youngest respondents (G3=41.6, G4=43.7) and the highest level of formal education (G3=6.6, G4=5.9). Farmer households in G1 tended to have the smallest household size (4.8 members).

2.5.1.2 Landholdings and coffee

Farmer households managed, on average, 8.7 hectares of land – including both agricultural land and forested areas – with landholdings ranging from 1.4 to 41.0 hectares. The land was distributed, on average, in 3.5 plots/land areas with some plots located in the close proximity to the house and others further from the homestead (some took up to three hours to reach). We did not find differences among the groups ($F(3, 155)=0.40$; $p=0.75$) in terms of land area, although producers in G4 had, on average, slightly more land than other groups (9.7 hectares). Farmer households reported having an average of 6.0 hectares under coffee production, and producing 40.2 *quintales* of coffee in total (1 quintal = 57.5 kilograms of parchment coffee). The land area under coffee is above average in Mexico (CEDRSSA, 2018) and some other parts of Chiapas (Soto-Pinto et al., 2000). Using a Tukey HSD test, we found significant differences between G1 farmers who had the largest land areas dedicated to coffee (7.1 hectares on average), and G2 farmers who reported the least hectares under coffee (5.4 hectares on average) ($p=0.05$). Similarly, Tukey's HSD test showed that farmers in G1 produced the most coffee average in total (56.3 quintales), whereas farmers in G2 had the lowest average total coffee production (30.1 quintales) ($p <0.01$). Farmers in G1 had the highest percentage of respondents who had renovated their coffee plots following the most recent coffee leaf rust outbreak (90.5 %), while the G2 had the lowest proportion (74.2 %).

2.5.1.3 Staple crops

Farmers producing maize or beans (G2 and G4) had on average 1.4 hectares of land reserved for growing these staple crops. However, we estimate that the average land area under production was considerably smaller, as average land included plots that were fallow or rented to other farmers during the time of the survey. The survey responses show that staple crop production is an activity that is typically learned from parents or grandparents at an early age; many farmers noted that they had been growing staple crops "their whole lives". We also found that many farmers in G1 and G3 had abandoned staple crop production within the past 10 years. In G1, 43.9 % of the producers said they had stopped growing staple crops, while for G3 the result was 21.1 %. These findings are consistent with two other studies conducted with CESMACH farmers (Fernandez and Méndez, 2018; Baca et al., 2014). When asked about the reasons for abandoning this activity, the most common explanations were the high workload required to maintain staple crops, time constraints, and lack of adequate land. Some farmers specifically mentioned that they had converted their *milpas* into areas for coffee cultivation.

2.5.1.4 Beekeeping

Beekeeping for honey production is a relatively new activity among CESMACH farmers, unlike most other on-farm activities, and is practiced on a relatively small scale. On average, honey producers had been practicing beekeeping for five years, and were managing approximately 20 beehives. Many farmers said they had initiated beekeeping due to a project through CESMACH (sponsored by Heifer International or Food 4 Farmers), or a governmental program. The data shows that beekeeping is less time-intensive than coffee production: farmers reported working approximately five days per month in apiculture, while coffee occupied an average of 20 days per month. Additionally, beekeeping shows potential for being an economically important activity for the farmers. More than 36.4 % of the honey producers considered apiculture “economically more attractive” than coffee. In the non-beekeeper groups, 9.5 % (G1) and 15.0 % (G2) said they had tried beekeeping within the past 10 years, but had abandoned the activity due to lack of technical assistance, increased workload, and/or health risks (e.g., allergies).

Table 2-1: Household and key activity characteristics

	Group 1		**Group 2**		**Group 3**		**Group 4**		**All**	
Number of households	42		89		19		17		167	
	mean	*sd*	*mean*	sd	*mean*	*Sd*	*mean*	*sd*	*mean*	*sd*
Age of interviewee	43.9	10.8	48.7	15.5	41.6	7.8	43.7	16.3	46.2	14.0
Years of formal education completed by the interviewee	5.3	3.3	3.9	3.4	6.6	3.6	5.9	3.9	4.8	3.6
Household size	4.8	2.1	6.3	2.5	6.6	2.0	6.0	2.4	5.9	2.5
Number of children and elderly (age: <15y and >64y)	1.7	1.6	2.4	1.6	2.3	1.4	2.1	1.4	2.2	1.6

Number of adults (age: 15y-64y)	3.1	1.7	3.9	1.9	4.3	2.3	3.9	2.0	3.7	1.9
Landholding size (including forest) (ha)	9.2	6.7	8.3	4.7	8.9	8.5	9.7	4.8	8.7	5.7
Coffee										
Land under coffee (ha)	7.1	4.7	5.4	2.6	5.5	1.5	6.7	4.4	6.0	3.4
Land under coffee (% of total land) (n= 155[a])	82	22.9	69.6	19.4	81.0	25.4	64.3	25.1	73.5	22.4
Coffee harvested (quintales of parchment coffee, total)	56.3	63.0	30.1	23.5	45.7	29.6	47.2	48.8	40.2	41.5
Renovation after coffee rust (% of households)	90.5 %		74.2 %		84.2 %		76.5 %		79.6 %	
Staple foods										
Land under maize and/or beans (ha)	n/a	n/a	1.4	1.4	n/a	n/a	1.5	1.2	1.4	1.4
Beekeeping										
Number of beehives	n/a	n/a	n/a	n/a	18.6	15.6	21.4	14.2	19.9	14.8

[a]Reliable information was not obtained from 12 respondents.

2.5.1.5 Characteristics of other livelihood activities

Our findings show that farmer households managed a variety of activities on their farms. In addition to coffee, farmers reported having an average of 4.1 productive activities. Excluding beekeeping and staple crop production as productive activities, we found differences between the number of on-farm activities among the groups ($F(3,163)=29.8$, $p=0.03$). A Tukey's HSD test showed some evidence that farmers in G4 (3.6 ± 1.1) were managing more on-farm activities than farmers in G1 (3.0 ± 1.1, p=0.09) and in G3 (2.8 ± 1.1, p=0.06).

Table 2-2: On-farm diversification activities per group

	Livelihood strategy groups				
	Group 1	Group 2	Group 3	Group 4	All
	% of households				
Beekeeping	0.0	0.0	100.0	100.0	21.6
Vegetables	78.6	78.7	52.6	82.4	76.0
Staple foods	0.0	100.0	0.0	100.0	63.5
Poultry	76.2	95.5	68.4	94.1	87.4
Farm animals (pigs, rabbits)	14.3	31.5	31.6	52.9	29.3
Livestock (cows, horses)	7.1	14.6	15.8	23.5	13.8
Fruit trees	100.0	96.6	100.0	100.0	98.2
Aquaculture	7.1	5.6	10.5	0.0	6.0
Other	1.9	9.0	0.0	5.9	8.3

	Group 1		Group 2		Group 3		Group 4		All	
	mean	*sd*	*mean*	*sd*	*mean*	*Sd*	*mean*	*sd*	*mean*	*sd*
Number of on-farm activities (excluding all key activities)	3.0	1.1	3.3	1.0	2.8	1.1	3.6	1.1	3.2	1.1
Number of on-farm activities (total, exc. coffee)	3.0	1.1	4.3	1.0	3.8	1.1	5.6	1.1	4.1	1.3

As Table 2-2 illustrates, nearly all households (98.2 %) had fruit trees, and 87.4 % of the respondents reported raising poultry. A Pearson Chi-squared test showed that the proportion of farmers raising poultry ($\chi^2(1)=16.3$, $p<0.01$) or farm animals ($\chi^2(1)=4.3$, $p=0.04$) differed between groups growing staple crops (G2 and G4) and those who were not (G1 and G3). The former were over seven times (7.2) more likely to raise poultry (95% CI: 2.5 - 20.8, $p<0.01$) and over two times (2.2) more likely to have farm animals than the latter (95% CI: 1.0 – 4.6, p=0.04). Maize is commonly used to feed farm animals and poultry, so its production may provide an advantage for growing milpas and raising poultry or farm animals, but we assume there are also other factors affecting farmers' decision to raise these animals. The least common activities of the activities listed in the survey were aquaculture and livestock (6.0 % and 13.8 %, respectively).

Land and labor were associated with livelihood diversification. We found a positive correlation between the total number of on-farm activities and the number of productive adults (15-64 years) in the household (r_s=0.3, p<0.01). Moreover, there was a positive correlation between the number of on-farm activities and total hectares of land managed by the household (r_s= 0.2, p<0.01).

2.5.2 Income

2.5.2.1 Sources of cash income

Coffee farmer households earned cash income from varying sources, as shown in Table 2-3. In addition to coffee, farmers reported having an average of 3.4 income sources. Other studies from coffee regions in Mesoamerica have reported similar results (Morris et al., 2013; Baca et al, 2014; Caswell et al., 2016). Coffee excluded, farmers had an average of 1.1 on-farm and 1.0 off-farm sources of income, as well as 1.3 income streams through different types of benefits, such as conditional cash transfer programs (e.g., *Prospera* for low-income families with children) and payments for ecosystem services (PES) schemes. It is notable that different types of benefits form part of the income portfolios of the vast majority of farmer households (86.2%), and many respondents listed benefits among the three most important income sources. As noted elsewhere, government subsidies are an important source of additional income for smallholder farmers (Jaffee, 2014: Robles Berlanga, 2011).The most commonly reported sources of income were cash transfers/agricultural subsidies (81.1 %), PES schemes (46.2 %), sale of animals or animal-based products (35.6 %), off-farm agricultural labor (29.6 %), and small businesses (21.9 %).

Although income-diversification is common among the producers, coffee remains the main source of agricultural income for many farmer households. Our findings show that 35.3 % of farmers reported coffee as the only source of agricultural income. The proportion of farmers who did not sell other agricultural products in addition to coffee differed among the groups ($\chi^2(3)=23.4$, $p<0.01$), with G1 having the highest proportion of coffee-dependent households. The probability of relying solely on coffee as a source of agricultural income were 2.1 times greater for G1 than for G2 (95% CI: 1.0 - 4.3, $p=0.06$), and 10.0 times greater than for G4 (95% CI: 2.0 - 49.4, $p<0.01$).

Our findings suggest that some on-farm activities may be more relevant for household consumption than for generating cash income. For example, while 96.2 % of households have fruit trees, only 18.9 % of farmers reported selling fruit. Also, a relatively small percentage of farmer households growing vegetables, corn or beans received cash income from their produce (11.2 %, 12.3 % and 21.7 %, respectively). Our qualitative data from informal conversations with farmers and results interpretation sessions suggests that the sale of agricultural products, such as vegetables and fruits, is more common than the survey results imply. Sales of vegetables and fruit tend to be small and sporadic, which may explain why more farmers did not report these as 'sources of income' (see Gerlicz et al., 2018). Some farmers mentioned that they barter excess agricultural products with family and community members, and use these (especially fruit) for feeding coffee pickers during the harvest.

Table 2-3: Income-related variables

	Livelihood strategy groups									
	Group 1		Group 2		Group 3		Group 4		All	
	mean	*sd*	*mean*	*sd*	*mean*	*sd*	*mean*	*sd*	*mean*	*sd*
Number of sources of income (excl. coffee)	2.6	1.3	3.4	1.7	3.4	1.5	4.6	1.8	3.4	1.7
On-farm (excl. coffee)	0.6	0.9	1.1	1.2	1.5	0.7	2.2	1.5	1.1	1.2
Off-farm (wage labor, business)	0.8	0.8	1	0.9	0.9	1.3	1.2	0.8	1	0.9
Benefits (governmental programs, PES)	1.2	0.6	1.4	0.6	1	0.8	1.2	0.9	1.3	0.7
% of households with coffee as the only on-farm source of income	57.1		37.8		0		5.9		35.3	

2.5.2.2 Sufficiency of income

As illustrated in Figure 2-4, farmers combining beekeeping with staple crop production (G4) had the highest probability of perceiving their income as 'sufficient', while the G2 farmers showed the lowest probability, although this was not statistically significant. Our findings suggest that the probability increases for all groups as the number of on-farm sources of income increases (Figure 2-3). The trend is similar but slightly weaker when all sources of income are taken into account. To further test the role of beekeeping in terms of income sufficiency we compared beekeepers (G3 and G4) to non-beekeepers (G1 and G2). Using a Pearson Chi-squared test we found that beekeepers appeared to perceive their income as sufficient more frequently than farmers who did not practice beekeeping (G1 and G2) ($\chi^2(2)=7.3$, $p=0.03$). As shown in Figure 2-4, 55.6 % of the beekeepers perceived their income as sufficient, 19.4 % more or less and 25.0 % not sufficient, while the same percentages for non-beekeepers were 33.6 %, 17.6 %, and 48.9 %, respectively. It is important to note that although our results imply that beekeeping may increase earnings, it could indicate the inverse; farmers with a higher income might be more inclined to invest in a new activity like beekeeping; therefore, we cannot suggest a causal relationship between beekeeping and income.

In addition to beekeeping, we found some evidence that landholdings and the volume of coffee production were associated with income sufficiency. Our results show that income sufficiency tended to increase as the volume of coffee produced ($r_s=0.2$, $p<0.01$), and land under coffee ($r_s=0.1$, $p=0.09$) and the total farm size ($r_s=0.1$, $p=0.11$) increased. We did not observe an association between income sufficiency and the number of on-farm activities that farmers were managing.

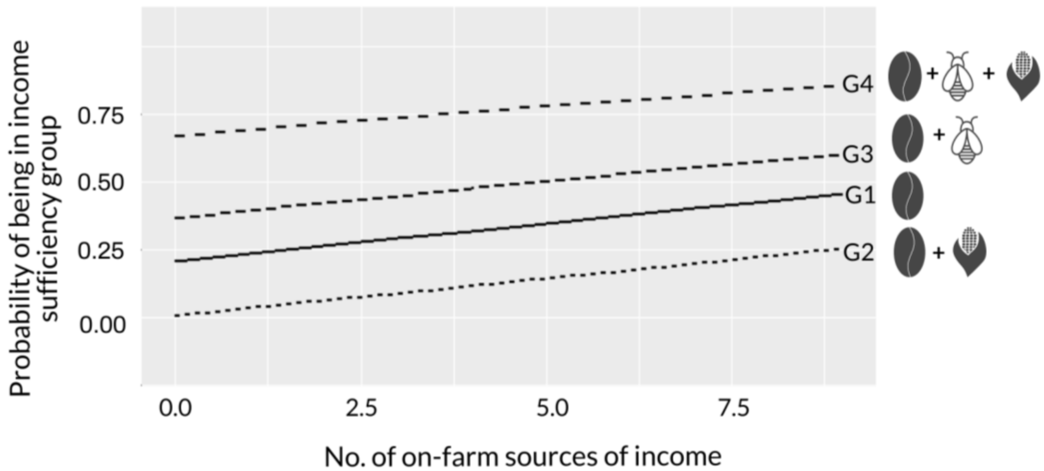


Figure 2-3: Probability of perceiving income as sufficient by group as the number of on-farm sources of income increases.

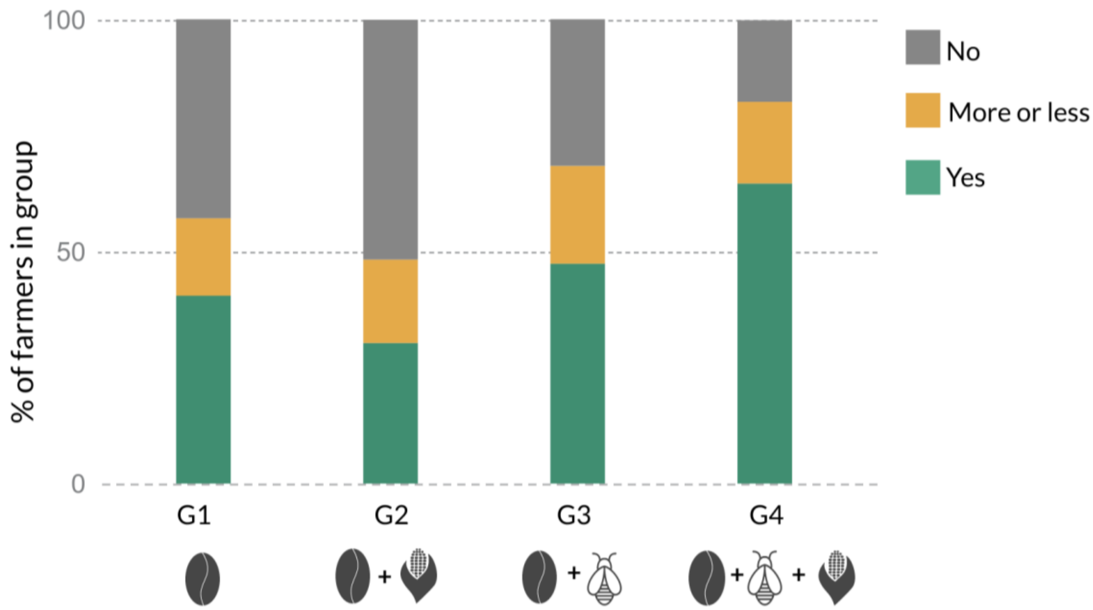


Figure 2-4: Perception of the sufficiency of income by group

2.5.3 Food security

2.5.3.1 Prevalence of seasonal food insecurity

Seasonal food insecurity was common among the interviewed coffee farmer households, with 71.9 % of all respondents reporting at least one month of food scarcity. On average, farmers suffered 2.5 thin months per year with some participants reporting up to 8.0 months, as shown in Table 2-4. These findings are similar to other studies reporting thin months among the CESMACH farmers. Baca et al. (2014) found that farmers experienced, on average, 2.5 months of food insecurity, while the findings by Fernandez and Méndez (2018) showed an average of 2.7 months (or 1.6 months, if including farmers who did not report thin months). Our results also concur with findings from a study in Northern Nicaragua, where farmers experienced, on average, 3.2 months of food insecurity in 2010 (Bacon et al., 2014).

Almost half of the participants experienced food insecurity from August through October, but in general, the thin months extended from June to December (see Figure 2-5). As shown in Figure 2-5, thin months overlap with the rainy season and corn/coffee pre-harvest periods, when household savings from previous coffee sales along with maize and bean reserves become depleted. The rainy season also affects the road conditions, which may hamper physical access to markets for food. Moreover, this is the time when staple food prices peak, especially corn, which increases the financial pressure on the families. Similar patterns have been observed in other regions where coffee is the main source of income, and maize and beans constitute important staple foods (Morris et al., 2013; Bacon et al., 2014; Fernandez and Méndez, 2018).

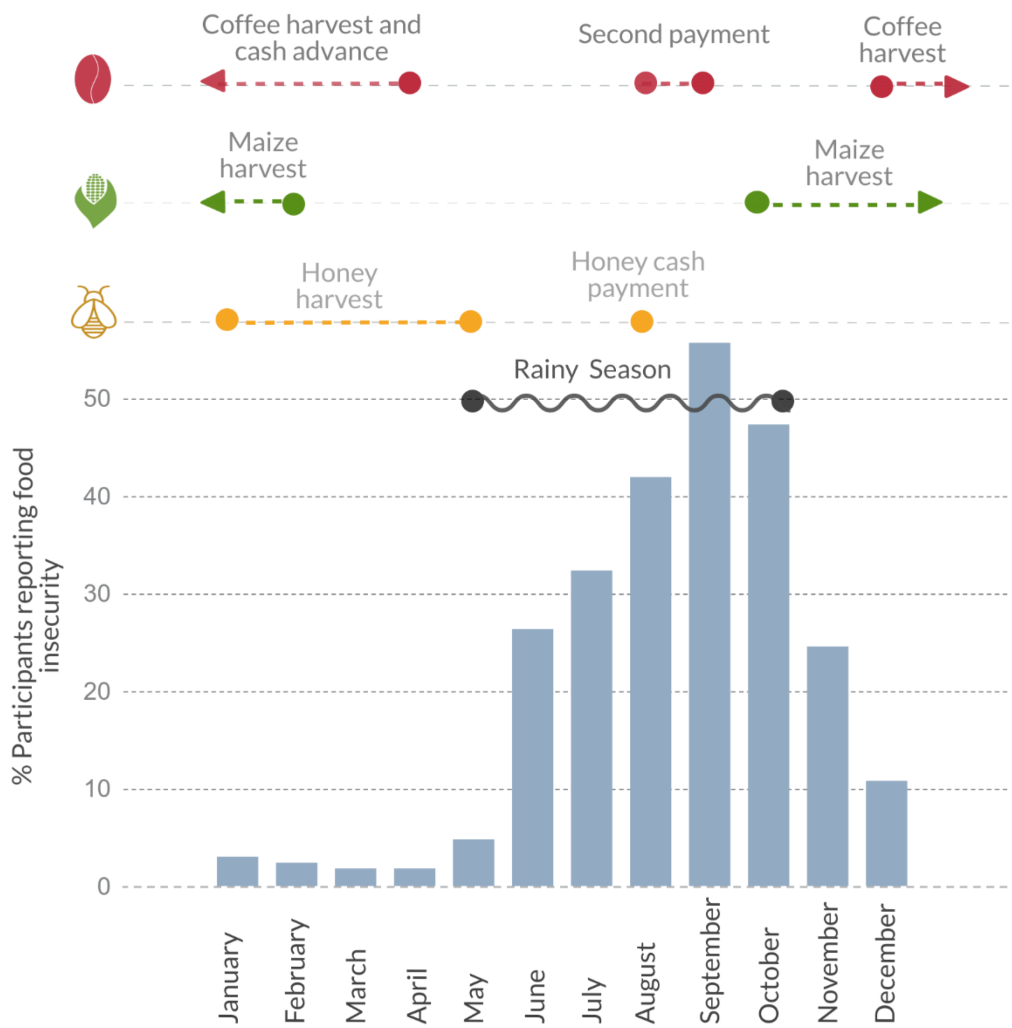


Figure 2-5: The thin months occur during the rainy season and when the maize storage has been depleted. In some years, coffee and maize harvest overlap, creating competing labor demands. Honey cash payments arrive at critical moments, helping farmers to cope with the thin months.

2.5.3.2 Type of on-farm diversification influences prevalence of thin months

Some evidence exists that the duration of seasonal food insecurity varies among the groups ($F(3,163)=2.2$, $p=0.09$). A Tukey's HSD test revealed that farmers combining coffee with staple food production and beekeeping (G4) experienced fewer months of seasonal food insecurity (1.3 ± 1.5) than farmers in G1 (2.8 ± 2.3, $p=0.07$), and G2 (2.6 ± 2.1, $p=0.08$). We did not find an association between the number of on-farm activities and the number of thin months ($r_s=0.04$, $p=0.59$), which suggests that specific activities, such as staple food production, may have a stronger impact on food security than the level of diversification. Additional data are needed to better understand the contributions of staple food production to food security. In the survey, only 27.4 % of the coffee farmers in G2 and G4 said that their maize production was sufficient to cover their annual consumption; this production covered only 6.5 months, on average. However, we did not find evidence of an association between the number of months of corn supply and the number of thin months ($r_s=-0.08$, $p=0.32$).

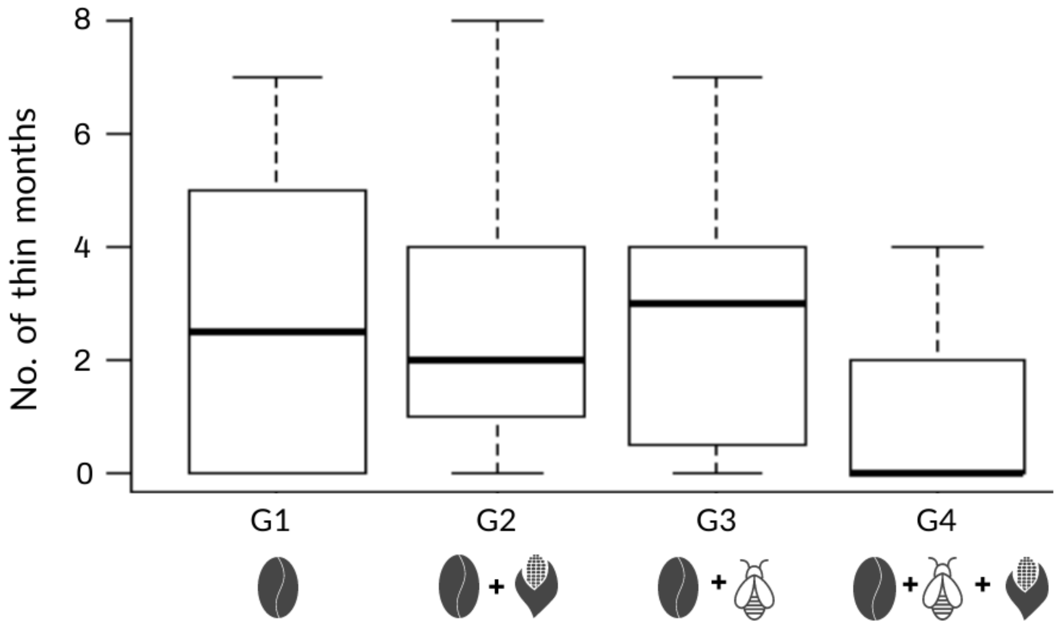


Figure 2-6. Farmers practicing milpa and beekeeping (G4) experienced fewer thin months than farmers in the other groups.

2.5.3.3 Income sufficiency, landholdings, and coffee production associated with fewer thin months

Our findings suggest that there is an association between the number of thin months and the level of income sufficiency. We found differences in the number of self-reported thin months among farmers perceiving themselves as ‘income sufficient’, ‘non-income sufficient’, and ‘more or less income sufficient’ ($F(2,164)=4.5$, $p=0.01$). A Tukey’s HSD test revealed that the largest difference was between ‘income sufficient’ and ‘non-income sufficient’ farmers ($p=0.01$), with the former reporting an average of 2.0 months of seasonal food insecurity and the latter 3.1 months.

We also found that as total farm size, land under coffee, and volume of coffee produced increased, the number of thin months reported by the participants decreased (r_s= -0.2, $p < 0.01$; r_s= -0.2, p=0.02; r_s=-0.2, p=0.02 respectively). Other studies from coffee lands in Mesoamerica have found a similar association between farm size and self-reported thin months (Baca et al., 2014, Bacon et al., 2014). Moreover, an increase in these same assets (total farm size, land under coffee, and volume of coffee was associated with a higher perceived income sufficiency, as discussed in section 4.2.2. However, we did not find evidence of an association between the number of sources of income and the number of thin months or between the number of on-farm income sources and thin months.

Table 2-4: Food-security-related variables

	Livelihood Strategies									
	Group 1		Group 2		Group 3		Group 4		All	
	mean	*sd*	*mean*	*sd*	*mean*	*sd*	*mean*	*sd*	*mean*	*sd*
Number of thin months	2.8	2.3	2.6	2.1	2.6	2.2	1.3	1.5	2.5	2.1
Number of months of corn supply	n/a		6.7	3.3	n/a		5.8	3.5	6.5	3.4
Number of edible plant species on-farm	23.1	9.7	22.2	8.1	19.2	10.2	27.3	9.5	22.6	9

2.5.3.4 Thin months and agrobiodiversity

On average, coffee farmers cultivated, hosted, and foraged around 22 different edible plant species on their land. Farmers in G4 reported a higher average of on-farm edible plants, when compared to the other groups of farmers ($F(3,163)=2.6$, $p=0.05$) (see Table 2-4). All farmers reported having wild greens on their land, such as nightshade (*Solanum americanum* n=161), correlon (*Solanum spp.* n=149), chipilin (*Crotalaria longirostrata*, n=122), and amaranth leaves (*Amaranthus spp.*, n=117). These greens are nutritionally important due to their high Vitamin A and iron content (FAO, 2008). Other common species included citrus (e.g., orange, lemon, grapefruit; n= 151), avocado (*Persea americana*, n=130), mango (*Mangifera indica*, n=104), pacaya (*Chamaedorea tepejilote*, n=143), and banana (*Musa spp.*, n=142). As mentioned above, trees provide multiple functions to coffee farmers, including shade for coffee trees, fruits for self-consumption, wood for cooking, timber for building, and nectar for bees.

In addition to the wild greens, other cultivated vegetables stood out in the survey. For example, chayote (*Sechium edule*, n=147) and squash (*Cucurbita sp.*, n=77), were frequently mentioned and local traditions utilize parts of the whole plant besides the fruit. For example, *chayote* and squash's vine shoots and squash flowers can be consumed, providing food before and after their fruits are ripe. Roots and tubers were also frequently reported, especially taro (*Colocasia esculenta*, n=102) and radish (*Raphanus raphanistrum*, n=72). Finally, multiple varieties of beans (*Phaseolus vulgaris)*, corn (*Zea mays*) and chili (*Capsicum annuum*) were mentioned by farmers growing these crops. However, we did not find a strong negative correlation between the number of on-farm edible plants reported by farmers and the number of self-reported thin months, as hypothesized (r_s=0.04, p=0.61). We believe this could be a consequence of the data collection methods (see Discussion).

2.6. Discussion and policy implications

2.6.1 Coffee remains the most important economic activity

Our findings indicate that while CESMACH coffee farmer households were generally diversified, coffee remained the most important economic activity. On average, farmers had one other agricultural source of income in addition to coffee, and more than 30 % had no other on-farm sources of income, which points to the relative importance of coffee (and potentially non-farm sources of income) as a source of revenue. A study from CESMACH indicates that around 70 % of farmers' income comes from the sale of coffee (Baca et al., 2014), providing further evidence of the central role of this cash crop for the farmer households. This dependency on coffee reflects the contextual factors that moved coffee from being an economic supplement to a mainstay for many Mexican households, leaving coffee-dependent farmers more vulnerable to the various shocks and stressors that affect the crop (Jaffee, 2014).

Previous studies have shown that a relatively low number of additional agricultural income sources can reflect either a long-term plan to specialize on coffee, or a risk-averse strategy to avoid potentially risky investments in new activities (see Tucker et al., 2010). Our field experience suggests that it can also result from various types of obstacles to market access for alternative agricultural products, or not having access to information about alternative crops. Additionally, coffee production as a component of self-identity is a relevant consideration, as it can serve to motivate farmers to improve their practices instead of choosing to diversify (Hausermann, 2014; Bielecki and Wingenbach, 2019). Whatever the motivation may be, specialization in coffee could be an increasingly risky strategy, considering projected impacts of climate change on coffee production (Imbach et al., 2017), and the volatility of international coffee prices (Jaffee, 2014).

2.6.2 Farmer characteristics influence the level and type of livelihood diversification

Our findings suggest that land (natural asset) and labor (human asset) are important resources for on-farm diversification. We found that households with larger landholdings and/or more productive workforce (adults between 15-65 years) tended to practice, on average, more agricultural activities on their farms. Although land availability does not necessarily translate into ability to benefit from it (see Ribot and Peluso, 2003), access to land seems to open opportunities for agricultural diversification, possibly at a lower risk than for land-constrained farmers (Tucket et al., 2010). Access to land may be limited due to various factors, such as membership status in the *ejido* (Morett Sánchez and Ruiz, 2017).

Our findings further point to tradeoffs in resource allocation. Households who reported not having other key activities in addition to coffee (G1) tended to have a smaller household size and fewer adults (15-65 years) than other groups, which suggests that these households may have less workforce to allocate toward alternative livelihood activities in addition to coffee. Farmers who discontinued growing staple crops also referred to competing resource demands, listing labor, time, and land constraints among the main reasons for abandoning the activity. In informal conversations and during the participatory data analysis sessions, some producers explained that households with less family labor found it difficult to allocate time for both coffee and staple food production, and tended to give preference toward cash crop production.

When looking at individual productive activities, we found that CESMACH farmers were most commonly engaged in activities that tend to require relatively low asset investments, and can be managed in coffee plantations or in-home gardens (i.e., fruit trees, poultry, and vegetables). The less common activities (i.e., aquaculture, livestock and beekeeping) appear to coincide with barriers to entry such as a need for more labor, specialized skills, financial resources, and/or suitable land. These findings align with other studies pointing to the importance of different types of asset building/consolidation for creating opportunities for livelihood diversification (Gerlicz et al. 2018; Bielecki and Wingenbach, 2019). This may be particularly important in a state that suffers from high levels of poverty and marginalization (CONAPO, 2015). CESMACH's beekeeping initiative offers an example of the positive effect of NGOs providing technical assistance and equipment to support farmers' engagement in the activity.

2.6.3 Different livelihood strategies have different effects on food and livelihood security

Coffee farmers growing corn and/or beans (G2) experienced, on average, fewer months of food scarcity than farmers who did not produce staple crops (G1 and G3), although they were generally more food insecure than farmers who produced honey in addition to coffee and staple crops (G4). These results point to the importance of staple food production for food security, echoing findings from several other studies (Isakson, 2009; Morris et al., 2013; Fernandez and Méndez, 2018). However, only a quarter of the households were producing enough maize to meet the households need for the whole year, which may be a result of low yields or the fact that self-produced maize is often used to feed coffee pickers and farm animals. Whatever the reason, many households would need to produce more staple crops to be fully self-sufficient. Due to potential trade-offs in the allocation of land and labor, this option may not be possible for all households.

In terms of income security, farmers combining all key activities (G4) were more likely to perceive their income as sufficient than other groups, whereas farmers in G2 showed the lowest probability of perceiving their income as sufficient. Our qualitative data suggest that beekeeping is an important factor in the relative success of having all key activities. Income from honey complements coffee-related income and, due to the timing of the payment for the product, provides an important source of revenue during the most critical months of food and income shortages (see Figure 2-5). However, we need additional data to understand why many farmer households in G2 were not able to generate an income that was sufficient for meeting the basic household needs, or why many farmers in G3 reported experiencing several months of food insecurity, on average, even though they reported being relatively income sufficient.

2.6.4 Planned and associated biodiversity can help to improve food security

In addition to a variety of managed food crops and fruit trees, a number of wild plants were available in farmers' land, often growing in coffee plots under the canopy of shade vegetation. As many coffee plots are in the buffer zone of El Triunfo Biosphere Reserve, the richness of the associated biodiversity is connected to the vicinity of this protected area. Although we did not find an association between crop species richness and thin months, results from other studies imply that the diversity of edible plants make an important contribution to the food security of farmer households and help cope with seasonal food insecurity (Bacon et al., 2014; Baca et al., 2014; Fernandez and Méndez, 2018). For instance, Fernandez and Méndez (2018) found that wild leafy greens that are rich in micronutrients were part of coffee farmer households' regular diet. However, there are some socio-cultural barriers to consuming wild plants, as some people consider them 'food for the poor' or 'backward'. For this reason, despite their nutritional qualities and cultural tradition, many people do not report them as part of their 'preferred diet'. This offers an opportunity for the cooperative and other initiatives to support a re-valuing and increased awareness of these plants as important sources of local, nutritious food.

2.6.5 Implications of our study

Our findings suggest that a combination of both market-oriented (i.e., coffee and honey) and subsistence activities (i.e., milpa) can have a stronger impact on food and income security than the production of subsistence food or commercial agricultural products alone. However, our analysis on livelihood assets shows that this type of strategy may not be accessible (or attractive) to all farmer households. This underscore the importance of: (1) identifying alternative diversification pathways that are accessible and compatible to different types of farmers who have different resources and interests; and (2) supporting farmers and their organizations to strengthen assets that can enable access to suitable diversification alternatives. To enable this, improved access to credit is essential for opening new opportunities (Robles Berlanga, 2011; Morris et al., 2013; Donovan and Poole, 2014). In addition, interventions that provide support to capacity building, technical assistance, and improved market access have been shown to help farmers to adopt new productive activities (Tucker et al., 2010).

We concur with literature that highlights the diversification of agricultural sources of income as an important strategy for reducing dependency on a single crop and enhancing resilience (Amekawa, 2011; HLPE, 2019). Our findings suggest that beekeeping for honey may be a good alternative for income diversification that can help to reduce dependency on coffee and boost household economy during the critical months of income and food scarcity. However, it is important to note that honey as a commodity is also subject to price volatility, and could increase farmers' vulnerability to price shocks. During the time of writing this paper, the price paid for a kilogram of honey by *Miel Real del Triunfo* was estimated to be around 30 $MXN, whereas in the past year it was 43 $MXN (personal communication, June 2019). Value added beehive products or stronger local markets could potentially help farmers to decrease vulnerability to price fluctuations (see Guevara and Romero, 2011; Altieri, 2009).

Our study raises some concerns about the future of staple food production. While more than 60% of the farmers in the study reported producing staple crops, over the last 10 years many farmers decided to stop growing corn and/or beans. These shifts should be understood in the context of NAFTA , where policy changes affecting maize production are designed to "support non-profitable farmers to transition to other crops and activities" (Keleman et al., 2009 p. 56). The abandonment of *milpa* also reflects a "tension between intensification and diversification" in a neoliberal economic system that is hostile to smallholder producers (Jaffee, 2014, p. 167).

Considering the importance of staple crops for Central American diets (Isakson, 2009; Bacon et al., 2014; Fernandez and Méndez, 2018), a tendency towards the abandonment of staple food production is likely to have negative consequences on farmer households' food security. Effects of this will be especially severe in years when coffee harvest fails, coffee prices plummet, or corn prices increase (Bacon et al., 2014; Morris et al., 2013). Additional side effects from these shifts will potentially lead to loss of landrace varieties of maize and beans, and traditional knowledge (see Isakson, 2009). Government, state, NGO, and community initiatives that support households to enhance staple crop production for consumption could have a positive impact on the food security of these households (see Isakson, 2009; Appendini and Quijada, 2016). Successful examples include community seed banks to conserve local varieties, and innovative distribution systems to maintain maize and/or bean prices, access and availability (Bacon et al., 2014).

2.6.6 Research limitations and future research

We used household surveys as a tool to get a ‘snapshot’ of farmers’ livelihoods. These data allowed us to characterize diversification strategies among CESMACH farmers, identify associations and trends, and refine research questions for the continuation of our PAR process. We are fully aware that these types of surveys have limitations. For instance, they are ineffective for capturing motivations and meanings behind livelihood decisions, or the dynamic and multiscalar nature of livelihoods (Creswell, 2014). While survey data support the identification of connections and tendencies between livelihood activities, assets, and outcomes, surveys alone are limited in describing causality between these elements (Creswell, 2014).

The livelihood strategy groups that guided our research were the result of a careful qualitative analysis of existing literature and our field experience. We also wanted to respect the interests of our PAR partner CESMACH, which we believe will contribute to the ‘actionability’ of our results (Méndez et al., 2017). Moreover, we wanted to avoid data dredging to reduce the chances of observing false positive results that can arise from re-categorizing and retesting data. However, we recognize that other categorizations (or typologies) would have been possible, and could have generated different kind of results on livelihood strategies and outcomes. Additionally, we are aware that the relatively small number of farmers in G3 and G4, as compared to G1 and G2, can be problematic in terms of making statistical inference.

We used crop species richness and MAHFP as proxies for assessing agrobiodiversity and food security. However, we are aware that crop species richness is a superficial indicator of food availability and accessibility because it may not relate directly to the quantity of food available for consumption. Similarly, MAHFP is a qualitative proxy for food accessibility and does not speak to other dimensions of food security, such as dietary quality. Moreover, the indicators rely on self-reported data, which is dependent on the memory or respondents, and are affected by the seasonal timing of the survey.

Livelihoods are fluid and dynamic, and an array of factors operating at different scales affect farmer households' livelihood portfolios/strategies (Ellis, 2000). These issues have been taken into account, as we continue with the next phases of our PAR process, where we will work with a smaller subset of farmers to deepen our understanding about farmer households' resources, motivations, livelihood portfolios, and outcomes. We will also seek to better understand the gendered nature of livelihoods (see Radel, 2012). In addition, our team will continue integrating agroecological principles and livelihood approaches to the study of diversification in smallholder coffee systems (Amekawa, 2011; HLPE, 2019).

2.7 Conclusions

The results from this study provide further evidence that diversification could be an important agroecological strategy for strengthening livelihoods and improving the food security and sovereignty of coffee farmers. This is particularly important considering that in our study, more than 70 % of farmer households reported experiencing food insecurity, and many farmers perceived their income as insufficient to meet the basic needs of their households. Our findings also show that a variety of factors regulate the effects of diversification on farmers' wellbeing, calling for conservative, non-generic conclusions. Contextual social, economic and ecological factors affect the ability of farmers to start a new livelihood activity and diversify their livelihood portfolio, while the characteristics of the activities, or strategies, determine the direction and magnitude of the livelihood benefits. Further studies exploring socio-ecological characteristics, decision-making processes, and structural aspects are needed to identify sustainable livelihood strategies that could enhance coffee farmers' food and livelihood security, and to find leverage-points for diversification interventions. These types of studies are increasingly important given the dynamic nature of smallholder coffee livelihoods, which require assessing realities that are constantly changing. International coffee markets continue to provide unfavorable conditions for smallholder farmers, and recent climate change scenarios point to the need to rapidly adapt to changing growing conditions. We concur with other authors that collaborative and participatory initiatives, which build bridges among farmers, academics, policy-makers, and the coffee industry, could lead to more sustainable livelihood outcomes for coffee farmers.

Acknowledgements

We would like to thank the project team, CESMACH staff and families, and the research assistants Keydi Marisol López Velasco, Bernardo Roblero Perez, Williams Salomón Roblero López, Melby Noriel Galindo Roblero, Vera Lucía Méndez Velázquez, Adrián Sánchez Alvarado and Grant Holub-Moorman. We are also grateful to Adriana Quiroga Carapia and Juan Antonio Hernández Lleaven for their assistance, and the three anonymous reviewers for their valuable insights.

Funding

The project Assessment of Diversification Strategies in Smallholder Coffee Systems (No AF 1507-086: No FDNC Engt 00063479) is supported under the "Thought for Food" Initiative of the Agropolis Foundation (through the "Investissements d'avenir" programme with reference number ANR10-LABX-0001-01"), Fondazione Cariplo and Daniel & Nina Carasso Foundation.

2.8 References

Albertin, A. and Nair, P.K.R., 2014. Farmers' Perspectives on the Role of Shade Trees in Coffee Production Systems: An Assessment from the Nicoya Peninsula, Costa Rica. *Human Ecology*, 32(4), pp. 443-463. https://doi.org/10.1023/B:HUEC.0000043515.84334.7**.**

Altieri, M.A., 2009. Agroecología, pequeñas fincas y soberanía alimentaria. *Ecología Política* 38, pp. 25-35.

Amekawa, Y., 2011. Agroecology and Sustainable Livelihoods: Towards an Integrated Approach to Rural Development. *Journal of Sustainable Agriculture* 35(2), pp. 118–62.

Appendini, K. and Quijada, M.G., 2016. Consumption strategies in Mexican rural households: pursuing food security with quality. *Agriculture and Human Values* 33, pp. 439–454. DOI 10.1007/s10460-015-9614-y.

Baca, M., Liebig, T., Caswell, M., Castro-Tanzi, S., Méndez, V.E., Läderach, P., Morris, B. and Aguirre, Y., 2014. *Thin months revisited*. Final report (October 16). International Center for Tropical Agriculture (CIAT) and Agroecology and Rural Livelihoods Group (ARLG), University of Vermont, Vermont.

Bacon, C. M., Mendez, E., and Brown, M., 2005. *Participatory action research and support for community development and conservation: examples from shade coffee landscapes in Nicaragua and El Salvador.* The Center for Agroecology & Sustainable Food Systems, Research Brief #6, pp. 1-12.

Bacon, C. M., Sundstrom, W. M., Flores Gómez, M. A., Méndez, V. E., Santos, R., Goldoftas, B. and Dougherty, I., 2014. Explaining the 'hungry farmer paradox': Smallholders and fair trade cooperatives navigate seasonality and change in Nicaragua's corn and coffee markets. *Global Environmental Change* 25, pp. 133–49.

Bathfield, B., Gasselin, P., López-Ridaura, S. and Vandame, R., 2013. A flexibility framework to understand the adaptation of small coffee and honey producers facing market shocks. *The Geographical Journal* 179(4), pp. 356–368.

Bielecki, C. D. and Wingenbach, G., 2019. Using a livelihoods framework to analyze farmer identity and decision making during the Central American coffee leaf rust outbreak: implications for addressing climate change and crop diversification. *Agroecology and Sustainable Food Systems*, 43(4), pp. 457-480. DOI: 10.1080/21683565.2019.1566191.

Bilinsky, P. and Swindale, A., 2010. *Months of Adequate Household Food Provisioning (MAHFP) for Measurement of Household Food Access: Indicator Guide (v.4)*. Washington, D.C.: FHI 360/FANTA.

Caswell, M., Méndez, V. E., Hayden, J., Anderzén, J., Cruz, A., Merritt, P., Izzo, V., Castro, S. and Fernandez, M., 2016. *Assessing Resilience in Coffee-Dependent Communities of Honduras, Nicaragua and Haiti*. Research Report. Agroecology and Rural Livelihoods Group (ARLG), University of Vermont, Burlington, Vermont.

[CEDRSSA] Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria, 2018. *El café en México. Diagnóstico y perspectiva*. Report. Retrieved from: http://www.cedrssa.gob.mx/files/10/30El%20caf%C3%A9%20en%20M%C3%A9xico:%20diagn%C3%B3stico%20y%20perspectiva.pdf

[CESMACH] Campesinos Ecológicos de la Sierra Madre de Chiapas, 2019. *La Cesmach: su origen, desarrollo y perspectivas de futuro. Sistematización de experiencias.* Quiroga Carapia, A. A. and Hernández Lleaven, J. A. (eds.). (*manuscript in preparation*).

[CONAPO] Consejo Nacional de Población, 2015. *Índice de marginación por entidad federativa y municipio 2015*. Retrieved from: https://www.gob.mx/cms/uploads/attachment/file/459287/06_Anexo_B1.pdf

Cortina Villar, S., Plascencia-Vargas, H., Vaca, R., Schroth, G., Zepeda, Y., Soto-Pinto, L., and Nahed-Toral, J., 2012. Resolving the conflict between ecosystem protection and land use in protected areas of the Sierra Madre de Chiapas, Mexico. *Environmental Management* 49(3), pp. 649-662.

Dasgupta, P., and Ray, D., 1986. Inequality as a determinant of malnutrition and unemployment: Theory. *Economic Journal*, 96, pp. 1011–1034

Donovan, J. and Poole, N., 2014. Changing asset endowments and smallholder participation in higher value markets: Evidence from certified coffee producers in Nicaragua. *Food Policy* 44, pp. 1–13.

Eakin, H., Benessaiah, K., Barrera, J. F., Cruz-Bello, G. M. and Morales, H., 2012. Livelihoods and landscapes at the threshold of change: disaster and resilience in a Chiapas coffee community. *Regional Environmental Change* 12, pp. 475–488.

Eakin, H., Appendini, K., Sweeney, S. and Perales, H., 2015. Correlates of Maize Land and Livelihood Change Among Maize Farming Households in Mexico. *World Development* 70, pp. 78-91. http://dx.doi.org/10.1016/j.worlddev.2014.12.012.

Ellis, F., 2000. *Rural livelihoods and diversity in developing countries*. Oxford University Press, Oxford.

[FAO] Food and Agriculture Organization of the United Nations, 2018. *The 10 elements of agroecology: guiding the transition to sustainable food and agricultural systems*. Retrieved from: http://www.fao.org/3/i9037en/I9037EN.pdf.

Fernandez, M. and Méndez, V. E., 2018. Subsistence under the Canopy: Agrobiodiversity's Contributions to Food and Nutrition Security amongst Coffee Communities in Chiapas, Mexico. *Agroecology and Sustainable Food Systems*, pp. 1–23. https://doi.org/10.1080/21683565.2018.1530326.

Gerlicz, A., Méndez, V. E., Conner, D., Baker, D. and Christel, D., 2018. Use and Perceptions of Alternative Economic Activities among Smallholder Coffee Farmers in Huehuetenango and El Quiché Departments in Guatemala. *Agroecology and Sustainable Food Systems* 43(3), pp. 310–28. https://doi.org/10.1080/21683565.2018.1532480.

Gliessman S.R., 2015. *Agroecology: the ecology of sustainable food systems*. 3rd Edition. CRC Press/Taylor & Francis, Boca Raton, Florida.

Guevara, F. and Romero, M., 2016. *La crianza de abejas como estrategia de diversificación: análisis de las cadenas de miel en El Tuma-La Dalia*. Cuaderno de investigación 54. UCA Publicaciones, Managua, Nicaragua.

Guzmán Luna, A., Ferguson, B. G., Schmook, B., Giraldo, O. and Aldasoro Maya, E. M., 2019. Territorial Resilience the Third Dimension of Agroecological Scaling: Approximations from Three Peasant Experiences in the South of Mexico. *Agroecology and Sustainable Food Systems* 43 (7-8), pp. 764-784. https://www.tandfonline.com/doi/full/10.1080/21683565.2019.1622619.

Hausermann, H., 2014. Maintaining the Coffee Canopy: Understanding Change and Continuity in Central Veracruz. *Human Ecology* 42, pp. 381–394.

[HLPE] High Level Panel of Experts on Food Security, 2019. *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. HLPE report 14. Retrieved from: http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-14_EN.pdf.

Imbach, P., Fung, E., Hannah, Navarro-Racinesa, C. E., Roubikd, D. W., Ricketts, T. H., Harvey, C. A., Donatti, C. I., Läderach, P., Locatelli, B. and Roehrdanz, P. R., 2017. Coupling of pollination services and coffee suitability under climate change, *PNAS* 114(39), pp. 10438-10442.

Isakson, R. S., 2009. No hay ganancia en la milpa: the agrarian question, food sovereignty, and the on-farm conservation of agrobiodiversity in the Guatemalan highlands. *The Journal of Peasant Studies* 36(4), pp. 725-759. DOI: 10.1080/03066150903353876

Jaffee, D., 2014. *Brewing justice: Fair trade coffee, sustainability, and survival*. Updated edition. University of California Press, Berkeley, California.

Jha, S., Bacon, C. M., Philpott, S. M., Rice, R. A., Méndez, V. E. and Läderach P., 2011. A Review of Ecosystem Services, Farmer Livelihoods, and Value Chains in Shade Coffee Agroecosystems. In: Campbell, W. B. and López Ortíz, S., Editors, 2011. *Integrating Agriculture, Conservation and Ecoturism: Examples from the Field.* Springer: Sacramento, California.

Keleman, A., Hellin, J., and Bellon, M. R., 2009. Maize diversity, rural development policy, and farmers' practices: Lessons from Chiapas, Mexico. *Geographical Journal* 175(1), pp. 52–70. https://doi.org/10.1111/j.1475-4959.2008.00314.x.

Lewin, K., 1946. Action research and minority problems. *Journal of Social Issues* 2(4), pp. 34–46. https://doi.org/10.1111/j.1540-4560.1946.tb02295.x

Luna-González, D. V, and Sørensen, M., 2018. Higher agrobiodiversity is associated with improved dietary diversity, but not child anthropometric status, of Mayan Achí people of Guatemala. *Public Health Nutrition*, (110), pp. 1–14. https://doi.org/10.1017/S1368980018000617.

Magaña Magaña, M. A. and Leyva Morales, C. E., 2011. Costos y rentabilidad del proceso de producción apícola en México. *Contaduría y Administración* 235, pp. 99-119.

Méndez, V.E., Caswell, M., Gliessman, S.R., and Cohen, R., 2017. Integrating Agroecology and Participatory Action Research (PAR): Lessons from Central America. *Sustainability* 9(5). https://doi.org/10.3390/su9050705.

Morett Sánchez, J. C. and Ruiz, C. C., 2017. Panorama de Los Ejidos Y Comunidades Agrarias En México. *Agricultura, Sociedad y Desarrollo* 14 (1), pp. 125–52.

Morris, K. S., Mendez, V. E. and Olson, M. B., 2013. 'Los Meses Flacos': Seasonal Food Insecurity in a Salvadoran Organic Coffee Cooperative. *Journal of Peasant Studies* 40(2), pp. 423–446. DOI: 10.1080/03066150.2013.777708.

Myers, R. and Pilegaard Hansen, C., 2019. Revisiting A Theory of Access: A review. *Society & Natural Resources*. DOI: 10.1080/08941920.2018.1560522.

Niehof, A., 2004. The significance of diversification for rural livelihood systems. *Food Policy* 29, pp. 321-338.

Pasupuleti, V. R., Sammugam, L., Ramesh, N. and Gan, S. H., 2017. Honey, Propolis, and Royal Jelly: A Comprehensive Review of Their Biological Actions and Health Benefits. *Oxidative Medicine and Cellular Longevity*, Article ID 1259510. https://doi.org/10.1155/2017/1259510.

Perfecto, I. and Vandermeer, J., 2015. *Coffee Agroecology: A New Approach to Understanding Agricultural Biodiversity, Ecosystem Services and Sustainable Development*. Routledge, Abingdon, UK.

Ponette-González, A. G., 2007. 2001: A Household Analysis of Huastec Maya Agriculture and Land Use at the Height of the Coffee Crisis. *Human Ecology* 35 (3), pp. 289-301.

Radel, C., 2012. Gendered livelihoods and the politics of socio- environmental identity: women's participation in conservation projects in Calakmul, Mexico. *Gender, Place & Culture* 19(1), pp. 61-82, DOI: 10.1080/0966369X.2011.617905.

Ribot, J. and Peluso, N. L., 2003. A Theory of Access. *Rural Sociology* 68(2), pp. 153–181.

Rice, R., 2008. Agricultural intensification within agroforestry: The case of coffee and wood products. *Agriculture, Ecosystems & Environment* 128(4), pp. 212-218.

Robles Berlanga, H. M., 2011. *Los productores de café en México: problemática y ejercicio del presupuesto*. Mexican Rural Development Research Reports 14. Woodrow Wilson International Center for Scholars.

Rodríguez Padrón, B. and Burger, K., 2015. Diversification and Labor Market Effects of the Mexican Coffee Crisis. *World Development* 68, pp. 19–29.

Ruiz Meza, E., 2015. Adaptive capacity of small-scale coffee farmers to climate change impacts in the Soconusco region of Chiapas, Mexico. *Climate and Development* 7(2), pp. 100–109.

Scoones, I., 2009. Livelihoods perspectives and rural development. *The Journal of Peasant Studies* 36(1), pp. 171-196.

Sherfey, J. 2017. The Cost of Financially Sustainable Coffee Production. *Roast Magazine* (May/June), pp. 71–82.

Soto-Pinto, L., Perfecto, I., Castillo-Hernandez, J., and Caballero-Nieto, J., 2000. Shade effect on coffee production at the northern Tzeltal zone of the state of Chiapas, Mexico. Agriculture, *Ecosystems and Environment* 80, pp. 61–69.

Toledo, V. M. and Moguel, P., 2012. Coffee and Sustainability: The Multiple Values of Traditional Shaded Coffee. *Journal of Sustainable Agriculture* 36(3), pp. 353–77.

Tucker C., Eakin, H., and Castellanos, E. J., 2010. Perceptions of risk and adaptation: Coffee producers, market shocks, and extreme weather in Central America and Mexico. *Global Environmental Change* 20, pp. 23–32.

Vellema, W., Buritica Casanova, A., Gonzalez, C. and D'Haese, M., 2015. The effect of specialty coffee certification on household livelihood strategies and specialization. *Food Policy* 57, pp. 13-25.

Westphal, S. M., 2008. Coffee Agroforestry in the Aftermath of Modernization: Diversified Production and Livelihood Strategies in Post-Reform Nicaragua. In: Bacon, C. M., Méndez, V. E., Gliessman, S. R., Goodman, D., and Fox, J. (Editors), 2008. *Confronting the Coffee Crisis: Fair Trade, Sustainable Livelihoods and Ecosystems in Mexico and Central America*. MIT Press, Cambridge.

Wickham, H., François, R., Henry, L. and Müller, K., 2018. dplyr: A Grammar of Data Manipulation. R package version 0.7.8. https://CRAN.R-project.org/package=dplyr.

CHAPTER 3. MULTIPLE VALUES OF BEEKEEPING AS AN ELEMENT OF DIVERSIFIED, AGROECOLOGICAL COFFEE FARMS

3.1 Introduction

Bees have ecological, economic, and social 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., 2013; Perfecto & Vandermeer, 2015; Imbach et al., 2017; Martínez-Salinas et al., 2022). Bee management can reduce coffee dependency and decrease smallholder farmers' vulnerability to persistent disturbances, such as fluctuating coffee prices and climate change (Bathfield et al., 2013; Anderzén et al., 2020; Tura Bareke, Wakjira & Kumsa, 2021). While the ecological contributions of bees in coffee systems are well documented, particularly in relation to the coffee crop (e.g., Ricketts et al., 2004; Perfecto & Vandermeer, 2015; Martínez-Salinas et al., 2022), fewer studies have examined beekeeping as a livelihood diversification alternative for smallholder coffee producers (Bathfield et al. 2013; Gerlicz et al., 2019; Anderzén et al., 2020; Guzmán-Luna et al., 2022).

This Participatory Action Research (PAR) study presents novel findings about beekeeping as a component of diversified, smallholder coffee systems in Chiapas, Mexico. It emerged in the context of a broader PAR process with *Campesinos Ecológicos de la Sierra Madre de Chiapas* (CESMACH) coffee cooperative and other partners beginning in 2017. The ongoing PAR process has focused on exploring characteristics of agricultural diversification in coffee-producing communities, the role diversification plays in agroecological transitions, and the ways in which it contributes to food sovereignty and economic resilience of peasant families (Guzmán-Luna et al., *in press*). The early research findings from the PAR process suggested that managing bees in addition to coffee could strengthen farmer families' livelihood and food security (Anderzén et al., 2020; Guzmán-Luna et al., 2022). CESMACH and its sister organization for beekeepers, *Apicultores Miel Real del Triunfo* (ART), expressed an interest in digging deeper and learning more about the opportunities, limitations, and trade-offs that beekeeping represents for smallholder coffee farmers. This resulted in two years of research with coffee farmer-beekeeper families and other PAR partners between 2018-19. We co-created a participatory, mixed-methods approach to explore the following questions:

1. To what extent beekeeping and coffee production are complementary agricultural activities?
2. Under what conditions can beekeeping be an economically viable diversification alternative for smallholder coffee farmers?
3. In what ways, other than income, does beekeeping benefit coffee farmer families and communities?
4. How do beekeepers perceive the future of beekeeping?

These questions led us to explore selected temporal and socio-economic aspects of beekeeping. In the following section, we will discuss why the aspects we chose to study were important for our research questions. We then present the background and methods of the study, followed by the main results emerging from surveys, focus groups, and semi-structured interviews with coffee farmer-beekeepers of CESMACH/ART. In the discussion and conclusions, we assess some of the opportunities and obstacles of beekeeping as an agroecological diversification strategy for coffee farmers and discuss the implications of this study.

This study was timely, as many smallholder coffee farmers in different parts of the world are finding it increasingly difficult to make a living on coffee alone and are seeking alternative strategies such as on-farm diversification[7] (Harvey et al., 2021; Anderzén et al., 2021). The results can support coffee farmers and their organizations in evaluating if beekeeping is a viable or desirable alternative for farm diversification that can contribute to agroecological transitions in coffee landscapes. While our data emerge from a specific context in Southern Mexico, we believe these findings can apply to other contexts where beekeeping is practiced as part of small or medium-scale diversified farming systems.

[7] Obviously, many factors affect coffee farmers' ability to respond to varying disturbances. For instance, in some cases, farmers with more land for coffee production may be less vulnerable than farmers with a limited land access.

3.2 Beekeeping as a diversification alternative

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; FAO, 2019; HLPE, 2019; Anderson et al., 2021). Mounting scientific and experiential evidence from different parts of the world show that diversified, agroecologically managed systems tend to be more resilient to various risks and disturbances (Gliessman 2015; de Roest et al., 2018). By maintaining and enhancing both 'planned' and 'associated' [8] biodiversity, these systems provide multiple benefits to people and ecosystems (Perfecto & Vandermeer, 2015). Importantly, diversified farms and territories can contribute to food security and sovereignty, as people produce culturally and seasonally appropriate, nutritious food, and rely less on purchased products (Jones, 2017; Luna-Gonzalez and Sørensen, 2018; Guzmán-Luna et al., 2022). Diversified systems can also generate multiple sources of income, thus helping manage economic risks and enhancing the economic independence of farmer families (CIDSE, 2018). Additionally, they can contribute to social and cultural cohesion in farming communities (Niehof, 2004).

Managing bees for honey is an example of an agricultural activity that peasant or family farmers have integrated into their farming systems for centuries. Archeological evidence shows that people in different geographies have been collecting honey and

[8] Planned biodiversity refers to plants, animals, and other organisms that farmers decide to integrate in their farms, while associated biodiversity is "everything else", i.e., all organisms that arrive or grow spontaneously as the landscape provides habitat for them (Perfecto & Vandermeer, 2015, p. 20).

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 (*Apis mellifera*) was developed (Crane, 2009). Beekeeping offers an attractive option for agricultural diversification in rural areas. Compared to many other agricultural activities, the time and input requirements are relatively low, and beekeeping can generate returns on investment rapidly (Schouten, 2020). Apiaries do not require large land areas, making the activity accessible to farmers with little or limited land access (Bathfield et al., 2016). Additionally, bees produce honey and other medicinal beehive products that contribute to the health and well-being of farmer families and community members. Beehive products can be sold to generate additional income streams, which can enhance producers’ economic well-being (Bathfied et al., 2016; Dolores-Mijangos et al., 2017; Gerlicz et al., 2019; Anderzén et al., 2020). Finally, honey can be stored for a long time, which means producers can sell it at any point or keep it as an ‘insurance’ to be sold in times of hardship (Schouten, 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 experience that many smallholder coffee farmer families in the tropics manage native bees and/or honeybees on their farms[9]. As apiaries do not require much space, they can often be easily integrated within coffee farms with limited land. Agroecological shade-coffee systems, common in smallholder coffee landscapes, provide suitable conditions for

[9] For example, our PAR partners, Equipo Abjeas and Food 4 Farmers, work closely with many coffee farmer-beekeeper groups in Mexico and Central America.

bees to thrive, as these biodiverse systems provide habitat and forage (Perfecto & 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, 2018; Martínez-Salinas et al., 2022; see Figure 3-1). A recent study shows that bees' pollination services have a positive impact on 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 Agroecology and Livelihoods Collaborative (ALC) at the University of Vermont (UVM) worked with farmers from CESMACH to calculate pollinators’ contributions to coffee plantations. As Figure 3-2 shows, the study found that approximately 24 % of the food harvested from coffee plots could be attributed to bees and other animal pollinators (Equipo Abejas, CESMACH & ALC, 2022).

Figure 3-1. Western honeybee (*A. mellifera*) on a coffee flower (photo: Janica Anderzén); and beekeepers of ART at a training (photo: Food 4 Farmers).

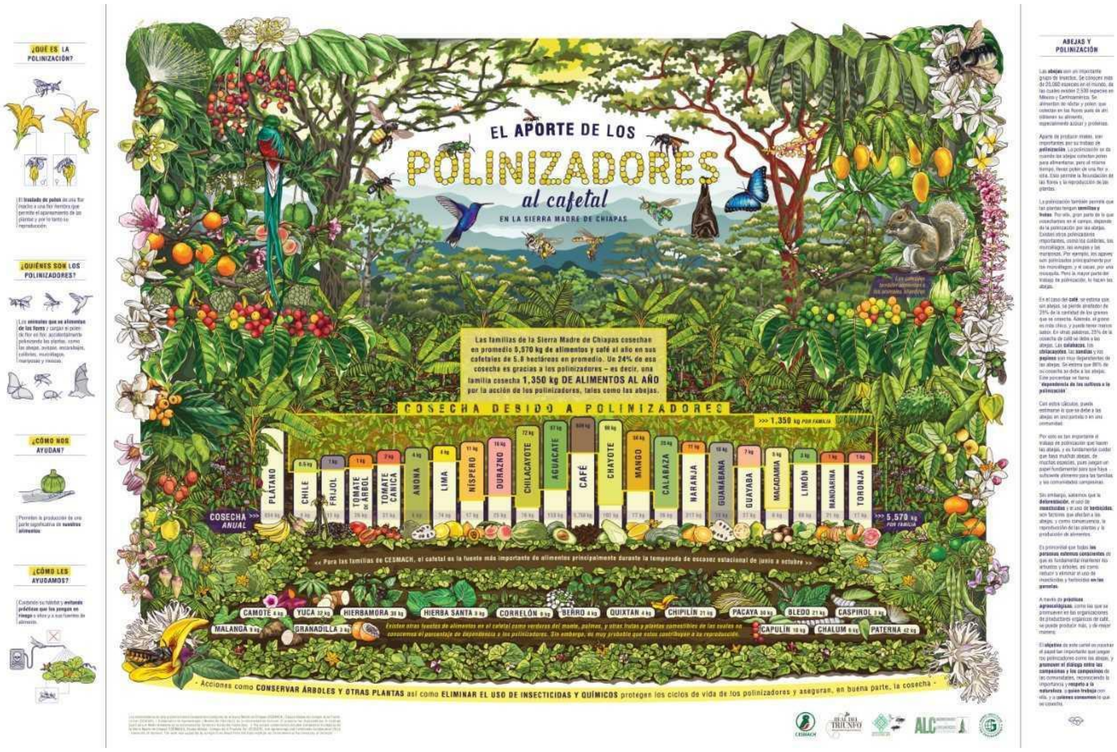


Figure 3-2. A poster illustrating the contributions of animal pollinators on food production in coffee plantations in Sierra Madre de Chiapas. The poster was co-created with farmers from CESMACH/ART, Equipo Abejas, and ALC (Equipo Abejas, CESMACH & ALC, 2022; design by Daniela Gallardo Olimón).

While the beneficial contributions of bees to coffee production are well established, less is known about the direct socio-economic impacts of beekeeping for coffee farmers and their communities. A baseline study with farmers from CESMACH coffee cooperative - that led to the development of the present study - found 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 income level (Anderzén et al., 2020). Similar findings were reported from coffee regions in Nicaragua (Guzmán-Luna et al., 2022). However, the baseline only pointed to a tendency, raising the additional questions: Could beekeeping be a suitable alternative for any coffee farming household? What aspects of beekeeping merit attention when considering its sustainability?

Agroecological diversification is generally considered a beneficial strategy for building sustainable farming systems that enhance the well-being and resilience of humans and ecosystems. Yet, many factors may enable or present barriers to specific types of agricultural diversification and affect their outcomes (IPES-Food, 2016). In this study, we focused on beekeeping as a complementary activity for smallholder coffee farmers and narrowed our focus to four aspects of beekeeping: temporal, economic, social, and future. We believe that these dimensions can help understand the current state of beekeeping and evaluate its potential for being an agroecological strategy that benefits farmer households and their communities. We recognize that ecological aspects of beekeeping are highly relevant for assessing the sustainability of beekeeping and merit attention in future research.

From a temporal perspective, time allocation and seasonality are important dimensions that can help evaluate 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 households typically grow various other crops and animals for consumption and sales (Fernandez & Méndez, 2018; Guzmán-Luna et al., 2022; Bacon et al., 2023). In this context, we wanted to understand better what the labor demands for beekeeping are, and how various tasks related to beekeeping align with those of other agricultural activities that peasant families carry out over the annual production cycle. To what extent is it possible to balance competing demands? How do families deal with trade-offs that emerge? We assess these in section 3.4.2.

From an economic perspective, diversification can be regarded as beneficial if it creates economic stability and beneficial resilience against shocks and disturbances (Ellis, 2000; HLPE, 2019). Findings from a baseline study, conducted and analyzed with farmers of CESMACH/ART at the beginning of our PAR process, provided evidence that beekeeping could be a good alternative for supporting farmer families' economic well-being (Anderzén et al., 2020; Guzmán-Luna et al., 2022). Other studies with beekeepers have shown that economic outcomes of beekeeping depend on an array of factors, such as the number of hives or production costs (Abejas de ECOSUR, 2008; Magaña Magaña, 2016; Schouten, 2020). To gain a more nuanced understanding of factors that affect the economic outcomes of beekeeping for ART members, we conducted a detailed analysis of the costs and benefits associated with beekeeping. We present these findings in section 3.4.3 and explore other economic aspects of beekeeping.

Agricultural processes are embedded in a broader system that "includes the social, cultural, and environmental processes of society" (Ament et al., 2022). Farmers' decisions and actions are rarely based on economic rationality alone but are affected by farmers' efforts to find a balance between "production and reproduction, the scale and intensity of farming, internal and external resources, and autonomy and dependence" (van der Ploeg, 2013, in McCune, 2019). As a result, many factors beyond economic considerations affect how farmer households structure their farms. These can be material but also include social relations and processes as well as relational values. The latter refer to non-economic values/drivers of agriculture and the relationship humans experience with land and nature (Himes & Muraca, 2018; Caswell et al., 2021; Bezner-Kerr et al., 2022). In section 3.4.4, we explore the non-economic benefits of beekeeping.

Finally, we studied farmers' thoughts about their future as beekeepers and the risks that they associated with managing honeybees. Changing climate, pests, and diseases, as well as pesticide use are among critical challenges that have implications on the well-being of bees and the quantity and quality of honey, and thus on beekeepers' livelihoods (IPBES, 2016; Carrera Palí, 2018; Vercelli et al., 2021; Baena-Díaz et al., 2022). Additionally, changes in the price of honey – both nationally and internationally – present another potential risk factor for beekeepers selling their honey (Contreras & Magaña Magaña, 2018). For coffee farmer-beekeepers, the effects of shifting prices can be particularly devastating if low honey prices coincide with poor coffee prices. In section 3.4.5, we discuss how beekeepers view their future in beekeeping and how they are preparing for some of the risks.

3.3 Approach and methods

3.3.1 Participatory Action Research (PAR) approach

This study was conducted in the context of a broader Participatory Action Research (PAR) process launched in 2017 with two smallholder coffee cooperatives, CESMACH in Mexico and PRODECOOP in Nicaragua. The overall goal of the project[10] was to gain a better understanding of the characteristics, benefits, and limitations of different types of agricultural diversification in smallholder coffee communities (see Anderzén et al., 2020, Bacon et al., 2021; Guzmán Luna et al., 2022). In addition to CESMACH and ART, the project partners in the Mexico site[11] included the Agroecology and Livelihoods Collaborative (ALC) at the University of Vermont (UVM), the Community Agroecology Network (CAN), and El Colegio de la Frontera Sur (ECOSUR). For this phase of the research project with beekeepers, we also partnered with Food 4 Farmers (F4F), a non-profit based in the US that has a long history of supporting beekeeping activities at CESMACH/ART.

PAR is a research approach that seeks to co-create actionable knowledge horizontally among non-academic and academic research partners, moving through iterative cycles of research, action, and reflection (Caswell et al., 2021). This study

---

[10] While intended to be a 3-year project, the timeline was extended by a year due to the global pandemic. Due to continued funding from various sources, the PAR project has transformed into a research-action process that builds on findings and experiences from the original project and continues to co-create knowledge and inform praxis around agroecological diversification.
[11] In Nicaragua, the project partners included Santa Clara University (SCU), Universidad Nacional Agraria (UNA) and CAN in Nicaragua.

resulted from a reflection of the research findings from the baseline study of the PAR process, described by Anderzén et al. (2020) and Guzmán Luna et al. (2022). The staff and board members of CESMACH and ART expressed an interest in better understanding the factors that contribute to the success of beekeeping as a livelihood diversification alternative. Additionally, members of the *Equipo Abejas* in ECOSUR had previously developed and applied a methodology to assess the costs and benefits of beekeeping (Abejas de ECOSUR, 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, ALC, and Food 4 Farmers collaborated to articulate the goals of the study and co-create a methodology that would allow ART and CESMACH to deepen their understanding of farmer motivations and factors affecting the outcomes of beekeeping. To our knowledge, our study represents the first PAR study focusing on the socio-economic aspects of beekeeping in coffee landscapes.

3.3.2 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 et al., 2015). Management of *A. mellifera* is a more recent activity that has steadily grown in importance nationwide. In 2019, Mexico ranked as the 9th biggest honey producer globally, having approximately 43,000 beekeepers (Secretaría de Agricultura y Desarrollo Rural, 2020). Chiapas is among Mexico's most significant producer states of honey (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, 2016).

Apicultores de Real del Triunfo (ART) is one of several honey producer organizations representing and supporting small honey producers in Chiapas. It was officially founded in 2018 and maintains close ties with its ‘parent’ 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. When we initiated the study in 2018, ART had 85 member beekeepers who produced 43 tons of honey that year. The organization sells most of the honey to one or several buyers, while some producers also trade 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 (Anderzén et al., 2020; Guzmán Luna et al., 2022), with honey being one of the few agricultural products that have an established infrastructure to support commercialization in addition to coffee. Management of honeybees (*A. mellifera*) is a relatively recent activity among the farmers, which has been supported by non-profits like Food 4 Farmers 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. The technical and material support and commercial connections that ART provides lowers barriers to becoming a beekeeper, and membership in the organization can smooth some of the risks related to the activity.

3.3.3 Methods and analysis

Methods. We used various participatory research methods, all of which were 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 carried out a household survey with 25 beekeepers (6 women and 19 men) from 13 rural communities. Twenty beekeepers had participated in the baseline survey of the PAR project (see section 3.3.1), and we invited five additional beekeepers from the organization 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.

We adapted the survey from a research method that members from Equipo Abejas had designed and used in the past with other groups of beekeepers (Vandame, 2008; see

Annex I 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 5 community promoters from the cooperative, the local coordinator, and on some occasions, a PhD student from UVM - 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. 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 all of them individually.

Our team facilitated several focus groups between 2018 and 2020. 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 Figure 3-3). Many of the beekeepers participating in the monthly survey participated in the focus groups.

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 these 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) and identify which factors had the biggest effect on economic profitability. In Appendix I, we describe in more detail the variables included in the quantitative analysis. 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 for identifying, analyzing, and reporting themes within the data (Braun and Clarke 2006). Many themes mirrored those included in the survey, while others emerged from the data after several rounds of analyzing the transcripts. We included representative quotations from the beekeepers to honor their voices. In our analysis and reporting, we triangulated findings from various data sources to find answers to our research questions.

Figure 3-3: Early versions of the agricultural calendar created in a focus group.

Sharing back. One of the principles of PAR is sharing results with the people and communities participating in the study, which also represents important moments of reflection (Méndez et al., 2017). During the study, there were several moments of sharing and reflection. For instance, in early 2020 members from ECOSUR, UVM, and F4F hosted a session with CESMACH and ART staff, board members, and a group of beekeepers to share the preliminary results. This session prompted much discussion around the implications and applicability of the findings, resulting in some action steps in ART. Additionally, after validating the cost-benefit summaries with the participants, we shared a corrected version with all participants, along with recommendations from a beekeeping specialist from *Equipo Abejas*.

3.4 Results

3.4.1. Characteristics of beekeepers

The characteristics of beekeepers participating in the study mirrored the different types of producers in the organization, ranging from very 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 apiaries and the largest producer in the group (with 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 to obtain a second harvest. The annual production volumes varied from 80 to 4463 kilograms per beekeeper, and the yield per hive ranged from 4 to 59.5 kilograms. 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/hive, according to the study by Magaña Magaña et al., 2016).

Table 3-1. General characteristics of beekeepers

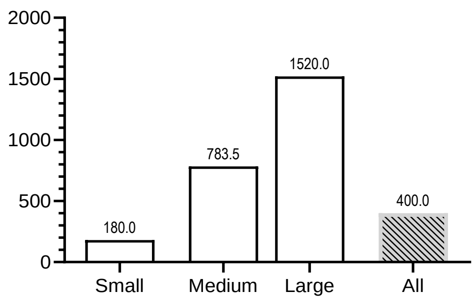
Characteristics	Mean (sd)	Min.	Max.
Age of the beekeeper	43 (12.3)	21	66
Years of experience in beekeeping	6 (3)	2	17
# of hives (colonies)	26 (16)	6	75
# family members working regularly in beekeeping	2.2 (1)	1	4

Beekeeping is often a family-run activity, with an average of two family members dedicating time to apiculture throughout the year. It is typical during the honey harvest for more family members to join the efforts and help with different harvest-related tasks. When considering all workdays dedicated to beekeeping annually (including both family and hired labor), 88.4% of the labor for beekeeping was done by family members, as contrasted with 50% of labor coming from family members for coffee production. In addition to family participation, six beekeepers (24 %) reported working together with other beekeepers in their communities with varying degrees of collaboration. As managing honeybees is still a relatively new activity in communities with

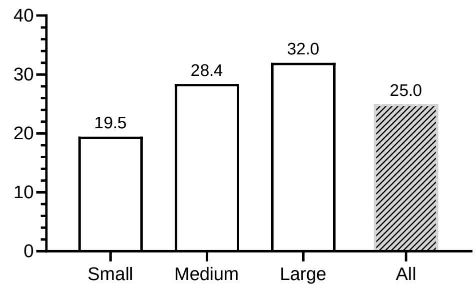
CESMACH/ART members, most beekeepers had five years or less of experience in beekeeping. In the families participating in the study, it was more common for men to be involved in beekeeping, although some apiaries were run mainly by women.

Table 3-2. 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 41> hives). Small producers not only had smaller total production, but on average they produced less honey per hive than medium and large producers.

Honey produced (total, kg)



Yield per hive (kg)



3.4.2. "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. We found that there are opportunities to integrate beekeeping into the annual coffee and maize production cycle without causing competing labor demands or additional time pressures for the farmers. 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 Figure 3-3). 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 have *milpas*, plant the maize 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 visited their apiaries, on average, 6.5 times a month and invested 69 days of family labor in beekeeping in a year (see Table 3-3). 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 than half a day in their apiaries, while coffee farming required longer hours. As one beekeeper explained:

"[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 plantations or milpas, farmers commonly visited their apiaries on the same day as they worked on coffee or maize.

Figure 3-3. Agricultural calendar showing activities related to diversified farming systems incorporating coffee, honey, and staple crop production

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 and a tie."* These kinds of views were likely voiced by established beekeepers with more years of experience[12]. Others pointed out that beekeeping is knowledge-intensive, and bees need attention and care consistently, like other farm animals. Neglecting regular visits to the apiary can lead to colony losses, which is one of the primary reasons why beekeepers drop the activity.

Table 3-3: 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**	**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

[12] An expert from *Equipo Abejas* notes that it is very common for new beekeepers to drop the activity (Vandame, personal communication).

3.4.3 Is beekeeping economically lucrative?

3.4.3.1 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 in CESMACH/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 shows 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 CESMACH/ART or locally. During the time of the study, the price paid by the major buyer of CESMACH/ART hit an all-time low (US$1.25/kg), which meant that the honey sold locally in the communities had a higher value (US$3.22/kg on average). This finding prompted much discussion in the session where we shared results from this study with member farmers and staff of CESMACH and ART and provided opportunities to reflect on how beekeeping could be economically viable even when prices are low. Boosting local honey sales was seen as one opportunity to mitigate the effects of uncertain honey markets and strengthen beekeeping as an economically lucrative activity.

Variable costs were the principal category of expenses for many beekeepers, as shown in Table 4. On average, transportation, inputs, and labor costs represented 69 % of all expenses (29 %, 26 %, and 14 %, respectively). Asset depreciation constituted, on average, 31 % of the production costs, with field equipment being a higher cost (21 %)

than processing equipment and vehicles combined (11 %). When dividing all production costs by the number of beehives and by 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 rentability 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 et al., 2017). Another study comparing Mexican and Guatemalan farmers found that the average production costs were $1.33 per kg of honey (Vandame, 2008).

Table 3-4: Summary of costs of production and gross returns in US dollars

	n	md	Min.	Max.
RETURNS (gross, $US)				
Honey sold to CESMACH/ART (US$1.25/kg)	23	525.0	62.4	4990.0
Honey sold in local markets (US$3.22/kg on average)	14	88.6	8.3	1299.6
Other beehive products[13]	1	52.0	52.0	52.0
Total gross income	25	**524**	**106.0**	**6290.0**
PRODUCTION COSTS ($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**

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

We were unable to collect data on the costs and returns of coffee production from the same farmers to compare the economic benefits from each activity. However, a study conducted by Cornell University and Fairtrade USA in 2015 with member farmers of the CESMACH cooperative found that the average cost of production (including opportunity costs) was US$2.43 per pound of parchment coffee (Sherfey, 2017). However, on average the farmers in the study reported receiving an average 'farm-gate' price of US$1.75 per pound of parchment coffee, which means many farmers could not recover their investments when the study was conducted (Sherfey, 2017). Although our studies are not directly comparable, the Cornell/Fairtrade USA study illustrates that coffee farming faces similar challenges as beekeeping, especially when prices are low.

3.4.3.2 Factors affecting profitability

We found that the number of hives, yield per hive, and production costs per hive were key factors contributing to the economic 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 the costs of production was less clear.

Table 3-5: 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 3 different price points.

		Price per kg of honey		
Income and utility	**Size of apiary**	**$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

Honey price is another critical factor that contributes to the profitability of beekeeping. We found that with the price paid to the beekeepers during the time of the study (US$1.25/kg), only a little over half (52 %) of the producers participating in the study 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 3-5 and Figure 3-3). We used two alternative price points, US$2.24 and US$3.12[14],

[14] The first 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 main buyer in 2020.

to see how an increase in the price would affect profitability. Using a price point of US$2.24 per kilogram of honey, 72 % of the beekeepers participating in the study would break even, while a price point of US$3.12 could help approximately 80 % of the producers make a profit. Regarding how the number of hives 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 from beekeeping. However, these hive number estimates represent trends because there are many factors that influence profitability per hive.

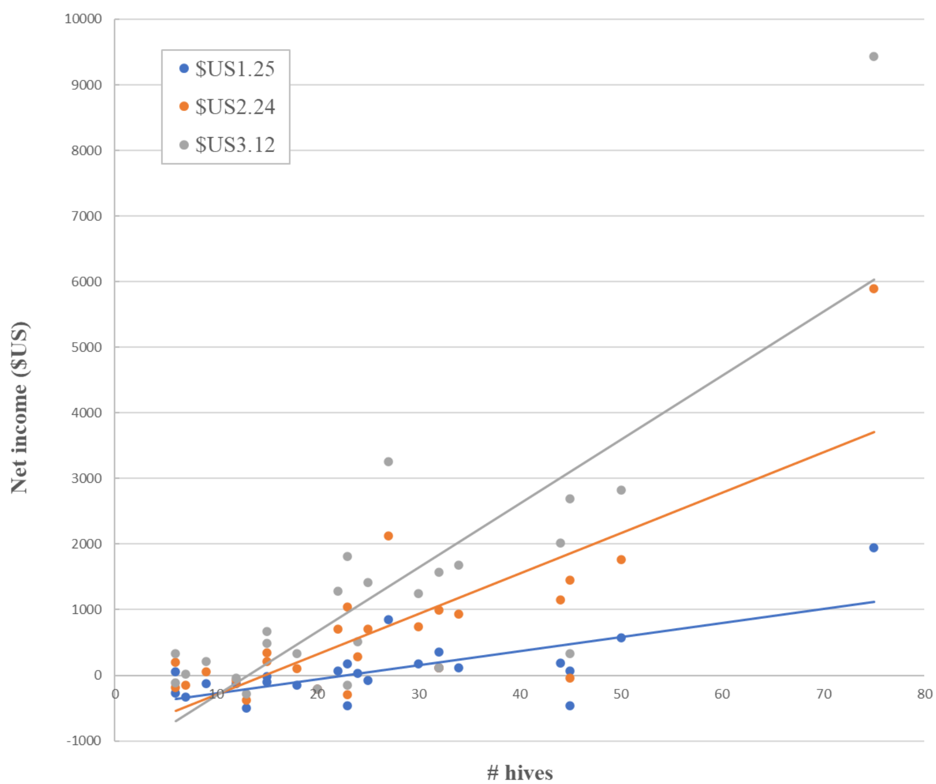


Figure 3-3: Impact of price and the number of hives on the income (net revenue) from beekeeping. Each color and line represent one of the three price points.

Beekeeping on a small scale is mainly done by beekeepers and their family members, as discussed in section 3.4.2. However, (unpaid) family labor is often not accounted for when 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), the income per day of family labor varied from a loss of US$13.4 to a gain of US$18. The income per day grew with the higher price points, with the effect being particularly considerable for medium and large producers. This suggests that beekeepers managing less than 20 beehives could see an increase in their income even with small increases in the number of beehives. However, these values are based on a small sample of beekeepers, and it is important to keep in mind that many factors affect the economic outcomes, such as the frequency in which beekeeper families visit their apiaries[15]. Additionally, it represents an oversimplification of the value of one's labor, which in the case of beekeeping

[15] For example, some producers typically visit the apiary with several family members, and thus might spend less time in the apiary than beekeepers who go by themselves. Also, as we'll learn in the following section, the time spent in the apiary has many additional benefits besides the potential economic gains, which may explain why some beekeepers visit their apiaries more frequently (which in turn, is reflected here as a lower utility per day of family labor).

contributes to not only producing honey but many other benefits that extend beyond the beekeeping families, as we will see in the next section.

3.4.4. 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 motivate and bring joy to the beekeepers. One of these is the nutritional and medicinal benefits of honey and other beehive products. All beekeepers participating 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 3.3.1. 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 that beekeeping was a vehicle for building and strengthening relationships, which occurred in different ways. First, many beekeepers mentioned how beekeeping is an activity that brings the family together, as all family members can participate in their own 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 have honey available to give to neighbors and family members. On the other hand, public opinion of beekeeping varied. 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 didn’t 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’ special connection with the bees, which for them represented a source of joy, peace, and respect. We heard many times 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 beekeepers 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 the responsibility beekeepers had for the well-being of the bees, 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.

3.4.5. The future of beekeeping

Many beekeepers were hoping to grow their apiaries, although they were aware of the challenges and risks related to having more hives. 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 in terms of resources and skills, and if there was a threshold for the number of hives that they could manage without compromising other farm activities. While some beekeepers were hoping to see a significant growth in their operation, most participants set cautious plans for increasing the number of hives. 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 the activity. Another common theme was the need for more technical training. Many participants said they didn't feel confident in their current skills to manage more beehives and hoped to deepen their knowledge.

Adverse effects of climate change concerned farmers when thinking about the future of beekeeping. 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 tested 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 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.

3.5 Discussion

The existing literature provides ample evidence that agroecologically managed farms and territories with high levels of diversity in terms of crops, animals, and livelihoods tend to benefit both ecosystems and people in multiple ways, as well as enhance the systems' resilience against a variety of risks and disturbances (de Roest et al., 2018). Several studies from different parts of the world have found beekeeping to be a beneficial, complementary activity that can be easily integrated into different types of small-scale farming systems (Wolff & Costa Gomes, 2015; Schouten, 2020). In this participatory action research study, we analyzed if this was the case for the smallholder coffee farmer-beekeepers in Chiapas, Mexico. We focused on selected temporal and socio-economic aspects of beekeeping and beekeepers' perceptions of the future to assess the opportunities, limitations, and trade-offs related to beekeeping as an agroecological diversification strategy in diversified coffee systems. Here we discuss some of our key findings and their implications (also summarized in Table 3-6). While these are organized by the four dimensions (time allocation/seasonality, economic, social, and future), in reality they intertwine and overlap.

Table 3-6: Obstacles/challenges and opportunities related to beekeeping in Sierra Madre de Chiapas

Dimension	Obstacles/challenges	Opportunities
Time allocation and seasonality	• Trade-offs among beekeeping and other agricultural activities (in particular coffee) • Stressors/risks (e.g., emigration) that may push farmer families to dedicate more family labor to coffee instead of other agricultural activities	• Training young people (especially women) in beekeeping families to become beekeepers • Creating planning tools through participatory processes (e.g., agricultural calendar) • Shifting the mentality of perceiving beekeeping as a "secondary" activity
Economic	• Fluctuating prices • Low number of colonies (*only an obstacle if income generation is a goal for the beekeeper*) • High production costs • Lack of credits/other financial resources	• Continued training on agroecological management practices that support the well-being of bees, improve the economic outcomes of beekeeping, and highlight non-economic values of beekeeping • Improving access to credits and other financial incentives for beekeepers • Creating tools for tracking costs and benefits of beekeeping • Supporting cost-sharing/collective work among beekeepers • Strengthening local markets for beehive products, and training beekeepers to produce and commercialize value-added products
Social	• Few women involved in beekeeping	• Encouraging the participation of women in beekeeping

	• Antagonism against beekeeping in some communities • Low consumption of beehive products	• Educating people about the multiple benefits of bees to ecosystems and people, • Strengthening local consumption of beehive products
Future	• Climate change • Use of insecticides • Uncertain markets	• Developing strategies for climate change adaptation • Educating people on the risks related to the use of agrochemicals that harm bees and other pollinators • Reducing the dependency on export markets

3.5.1 Complementarities and trade-offs

Diversified farms tend to be labor intensive, and small family farms relying mainly on family labor need to constantly make decisions on how to allocate time and organize their labor (Tacconi et al., 2022). Adding new agricultural activities to the farm design can either be a smooth addition or cause an added time constraint for members of farmer families (Niehof, 2004). In this study, we found that when considering temporal factors - namely allocation of time and seasonality - beekeeping can be a good diversification alternative for coffee farmer families. The agricultural calendar and surveys showed that it is less time and labor-intensive than coffee and does not generally add significantly to farmers' workload during times when coffee and/or corn production require the most attention. However, overlaps occasionally occur, posing trade-offs for farmer families balancing their time and resources among coffee and other on- and off-farm activities. These overlaps may become more permanent (or alternatively, disappear) with changes in climate. Other factors, such as increased emigration from coffee communities and reduced flows of temporal workers during the coffee harvest, add to the time pressures many farmer families experience (Harvey et al., 2021).

There are opportunities to manage some of the trade-offs related to time allocation. The technical/leadership team of ART brought up some possible strategies to ensure that coffee farmer-beekeepers can manage multiple activities successfully. First, they noted that more young people within beekeeper families could be trained in beekeeping and assume some of the responsibilities in the apiary, especially during busy times of the year. Acquiring new professional skills could also reduce the emigration of young people and facilitate farm succession. Second, coffee has historically been the main livelihood activity in many regions across Mesoamerica (Jaffee, 2014). While the crop has created well-being in rural areas, the specialization in coffee has also reduced agricultural diversity and created a dependency on this commodity. As Guzman Luna and others (2022) observed, the specialization in coffee is a major obstacle for transformative agroecology in coffee landscapes. The ART team noted a need to shift the mentality of perceiving beekeeping as “secondary” to coffee and start treating it as a complementary activity with multiple benefits beyond income. Finally, good planning can support the integration of beekeeping into the annual farming cycle of coffee farmers (or other types of producers). Popular educational tools that are created through a participatory process, such as the agricultural calendar, can help with long-term planning. The calendar can also serve as a decision-making tool for farmers considering becoming beekeepers.

3.5.2 Economic sustainability of beekeeping

Beekeeping has the potential to strengthen coffee farmer households' livelihoods and economic resilience, but the outcomes depend on many factors, including available resources, skills, and honey prices. We found that the number of beehives and yield per hive had the strongest impact on the profitability of beekeeping, suggesting that both the size of the apiary and management practices affect economic outcomes. Similar findings have been found in other studies assessing the economic aspects of beekeeping (Magaña Magaña & Leyva Morales, 2011; Schouten, 2020). Honey price is another important contributor to profitability. We observed that low prices affected most beekeepers in our study, but farmers with 20 or fewer hives were at a major disadvantage when honey prices dropped. At a higher price point, most beekeepers (including some of the smaller producers) could generate income. This shows that while beekeeping can be economically beneficial for farmers, a reliance on export markets can also contribute to economic vulnerability, especially since coffee as an agricultural commodity is highly susceptible to price fluctuations (see also Contreras & Magaña Magaña, 2017). Following van der Ploeg's (2021) thinking, the impacts of the shifting prices depend on how farms are structured, that is, how farmers mobilize their time and resources between market-oriented activities and those geared toward consumption or reproduction. Van der Ploeg calls this the "degree of commoditization" and notes that "assessing the right balance (--) helps to create relative autonomy" (van der Ploeg 2021, p. 59).

While it is useful to analyze factors affecting the profitability of beekeeping, other aspects should be considered when evaluating the economic impacts of beekeeping. An important factor we observed when working on the baseline study for the PAR process (described in Chapter 2) was the timing of the payment for honey. The payment often comes at a time of the year when money from coffee is running low and the prices for staple foods spike, suggesting that even a modest income from beekeeping can be critical for supporting household expenditure or investing back in agriculture (Anderzén et al., 2020). Moreover, beekeeping does not only benefit beekeeper households, but the economic impacts extend beyond the family unit. Our study showed that beekeeping created employment in communities, which can be significant in remote communities with limited employment opportunities. Other studies have similarly pointed to opportunities to generate rural employment through beekeeping (e.g., Yusuf et al., 2014: Hinton et al., 2020). Finally, it is essential to note that income generation is not the primary goal for all producers, and some beekeepers prioritize other elements of beekeeping, such as nutritional benefits or enjoyment.

Economic sustainability of a system and its resilience builds on the stability of income over time, in addition to the income itself (FAO, 2019). Many measures can be taken to support the long-term economic sustainability of beekeeping. Our findings and experiences strongly suggest that farmer organizations (e.g., cooperatives) and their collaborators are in a good position to promote these. First, building capacity with a focus on agroecological approaches is needed 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 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. Second, it is essential to create financial mechanisms that provide loans/credits for farmers to have a better capacity to invest in beekeeping (see Hinton et al., 2020; Schouten, 2020). Third, strengthening local markets for honey and other beehive products can potentially reduce dependency on export markets and build stronger local economies, both important dimensions of agroecological transitions (CIDSE, 2018). Fourth, reducing reliance on external outputs can decrease costs and contribute to the long-term sustainability of beekeeping. Fifth, as we have proposed elsewhere, organized coffee farmer-beekeepers could take advantage of their connections within the coffee industry and find synergies between the commercialization of coffee and honey (ALC & Gund Institute, 2021).

3.5.3 Beekeeping as relationship building

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 & 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 Delgago 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 towards nature (Luna Delgago et al. 2022, p. 18). In another study conducted with hobbyist beekeepers in Canada, Rebecca Ellis (2022) observed that the beekeepers she worked with developed "a sensuous and embodied relationship with honeybees that typifies playful work" and embodied an "expression of delight, enchantment, and curiosity". While beekeepers of ART are more dependent on the income generated through beekeeping than hobbyist beekeepers in a wealthy country, it can be argued that for many beekeepers participating in this study, the relational values were equally important as the "instrumental" values (i.e., income generation) of beekeeping. Perhaps for this reason, many described beekeeping as 'easy'.

Benefits from beekeeping trickled beyond the beekeeping families. In some communities, beekeepers assumed the role of educators, thus promoting horizontal learning and knowledge exchange. Beekeepers also contributed to the nutrition and health of community members by producing honey and beehive products with high nutritional and medicinal values. Additionally, as many producers gave away honey in addition to (or in lieu) of selling it, they helped strengthen solidarity economies in their communities. During the time of the study, the consumption of beehive products was relatively low in communities with CESMACH/ART member farmers. 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. This suggests that there is an opportunity to promote beekeeping as a strategy towards building food sovereignty in the communities by encouraging the use of these local products and, consequently, reducing the dependency on external inputs, like white sugar and certain types of medicine (see also Delgado et al., 2022).

3.6. Conlusions

This participatory action research study provides evidence of multiple values of beekeeping as an element of diversified coffee landscapes. It demonstrates that in this context, 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. Our findings also show that beekeeping can generate economic gains for peasant families but the profitability hinges on various factors, such as the price for honey, yield per hive, and the number of beehives. We argue that efforts to support beekeeping as a diversification strategy should take a holistic approach, underscoring the potential of apiculture to support the well-being and resilience of beekeeping families and strengthen food sovereignty and local economies (including solidarity economies) in peasant communities. We propose that future studies continue exploring the trade-offs and synergies related to combining beekeeping with other agricultural activities, and examine gendered aspects of beekeeping.

3.7 Acknowledgements

Many people contributed to designing and carrying out the study and to analyzing and writing the results: Rigobero Hernandez Jonapá, Bernardo Roblero Perez, Williams Salomón Roblero López, Inés Lucia Perez, Alejandra Perez Lara, David Armando Anzueto Coutiño, and Caralampio López Garcia from CESMACH; Susi Marconi Muños Roblero, and José Antonio López Pérez from ART; Rémy Vandame, Omar Argüello Nájera, and *Luis Mondragón* Muñoz from Equipo Abejas at ECOSUR; Beatriz Ocampo from Food 4 Farmers; and Scott Merrill from UVM. Thank you.

3.8 References

Agroecology and Livelihoods Collaborative (ALC), and the Gund Institute for Environment. (2020). *Agroecology and livelihoods in global coffee systems. Diverse, multifunctional farms key to sustainability*. Research brief, December.

Ament, J., Tobin, D., Merrill, S. C., Morgan, C., Morse, C., Liu, T. L., and Trubek, A. (2022). From Polanyi to policy: A tool for measuring embeddedness and designing sustainable agricultural policies. *Frontiers in Sustainable Food Systems 6*. https://doi.org/10.3389/fsufs.2022.983016

Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., Pimbert, M. P. (2021). *Agroecology Now! Transformations towards more just and sustainable food system*. Palgrave Macmillan. https://www.palgrave.com/gp/book/9783030613143.

Anderzén, J., Guzmán Luna, A., Luna-González, D. V., Merrill, S. C., Caswell, M., Méndez, V. E., Hernández Jonapá, R., and Mier y Terán Giménez Cacho, M. (2020). Effects of on-farm diversification strategies on smallholder coffee farmer food security and income sufficiency in Chiapas, Mexico. *Journal of Rural Studies 77*, 33-46. https://doi.org/10.1016/j.jrurstud.2020.04.001

Anderzén, J., Méndez, V.E., Griffeth, M., McHugh, C., Gilman, C., Barahona, C., & Peyser, R. (2021). *State of the Smallholder Coffee Farmer: An Initiative Towards a More Equitable and Democratic Information Landscape*. Research Report. Agroecology and Livelihoods Collaborative (ALC), University of Vermont/Statistics for Sustainable Development (Stats4SD)/Heifer International/Lutheran World Relief (LWR). Burlington, Vermont, U.S.A.

Bacon, C. M., Flores Gomez, M. E., Shin, V., Ballardo, G., Kriese, S., McCurry, E., Martinez, E., and Rivas, M. (2023). Beyond the bean: Analyzing diversified farming, food security, dietary diversity, and gender in Nicaragua's smallholders coffee cooperatives. *Agroecology and Sustainable Food Systems*, *47*(4), 579-620. https://doi.org/10.1080/21683565.2023.2171172

Bacon, C. M., Sundstrom, W. A., Stewart, I. T., Maurer, E., and Kelley, L. C. (2021). Towards smallholder food and water security: Climate variability in the context of multiple livelihood hazards in Nicaragua, *World Development 143*: 105468. https://doi.org/10.1016/j.worlddev.2021.105468.

Baena-Díaz, F., Chévez, E., Ruiz de la Merced, F., and Porter-Bolland, l. (2022). Apis mellifera in Mexico: honey production, melliferous flora and pollination aspects. Review. *Revista mexicana de ciencias pecuarias 13*(2). https://doi.org/10.22319/rmcp.v13i2.5960

Bathfield, B., Gasselin, P., García-Barrios, L., Vandame, R., and López-Ridaura, S. (2016). Understanding the long-term strategies of vulnerable small-scale farmers dealing with markets' uncertainty. *Geographical Journal, 182*(2), 165–177. https://doi.org/10.1111/geoj.12142

Bathfield, B., Gasselin, P., López-Ridaura, S. and Vandame, R., 2013. A flexibility framework to understand the adaptation of small coffee and honey producers facing market shocks. *The Geographical Journal 179*(4), 356–368.

Bezner Kerr, R. B., Liebert, J., Kansanga, M., & Kpienbaareh, D. (2022). Human and social values in agroecology: A review. *Elementa, 10*(1), 1–24. https://doi.org/10.1525/elementa.2021.00090.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Caswell, M., Maden, R., McCune, N., Méndez, V.E., Bucini, G., Anderzén, J., Izzo, V., Hurley, S.E., Gould, R.K., Faulkner, J., and Juncos-Gautier, M.A. (2021).

Amplifying Agroecology in Vermont: Principles and Processes to Foster Food Systems Sustainability. White Paper. Agroecology and Livelihoods Collaborative. University of Vermont: Burlington, Vermont, USA.

Cely-Santos, M., and Lu, F. (2019). Intersections between rural livelihood security and animal pollination in Anolaima, Colombia. *Geoforum 104*, 13-24.

Contreras Uc, L., and Magaña Magaña, M. A. (2017). Costos y rentabilidad de la apicultura a pequeña escala en comunidades mayas del Litoral Centro de Yucatán, México Cost. *Investigación y Ciencia de La Universidad Autónoma de Aguascalientes*, *costos y rentabilidad en la apicultura*, 52–58. https://doi.org/10.1017/CBO9781107415324.004

Contreras Uc, L.C., and Magaña Magaña, M.A. (2017). Costos y rentabilidad de la apicultura a pequeña escala en comunidades mayas del Litoral Centro de Yucatán, México. *Investigación y Ciencia 25*(71), 52-58.

Coopération Internationale pour le Développement et la Solidarité (2018). *The principles of agroecology: Towards just, resilient and sustainable food systems*. CIDSE, Belgium. https://www.cidse.org/2018/04/03/the-principles-of-agroecology/.

Crane, E. (1999). *The world history of beekeeping and honey hunting*. New York: Routledge.

de Roest, K., Ferrari, P., and Knickel, K. (2018). Specialisation and economies of scale or diversification and economies of scope? Assessing different agricultural development pathways. *Journal of Rural Studies 59*, 222–231. https://doi.org/10.1016/j.jrurstud.2017.04.013.

Delgado, Y. L. (2022). Crianza de abejas nativas : una pedagogía agroecológica con raíces. *Revista Brasileira de Educação do Campo*, pp. 1–27.

Dolores-Mijangos, G. de Jesús Santiago-Cruz, MA, Arana-Coronado, J., and Utrera-Quintana, F. (2017). Estudio del impacto de la actividad apícola en el Istmo de Tehuantepec, Oaxaca, México. *Agricultura Sociedad y Desarrollo, 14*, 187-203.

Ellis, F., 2000. *Rural livelihoods and diversity in developing countries*. Oxford University Press, Oxford.

Equipo Abejas at El Colegio de la Frontera Sur (ECOSUR), Campesinos Ecológicos de la Sierra Madre de Chiapas (CESMACH), Agroecology and Livelihoods Collaborative (ALC) at the University of Vermont (UVM). (2022). *Aporte de los polinizadores al Cafetal en la Sierra Madre de Chiapas*. Educational poster. https://bit.ly/3lh4ylN.

Fernandez, M. and Méndez, V. E., 2018. Subsistence under the Canopy: Agrobiodiversity's Contributions to Food and Nutrition Security amongst Coffee Communities in Chiapas, Mexico. *Agroecology and Sustainable Food Systems*, 1–23. https://doi.org/10.1080/21683565.2018.1530326.

Gerlicz, A., Méndez, V. E., Conner, D., Baker, D. and Christel, D., 2018. Use and Perceptions of Alternative Economic Activities among Smallholder Coffee Farmers in Huehuetenango and El Quiché Departments in Guatemala.

Agroecology and Sustainable Food Systems, 43(3), 310–28. https://doi.org/10.1080/21683565.2018.1532480.

Gliessman, S.R. (2015). *Agroecology: the ecology of sustainable food systems*. 3rd Edition. CRC Press/Taylor & Francis, Boca Raton, Florida.

Guzmán Luna, A., Bacon, C. M., Méndez, V. E., Flores Gómez, M. E., Anderzén, J., Mier y Terán Giménez Cacho, M., Hernández Jonapá, R., Rivas, M., Duarte Canales, H. A., and Benavides González, Á. N. (2022). Toward Food Sovereignty: Transformative Agroecology and Participatory Action Research With Coffee Smallholder Cooperatives in Mexico and Nicaragua. *Frontiers in Sustainable Food Systems, 6(August)*. https://doi.org/10.3389/fsufs.2022.810840.

High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. HLPE Report 14. HLPE, Rome. https://www.fao.org/agroecology/database/detail/en/c/1242141/.

Himes, A., & Muraca, B. (2018). Relational values: the key to pluralistic valuation of ecosystem services. *Current Opinion in Environmental Sustainability 35*, 1–7. https://doi.org/10.1016/j.cosust.2018.09.005.

Hinton, J., Schouten, C., Austin, A., and Lloyd, D. (2020). An Overview of Rural Development and Small-Scale Beekeeping in Fiji. *Bee World*, *97*(2), 39–44. https://doi.org/10.1080/0005772x.2019.1698104

Imbach, P., Fung, E., Hannah, Navarro-Racinesa, C. E., Roubikd, D. W., Ricketts, T. H., Harvey, C. A., Donatti, C. I., Läderach, P., Locatelli, B. and Roehrdanz, P. R., 2017. Coupling of pollination services and coffee suitability under climate change, *PNAS*, *114*(39), 10438-10442.

IPBES (2016). T*he assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production*. S.G. Potts, V. L. Imperatriz-Fonseca, and H. T. Ngo (eds). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 552 pages. https://doi.org/10.5281/zenodo.3402856

IPES-Food. (2016). *From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems.* International Panel of Experts on Sustainable Food systems. http://www.ipes-food.org/_img/upload/files/UniformityToDiversity_FULL.pdf

Jones, A.D. 2017. Critical review of the emerging research evidence on agricultural biodiversity, diet diversity, and nutritional status in low- and middle-income countries. *Nutrition Reviews, 75*(10), 769–782. doi:10.1093/nutrit/nux040.

Klein, A., Vaissière, B., Cane, J., Steffan-Dewenter, I., Cunningham, S., Kremen, C., and Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society. B, *Biological Sciences, 274*(1608), 303-313.

Lentz, E., Bezner Kerr, R., Patel, R., Dakishoni, L., and Lupafya, E. (2019). The Invisible Hand that Rocks the Cradle: On the Limits of Time Use Surveys. *Development and Change*, *50*(2), 301–328. https://doi.org/10.1111/dech.12426.

Luna-González, D. V, and Sørensen, M., 2018. Higher agrobiodiversity is associated with improved dietary diversity, but not child anthropometric status, of Mayan Achí people of Guatemala. *Public Health Nutrition*, *21*(11), 2128-2141. https://doi.org/10.1017/S1368980018000617.

Magaña Magaña, M.A, and Levy Morales, C.E. (2011). Costos y rentabilidad del proceso de producción apícola en México. *Contaduría y Administración 235* (septiembre-diciembre), pp. 99-119.

Magaña, M. A., Tavera, M. E., Salazar, L. L., and Sanginés, J. R. (2016). Productividad de la apicultura en México y su impacto sobre la rentabilidad. *Revista Mexicana de Ciencias Agrícolas 7(February)*, 1103–1115.

Martinez-Salinas, A., Chain-Guadarrama, A., Aristizabal, N., Vilchez-Mendoza, S., Cerda, R., and Ricketts, T. H. (2022). Interacting pest control and pollination services in coffee systems. *Proceedings of the National Academy of Sciences of the United States of America*, *119*(15), 1–7. https://doi.org/10.1073/pnas.2119959119.

Méndez, V.E., Caswell, M., Gliessman, S.R., and Cohen, R., 2017. Integrating Agroecology and Participatory Action Research (PAR): Lessons from Central America. *Sustainability*, *9*(5). https://doi.org/10.3390/su9050705.

Niehof, A., 2004. The significance of diversification for rural livelihood systems. *Food Policy 29*, 321-338.

Perfecto, I., and Vandermeer, J., 2015. *Coffee Agroecology: A New Approach to Understanding Agricultural Biodiversity, Ecosystem Services and Sustainable Development.* Routledge, Abingdon, UK.

QSR International Pty Ltd. (2018). *NVivo (Version 12)*. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home

Quezada-Euán, J. J. G., May-Itzá, W. de J., and González-Acereto, J. A. (2001). Meliponiculture in Mexico: Problems and perspective for development. *Bee World*, *82*(4), 160–167. https://doi.org/10.1080/0005772X.2001.11099523.

R Core Team (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Ricketts, T. H., Daily, G. C., Ehrlich, P. R., & Michener, C. D. (2004). Economic value of tropical forest to coffee production. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(34), 12579–12582. https://doi.org/10.1073/pnas.0405147101

Schouten, C. N. (2020). Factors influencing beekeepers income, productivity and welfare in developing countries: a scoping review. *Journal of Apicultural Research, 60*(2), 204–219. https://doi.org/10.1080/00218839.2020.1844464

Secretaría de Agricultura y Desarrollo Rural. (2020). La apicultura en México. Retrieved from: https://www.gob.mx/agricultura/articulos/la-apicultura-en-mexico?idiom=es

Tacconi, F., Waha, K., Ojeda, J. J., & Leith, P. (2022). Drivers and constraints of on-farm diversity. A review. *Agronomy for Sustainable Development, 42*(1). https://doi.org/10.1007/s13593-021-00736-6.

The Food and Agriculture Organization of the United Nations (2018). *The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems*. FAO, Rome. http://www.fao.org/documents/card/en/c/I9037EN/.

van der Ploeg, J. D. (2021). *Peasants and the Art of Farming: A Chayanovian Manifesto.* 2021 edition. Practical Action Publishing.

Vandame, R. (2008). *Determinación de los costos de producción y de las utilidades de los pequeños apicultores en organizaciones de Guatemala y México*. Equipo Abejas, ECOSUR.

Vandame, R., Ayala, R., Guzmán, M., Balboa, C., Esponda, J., and Mérida, J. (2012). *Diversidad de abejas (Hymenoptera: Apoidea) de la Reserva de la Biosfera El Triunfo, Chiapas.* El Colegio de la Frontera Sur. Unidad Tapachula. Informe final SNIB-CONABIO, proyecto No. BK063. México D. F

Vercelli, M., Novelli, S., Ferrazzi, P., Lentini, G., & Ferracini, C. (2021). A Qualitative Analysis of Beekeepers' Perceptions and Farm Management Adaptations to the

Impact of Climate Change on Honey Bees. *Insects 12*, 228. https://doi.org/10.3390/insects12030228

Wolff, L. F., and Gomes, J. C. C. (2015). Beekeeping and Agroecological Systems for Endogenous Sustainable Development. *Agroecology and Sustainable Food Systems 39*(4), 416–435. https://doi.org/10.1080/21683565.2014.991056.

Yusuf, S., Lategan, F., & Ayinde, I. (2014). Creating youth employment through modern beekeeping: Case study of selected youth trained in Moro Local Government Kwara State, Nigeria. *South African Journal of Agricultural Extension*, 42(2), 1-9.

CHAPTER 4: APPLYING AND ADAPTING AGROECOLOGICAL PRINCIPLES TO BEEKEEPING: AN EXPLORATORY STUDY WITH COFFEE FARMER-BEEKEEPERS

4.1 Introduction

Agroecology is a transformative approach advocating for agricultural and food systems that enhance ecosystem health, “attend to the physical, psychosocial, and spiritual needs of people”, and prioritize questions of equity and justice (Bezner-Kerr et al., 2022; Anderson et al., 2021). Agroecology builds on ecological, socio-economic, cultural, and political principles that inform context-specific practices and decision-making. These principles also provide direction for agroecological transitions and transformations (Wezel et al., 2020: Anderson et al., 2021). Several principles and transition frameworks have been developed over the past decades, reflecting different dimensions of agroecology (e.g., Altieri and Nicholls, 2005; Gliessman, 2015; CIDSE, 2018; FAO, 2018; HLPE, 2019; INKOTA; 2019; Anderson et al., 2019; Caswell et al., 2021; Anderson et al., 2022). In parallel, an increasing number of agroecology-oriented studies are engaging with these frameworks to test, revise, question, or refine them, and thus contribute to validating principles-based approaches as central to agroecology (e.g., Dumont et al., 2016; IPES-Food, 2018; Toffolini et al., 2019; Barrios, 2020; Morgan & Trubek, 2020; Giraldo & Rosset, 2022; Frank et al., 2022). The depth and scope of this engagement varies. While some studies merely mention the importance of principles to agroecological approaches, others share examples of practical applications of principles and/or transition frameworks or take a deep dive into their theoretical or epistemological foundations (see Elementa's special issue on "Principles-based Approaches in Agroecology" for recent examples).

While the literature on agroecological principles is growing, there is a need for more applied studies that test how principles frameworks are used in practice. More specifically we need to see how they can be adapted to different geographic and socio-political contexts and their ability to guide agroecological transitions (e.g., Teixeira et al., 2018; Toffolini et al., 2019). In this chapter, we describe experiences from a Participatory Action Research (PAR) process with beekeepers in Chiapas, Mexico. We worked with coffee farmer-beekeepers of *Apicultores Real del Triunfo* (ART) cooperative for over two years, in order to study socio-economic aspects of beekeeping in the context of diversified coffee systems. Upon concluding the study, we engaged in collective reflections on how the results and experiences from the PAR study could support ART in their strategic planning and decision-making. These reflections led us to explore opportunities for applying an agroecology principles approach to the case study, as a way to deepen our analysis and enhance the 'actionability' of the findings in the long term.

We used the framework *Agroecological Principles for Beekeeping,* developed by *Equipo Abejas* ('Bee Team') at *El Colegio de la Frontera Sur* (ECOSUR), to guide the exploratory process. The goal of this chapter is to better understand how agroecology principles can be used in practice and the extent to which they can support actors in designing and implementing agroecology transitions in their territorial context. This study had three specific objectives: (1) examine the alignments of the *Agroecological Principles for Beekeeping* with two internationally used principles frameworks; (2) explore the application of beekeeping-specific agroecology principles to the case study with beekeepers of ART; and (3) propose a beekeeping-specific transition approach by adapting existing transition frameworks (e.g. Caswell et al., 2021; Anderson et al., 2022) for this sector-specific application. This study contributes to the growing literature on the application of agroecology principles and transition frameworks by providing insights from a context-specific application of agroecological principles.

4.2 On agroecology principles and transition frameworks

4.2.1 Agroecology principles as guidelines

Agroecology is a process of continuous transition that offers multiple pathways towards ecologically sound and socially just agricultural and food systems (Anderson et al., 2021; Gliessman et al., 2022). Instead of prescriptive rules or recipes, agroecological approaches are grounded in *principles* that have general relevance and can be adapted to varying geographic and socio-political contexts (Bell & Bellon, 2018; Anderson et al., 2021). Often characterized as ‘building blocks’ or ‘guidelines’, agroecological principles can be seen as guidelines for decision-making, action, and behavior at different scales, and helpful to set priorities for agroecological transitions (CIDSE 2018; Wezel et al., 2020; Patton, 2022). Principles are also used for assessing the extent to which a system reflects the tenets of agroecology and to evaluate changes over time (TAPE, 2019;

Patton, 2022). FAO's Tool for Agroecology Performance Evaluation (TAPE) is an example of an assessment framework designed to measure the "multi-dimensional performance of agroecological systems across the different dimensions of sustainability" (TAPE, 2019; see also Biovision, n.d.; Kapgen & Roudart, 2020).

Several sets of principles have been developed over time, emphasizing different dimensions of agroecology and reflecting the evolution of agroecology as a field (Wezel et al., 2020; Mason et al., 2020). While some focus on ecological aspects of agriculture (e.g., Nicholls et al., 2016), others also address social, economic, political, and/or spiritual elements of agricultural and food systems[16] (e.g., Nyeleni, 2015; CIDSE, 2018; FAO, 2018; HLPE, 2019; INKOTA, 2019; Kapgen & Roudart, 2020). The latter types of principles frameworks have emerged and gained foothold over the past decade, as more actors are positioning agroecology as a transformative, justice-oriented, and rights-based approach (Wezel et al., 2020; Anderson et al., 2021). Michael Patton (2021) notes that principles frameworks are flexible, being constantly negotiated and re-defined by different actors. As an example, Kapgen & Roudart (2020) recently proposed a modified set of agroecology principles that is targeted for development cooperation contexts, and includes methodological principles in addition to ecological, socioeconomic, and political ones. Coe and Coe (2023) advocate for adding a principle that acknowledges the importance of "building an ecological mindset", while Giraldo and Rosset (2022) underscore the emancipatory potential of agroecology and describe seven social and

[16] The evolution of agroecology principles is also reflected in how they are formulated, with many frameworks containing explicitly normative statements in addition to causative ones (Wezel et al., 2020).

political principles summarizing the transformative elements of “emancipatory agroecologies” (as opposed to industrial agriculture, and neoliberal and reformist agroecologies).

While most sets of principles are applicable to any context, there are some examples of frameworks tailored for a specific agricultural activity (e.g., Peeters & Wezel, 2017). One such example is *Agroecological Principles for Beekeeping,* a framework resulting from a participatory process led by *Equipo Abejas* (‘Bee Team’) at ECOSUR university, in Chiapas, Mexico. Originally, *Equipo Abejas* developed the principles to support their educational work and outreach, but over the past years they have worked with several groups of beekeepers to enrich the framework. The framework consists of eight principles that holistically address environmental, economic, social, and spiritual aspects of beekeeping at the farm, community, and organizational levels. *Equipo Abejas* describes the principles framework as a flexible, living document, and invites users to test and adapt the principles to their needs and context. In section 3.2 we explain how we used the framework in this study.

4.2.2 Framing Agroecology Transitions and Transformations

In parallel to the evolution of principles, various frameworks and approaches have emerged over the past decades for conceptualizing how agroecological transitions and transformations[17] unfold (Gliessman, 2015; Duru et al., 2015; IPES-Food, 2018; Tittonell, 2019; Anderson et al., 2019; Ong et al., 2020; Tittonell, 2020; Wezel et al., 2020; Anderson et al., 2022). These approaches "offer diverse kinds of narratives to explain what takes place during agroecological transitions" (Caswell et al., 2021, p. 16), and identify leverage points and barriers to change. While each framework provides unique perspectives, they typically view agroecology transitions and transformations as non-linear and context-specific processes happening at different scales and involving a variety of actors. Agroecological approaches to transitions in food systems generally privilege the protagonism of farmers and the centrality of farmer knowledge in these processes (Teixeira et al., 2018).

One of the most well-known frameworks is Stephen Gliessman's five levels of food systems change, describing actions that farmers can take on their farms to transition toward more sustainable production systems (levels 1-3), and more profound changes that need to occur to transform the broader food system (steps 4-5). A model developed by IPES-Food (2018) describes four key domains and seven leverage points for food systems change, while Anderson et al. (2019) identify six critical domains for transformation and discuss the enabling and disabling factors for each domain. Anderson et al. (2019, p. 195) argue that the territorial scale is the most critical for transformations and underscore the critical role of collective action and social movements in "building

---

[17] Transitions can be understood as incremental steps towards more improving and enhancing the sustainability of the current situation, while transformations refer to more profound structural changes within the food systems and other socio-political systems they are embedded in (Wezel et al., 2020; Caswell et al., 2021).

and amplifying political power and community agency to advance agroecology transformations”.

While there seems to be a growing consensus on the value of a principles-based approach to agroecology, few transition/transformation frameworks explicitly explain how principles can support agroecological transitions. There are some notable exceptions, such as the work by Wezel et al. (2020) that links the 13 principles by HLPE with Gliessman’s five levels of food systems change. Biovision’s *Agroecology Criteria Tool* (ACT) is a design/assessment instrument that also uses Gliessman’s model but connects it with FAO’s 10 *Elements of Agroecology*. Their Agroecology Info Pool showcases how different actors have been using the ACT. Another example of integrating principles in a transition framework emerged at the University of Vermont, where a transdisciplinary team worked with community partners to develop an *Agroecological Assessment for Sustainability Framework* (AASF). The AASF is a holistic approach that is grounded in agroecological principles, relational values, and elements from different transition frameworks, and provides a ‘roadmap’ for actors planning to enhance the sustainability of their farms or systems (Caswell et al., 2021). The Agroecology Support Team of the Collaborative Crop Research Program of the McKnight Foundation built on this model and developed their ‘process-oriented, action-reflection approach to agroecological transitions’ (Anderson et al., 2022). We will come back to these two approaches in section 4.3.2.

4.2.3 Grounding principles frameworks

Patton argues that while principles can "provide overall guidance", they need to be "translated into and interpreted for application within a specific context" (Patton, 2021, p. 3). He adds that principles evolve not only through discussions and debates over their meanings but also through their application in practice (ibid.). However, there has been relatively little systematic examination of the development of locally and context-specific principles, and thus little understanding of how principles are being adapted, developed, and deployed as normative guidance for transition processes on the ground. Some notable exceptions include the work by Caswell et al. (2021, discussed above) and a PAR study from Vermont, USA (Juncos-Gautier, 2021), where a researcher applied the CIDSE principles to evaluate agroecological performance of urban farms in the town of Burlington. She then used the findings to help the research partners assess their transformational potential (Juncos-Gautier, 2021). In Kenya, Uganda, Malawi and Tanzania, a network of farmer research teams adapted FAO's TAPE tool for agroecological assessment to reflect their needs and context. The process also included reflections among farmers about the meaning and applications of the principles in each country (Namirembe et al., 2022; see also other articles in Elementa's "Special Feature: Principles-based Approaches in Agroecology").

This PAR study contributes to the growing literature on agroecology principles and transitions by using a case study with coffee farmer-beekeepers in Southern Mexico to adapt the *Agroecological Principles for Beekeeping*. It also proposes an approach for agroecological transitions in beekeeping that builds on frameworks proposed by Caswell et al. (2021) and Anderson et al. (2022) and seeks to integrate beekeeping-specific principles. By doing so, the study aims to narrow the gap between the theory and 'praxis' on agroecological principles and transitions. In the following, we will first explain why we decided to use agroecological principles in this study and then describe our approach more in detail.

4.3. Our research approach and methods

4.3.1 Moving through cycles of research, reflection, and action: our PAR process

This work resulted from an ongoing Participatory Action Research (PAR) process with ART and *Campesinos Ecológicos de la Sierra Madre de Chiapas* (CESMACH) coffee cooperative[18]. PAR is an action-oriented approach that brings together a diversity of actors to learn and co-create knowledge around collectively defined issues (Utter et al., 2021). PAR seeks to democratize science by challenging top-down research approaches, integrating different types of knowledge, and prioritizing voices of people who have traditionally been "excluded from material benefits and from epistemological production" (Cuéllar-Padilla and Calle-Collado 2011, p. 373; see also Fals Borda, 1979). Méndez et al. (2017) argue that PAR is a good fit for agroecology-oriented research, as they PAR and agroecology similar foundational principles and goals, including their focus on

[18] These two organizations are closely linked, sharing many members and some staff members, and using same physical spaces.

context-specific adaptations and commitment to equity and justice (Méndez et al., 2017; Milgroom et al. 2016). Several authors have suggested that combining the two approaches can increase the transformative potential of research (Anderson et al., 2019; Guzmán-Luna et al., 2022).

PAR processes tend to be cyclical, moving through (often overlapping) phases of research, reflection, and action (Caswell et al., 2021). Due to its reflective character, PAR provides opportunities to pivot from the original plans and dig deeper into emerging issues (Méndez, personal communication). This is what happened in our PAR process. In 2017, an interdisciplinary and international team of practitioners and researchers[19] collaborated with CESMACH to study agricultural diversification in smallholder coffee systems in the Sierra Madre de Chiapas. The goal was to gain a better understanding of the ways in which diversification could support food and livelihood security of peasant families (Anderzén et al., 2020; Gúzman Luna et al., 2022).

The first phase of the process, a baseline study, showed that beekeeping had the potential of decreasing dependency on coffee and enhancing farmer families' resilience (Anderzén et al., 2020; Guzmán-Luna et al., 2022; see Chapter 2). A reflection of the early findings led to two years of research with beekeepers of ART, with the objective of gaining a deeper knowledge about the characteristics, challenges, and opportunities of beekeeping as an element of multifunctional coffee farms. For a year, our team visited 25 beekeeper members of ART, monthly, documenting activities in the apiary, costs of

[19] The key organizations involved were CESMACH/ART, University of Vermont (UVM), El Colegio de la Frontera Sur (ECOSUR), and Community Agroecology Network (CAN).

production, and benefits from beekeeping. We also facilitated several focus groups and workshops with beekeepers (see Chapter 3 for a detailed description of the methods). Upon concluding the field work, the team validated the results with ART and its members, and shared back the final observations. However, this was not the end of the process. Conversations and reflections around the findings and experiences prompted a series of new questions – What's next? How could the results and experiences from the study help inform future planning and actions to enhance the sustainability of beekeeping in the long term?

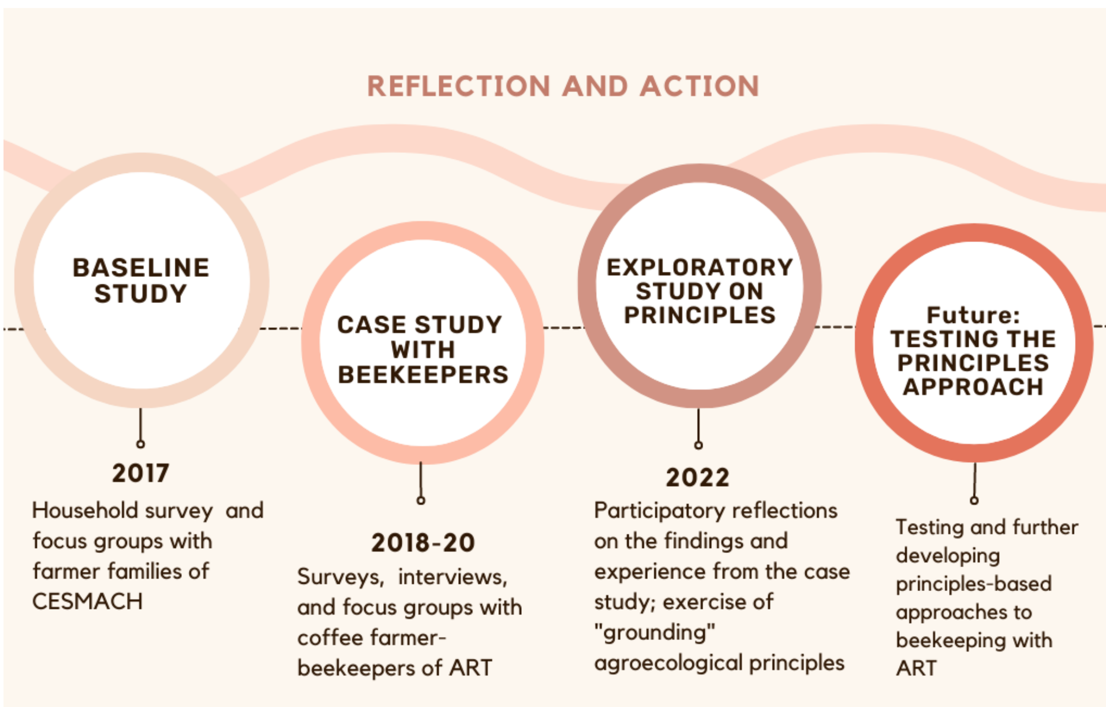


Figure 4-1: Phases of the PAR process that led to this study, and plans for future.

These questions set in motion another PAR cycle in 2022. A researcher from UVM (and the author of this dissertation) introduced to ART staff members the idea of using *Agroecological Principles for Beekeeping* to draw lessons from the case study and envision what agroecological transitions for beekeeper-coffee farmers could look like. The idea caught their interest and together the group started exploring the possibilities of deploying agroecological principles to support the work of ART and its members. This phase consisted of several sessions online and one in person in Mexico, as well as email exchanges. The ideas emerging from these conversations were also shared and discussed with members of *Equipo Abejas*, Food 4 Farmers[20], and other collaborators who provided important feedback.

4.3.2 Applying a principles lens to beekeeping

In this exploratory work, we used and adapted the *Agroecological Principles for Beekeeping* in several ways. As the first step, we analyzed how these context-specific principles align with two general principles frameworks, one developed by *Coopération Internationale pour le Développement et la Solidarité* (CIDSE, 2018) and one by the *High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security* (HLPE, 2019). The aim was to identify commonalities and differences between context-specific principles (beekeeping) and 'general' agroecology principles

[20] Food 4 Farmers is a Vermont-based non-profit that has been supporting the beekeeping initiative at CESMACH/ART for many years.

that could be applied to any context (CIDSE and HLPE). The CIDSE and HLPE frameworks were chosen for the comparison as they represent internationally acknowledged sets of agroecology principles and consider multiple dimensions of agroecology. We describe the results in section 4.4.

We then applied the beekeeping-specific principles to our case study with beekeepers of ART. First, we used a principles lens to deepen our analysis of the empirical findings emerging from over two years of participatory research. The goal was to use the principles to identify strengths and obstacles that beekeepers of ART were experiencing. It was not possible to conduct a systematic assessment of the depth of engagement of beekeepers with these principles[21]. Second, tested how the *Agroecological Principles for Beekeeping* could be adapted to the specific context of beekeeper-coffee farmers in the Sierra Madre de Chiapas. In the document outlining the principles, each principle is accompanied by a description of its purpose and scope, along with several possible expressions/manifestations of the principle that can help orient planning and action (Equipo Abejas, n/d; see Table 4-1). As part of our process, we used findings and experiences from the case study - described in detail in Chapter 3 - to reflect on the meanings the principles could have for this group of beekeepers. More specifically, we collectively developed several additional expressions/manifestations for selected principles to complement the existing list (see Appendix II for a complete list). This

[21] That type of assessment would have required a different methodology from early on, since the original research instruments were not designed around agroecological principles. As noted above, the principles approach emerged from reflections on the findings of the study with beekeepers.

wider set of contextualized examples of the principles has been constructed in order to encourage ART and its membership to integrate agroecological principles into their strategic planning and action.

Table 4-1: Example of a principle from the *Agroecological Principles for Beekeeping* frameworks and its possible manifestations/expressions.

PRINCIPLE		**EXPRESSIONS/MANIFESTATIONS OF THE PRINCIPLE**	
	From the framework	**Expressions/manifestations emerging from the case study**	**Supporting data**
#3 - Seeks diversification and integration in the production	*Example*: The apiary is part of a unique production system in which milpa, coffee plantations, pasture, and home gardens strengthen each other.	**?**	**?**

Agroecological Principles for Beekeeping includes eight principles that consider ecological, economic, social, and spiritual elements of beekeeping. While we recognize that all eight principles are equally important for the sustainability of beekeeping, in this research we narrowed our focus to four principles. This decision was made because we were only able to collect data on these four principles. Ideally, we would have been able to analyze all eight principles, but we were constrained by time and resources. Therefore, we centered our analysis only on those principles that were the most closely related to the themes of the study and could be analyzed against empirical data. The selected four principles (in bold) address socio-economic aspects of beekeeping[22]:

#1 - Secures the wellbeing of bees

#2 - Promotes autonomy in production

#3 - Seeks diversification and integration in the production

#4 - Generates healthy beehive products for everyone

#5 - Strengthens the wellbeing of peasant families and their communities

6 - Cares for the environment

#7 - Promotes organizational wellbeing

#8 - Respects and cultivates spirituality

Finally, we created a proposal for an agroecology transition framework for beekeeper-coffee farmers that integrates beekeeping-specific agroecology principles. We built on frameworks developed by Caswell et al. (2021) and Anderson et al. (2022, an adaptation of Caswell et al., 2021) that view agroecological transitions as an iterative process with three phases. In the first phase, participants working together for agroecology transitions come together to discuss values, aims, and understanding about agroecology in order to lay “common ground” for the transition process (see Figure 4-2).

[22] They also align with key dimensions of social wellbeing – material, relational, and subjective/cognitive (see White, 2009) – which, as Bezner-Kerr et al. (2022) explain, are present in many socio-economic principles of agroecology.

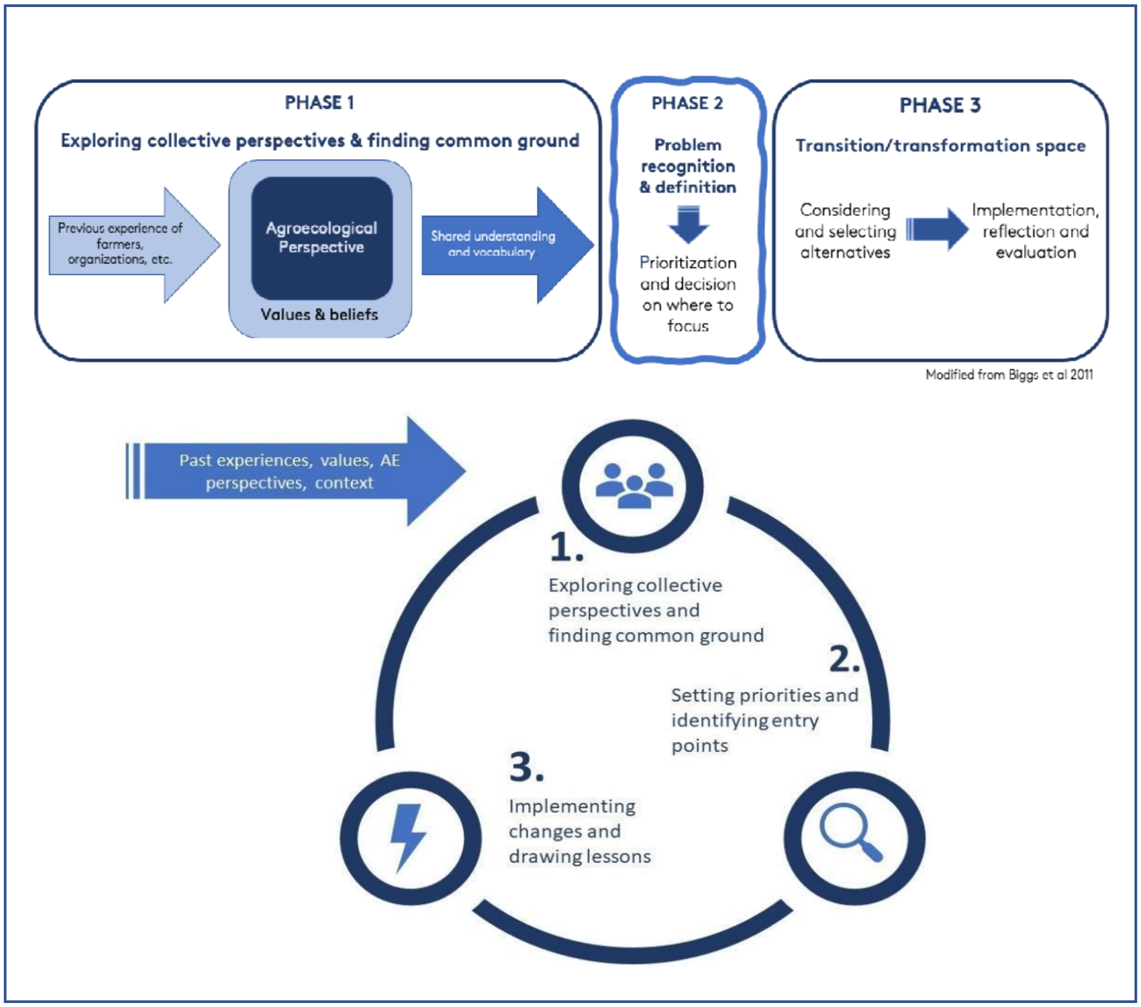


Figure 4-2. Agroecological transitions approach by Caswell et al., 2021 (top), and the three phase "process-oriented, action-reflection approach" to agroecological transitions by Anderson et al., 2022 (bottom).

In the second phase, participants analyze the situation in the territory in order to establish a baseline, define issues and set specific goals for transition. This analysis forms the basis for identifying and prioritizing efforts and finding entry points in the form of tangible interventions/projects within a wider goal of agroecological transitions. Finally, ideas and plans are implemented, tested, evaluated, and reflected upon. We chose this transition framework because it is applicable to farm/organizational scale, incorporates values and principles, and provides concrete steps for planning and action, while acknowledging that a transition will seldom be a linear process. In section 4.4.3, we present ideas for an agroecological transition approach for coffee farmer-beekeepers.

4.3.3 ART and its Beekeepers

Apicultores Miel Real del Triunfo (ART) is a cooperative of small-scale beekeepers, founded officially in 2018. ART is closely connected with *Campesinos Ecológicos de la Sierra Madre de Chiapas* (CESMACH), a cooperative of smallholder coffee producers with nearly 30 years of experience in commercializing coffee. Their facilities are located across the street from one another in the town of Jaltenango de la Paz, in Southern Chiapas, and the two organizations share many members. Over the years, the beekeeping group has been supported by many non-profit organizations (like Food 4 Farmers) and governmental programs, as well as beekeeping experts at ECOSUR. The beekeepers mainly manage Western honeybees (*A. mellifera*), while some producers also harvest honey from native (stingless) bees for self-consumption. ART calls its honey 'agroecological', as it is produced in biodiverse coffee agroforestry systems with predominantly organic/agroecological management practices. Additionally, many of the communities where honey is produced are located in the buffer zone of *El Triunfo Biosphere Reserve,* a biodiversity hotspot and a protected area where the use of agrochemicals is restricted. While not yet certified, ART is planning on pursuing an organic certification for its honey.

The 25 beekeepers who participated in the study reflect the diversity of producers in ART, which at the time of the study had 85 members. The participants included both women (n=6) and men (n=19) with varying levels of experience, managing either small (<20 hives), medium (21-40 fives), or large operations (>41 hives) (see Table 4-2). The smallest producer in the group had six colonies, while the largest was managing 75 colonies in four apiaries. The annual production volumes varied between 80 and 4463 kilograms and the yield per hive was between 4 and 59.5 kilograms. All beekeepers were also coffee farmers, with coffee typically being the main agricultural activity in terms of income.

Table 4-2: Characteristics of beekeepers participating in the study (n=25)

Characteristics	**Median**	**Min.**	**max.**
Number of beehives	23	6	75
Years of experience in beekeeping	5	2	2, 17
Honey produced per year (kg)	400	80	80, 4462.5
Yield per hive (kg)	25	4	4, 59.5
Honey sold to ART or locally (%)	92.1	66.7	66.7, 98.7

4.4. Results

4.4.1 Alignments between principles frameworks

The *Agroecological Principles for Beekeeping* framework by *Equipo Abejas* provides guidance to agroecological approaches in beekeeping. While it is focused on a specific agricultural activity, the proposed principles share many similarities with the frameworks developed by CIDSE (2018) and HLPE (2019). In general terms, all three frameworks align in their vision of creating agricultural and food systems that support ecosystem health and enhance the socio-economic well-being of farmers and their communities (see Table 4-3). More specifically, they all include principles addressing diversity/diversification (economic and/or agricultural); integration, synergy, and complementarity among different elements of agroecosystems; input reduction; horizontal learning among farmers; strengthening of local knowledge; prioritization of local food systems and markets; and inclusion of all people (in particular, women and youth) in decision-making.

There are also some differences. *Agroecological Principles for Beekeeping* framework places a strong focus on the well-being of bees, which is reflected in several principles (#1, #2, #4, #6, and #8). Adhering to a non-anthropocentric view of nature, the framework emphasizes the intrinsic value of bees and advocates for respectful and harmonious relationship between humans and bees. As a comparison, the HLPE framework addresses the well-being of animals in its principle #4, although the brief description (“Animal health: ensure animal health and welfare”) does not provide much guidance for the interpretation. CIDSE principles do not explicitly mention animal health.

Another unique characteristic of the beekeeping-specific framework is the importance it places on cultivating spirituality (principle #8). As described in the framework, spirituality is associated with a harmonious living with nature and with an understanding of humans as both thinking and ‘sentient’ beings (in Spanish ‘*sentipensantes*’). The CIDSE framework also acknowledges the importance of spirituality in its principle #13 (“Strengthens food producers, local communities, culture, knowledge, and spirituality”), connecting it to the relationship with the land and environment. HLPE principles, in turn, do not discuss this dimension of agroecology.

Some other differences among the frameworks include references to producer-consumer relationships and to soil health that are present in HLPE and CIDSE frameworks but not in the beekeeping principles. The CIDSE and *Agroecological Principles for Beekeeping* frameworks call for community autonomy, while the HLPE alludes to it but does not use the term ‘autonomy’. Finally, only the CIDSE framework explicitly addresses climate change in one of its environmental principles (“Supports resilience and adaptation to climate change”).

Table 4-3: Alignments of ‘Agroecological Principles for Beekeeping’ with other principles frameworks

Agroecological Principles for Beekeeping	CIDSE principles	13 consolidated principles of Agroecology by HLPE
1. Secures the wellbeing of bees	No direct equivalent *Related:* Enhances integration of various elements of agroecosystems Nourishes biodiversity and soils	4. *Animal health*. Ensure animal health and welfare. 5. *Biodiversity*. Maintain and enhance diversity of species, functional diversity and genetic resources and thereby maintain overall agroecosystem biodiversity in time and space at field, farm and landscape scales.
2. Promotes autonomy in production	Promotes healthy diets and livelihoods Increases resilience through diversification of farm incomes and strengthens community autonomy	*2. Input reduction***.** Reduce or eliminate dependency on purchased inputs and increase self-sufficiency.
3. Seeks diversification and integration in the production	Increases resilience through diversification of farm incomes and strengthens community autonomy	*6. Synergy***.** Enhance positive ecological interaction, synergy, integration and complementarity amongst the elements of agroecosystems (animals, crops, trees, soil and water). *7. Economic diversification***.** Diversify on-farm incomes by ensuring that small-scale farmers have greater financial independence and value addition opportunities while enabling them to respond to demand from consumers.
4. Generates healthy beehive products for everyone	Promotes healthy diets and livelihoods	*9. Social values and diets***.** Build food systems based on the culture, identity, tradition, social and gender equity of local communities that provide healthy, diversified, seasonally and culturally appropriate diets
5. Strengthens the wellbeing of peasant families and their communities	Aims to enhance the power of local markets and build on a social and solidarity economy vision Strengthens food producers, local communities, culture, knowledge, spirituality	*7.Economic diversification***.** (see description above) *9. Social values and diets***.** (see description above) *10. Fairness***.** Support dignified and robust livelihoods for all actors engaged in food systems, especially small-scale

		food producers, based on fair trade, fair employment and fair treatment of intellectual property rights**.** 11. *Connectivity*. Ensure proximity and confidence between producers and consumers through promotion of fair and short distribution networks and by re-embedding food systems into local economies.
6. Cares for the environment	Nourishes biodiversity and soils Eliminates use of and dependence on agrochemicals	*5. Biodiversity***.** *6. Synergy***.**
7. Promotes organizational wellbeing	Encourages diversity and solidarity among peoples, encourages women and youth empowerment Promotes farmer to farmer exchanges for sharing knowledge Encourages new forms of decentralized, collective, participatory governance of food systems	*13. Participation***.** Encourage social organization and greater participation in decision-making by food producers and consumers to support decentralised governance and local adaptive management of agricultural and food systems.
8. Respects and cultivates spirituality	Strengthens food producers, local communities, culture, knowledge, spirituality	No direct equivalent.

4.4.2 Applying a principles lens to the PAR case study with beekeepers of ART

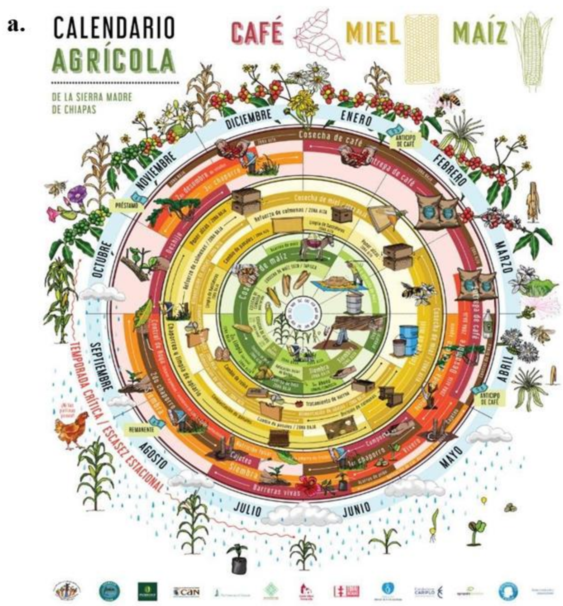
In this section, we provide examples of how we applied and adapted *Agroecological Principles for Beekeeping* to our case study with beekeepers of ART. As explained in section 3.2, part of this exercise consisted of developing a set of new contextualized expressions/manifestations for the four principles that we focused on. We describe some of them in more detail here, using number codes that follow the numbering of the principles - e.g., E3.1, E3.2, and E.3.3 for Principle #3 (E=expression/manifestation). A complete list is included in Appendix II.

4.4.2.1 Beekeeping as an element of a diversified system

Many findings from the case study can be analyzed using principle #3 that focuses on diversification and integration. This principle proposes that in an agroecological system, beekeeping ideally co-exists with other agricultural activities that are mutually beneficial and together help build resilience. The group of beekeepers participating in the case study manage their apiaries in diversified systems where beekeeping is practiced along with coffee production, *milpa* (corn, beans, squash, and/or other crops), home gardens, and other agricultural activities (see Anderzén et al., 2020; Guzmán-Luna et al., 2022). Recognizing that diversification implies allocating time and resources among various tasks, one of the objectives of our study with ART was to gain a better understanding of how well beekeeping aligns with other important agricultural activities.

An agricultural calendar - co-created with farmers of ART/CESMACH and laying out the annual farming cycle of coffee, *milpa* and beekeeping – showed that generally the most labor-intensive tasks of beekeeping do not overlap with those related to coffee or *milpa* production (see Figure 4-3a). However, in some years the coffee harvest extends to the months of honey harvest, creating trade-offs in terms of time use and labor. These situations test farmer families' adaptive capacity and priorities, and prompt the question: To what extent and under what conditions is it possible to manage bees in a sustainable way without compromising other activities? Findings and reflections in temporal aspects and complementarity of farming activities led the team to formulate E3.1 (“Beekeeping complements and does not compete with other agricultural activities, such as coffee”, see Table 4-4).

a.



b.

Days of family labor	MD	min., max.
Beekeeping	69	16, 272
Coffee	261	50, 767
% of family labor	**MD**	**min., max.**
Beekeeping	88.4	37.8, 100
Coffee	50.0	15, 92

c.

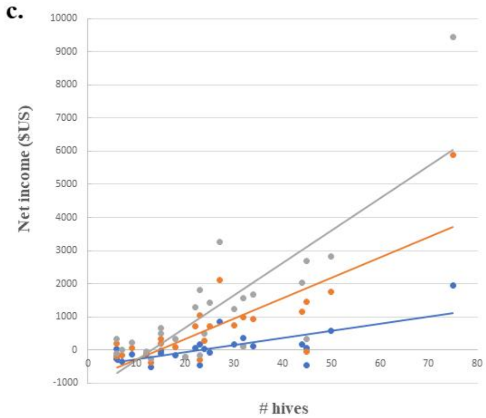


Figure 4-3. Agricultural calendar showing annual farming activities in coffee, *milpa*, and beekeeping (a). Days and percentages of family labor in beekeeping and coffee (b). Effect of increasing the number of hives on net income using three price points - $US1.25 (blue), $US2.24 (orange), and $US3.12 (gray) (c).

We also found that beekeeping is generally less time consuming than coffee production, the main agricultural activity for most farmers in the group. While in beekeeping the proportion of family labor[23] was higher than in coffee, families worked

[23] I.e., days of family labor/total days of labor

annually less days in beekeeping than coffee (see Figure 4-3b). However, it is important to dig a little deeper and consider how the responsibilities are divided among family members. Does the workload accumulate on one or a few people in the family and if so, who? Do other tasks, like reproductive work, limit some family members' (in particular, women's) possibilities to participate? With these questions in mind, the team added E3.2 ("The time devoted to beekeeping is manageable for all family members who are interested in beekeeping").

Finally, our economic analysis showed that to be able to break even in years of low prices, beekeepers would need to manage approximately 20 hives or more (see Figure 1c). However, this may not be a realistic – or a desirable – goal for all beekeepers, considering other labor and financial needs in diversified farms as well as the level of technical skills required. As noted by colleagues from ART, the decision to grow (or not) should be made considering beekeeping as an element of a diversified landscape. Growing too much or too fast may pose additional time pressures on some members of the family or create an economic burden. Therefore, the ART team articulated that for the sustainability of beekeeping, it is important that the number of beehives is proportional to the physical, human, natural and economic resources that families have available (E3.3).

Table 4-4. Expressions/manifestations of principle 3.

PRINCIPLE	EXPRESSIONS/MANIFESTATIONS OF THE PRINCIPLE		
	From the framework	**New expressions emerging from the case study**	**Supporting data**
#3 - Seeks diversification and integration in the production	The apiary is part of a unique production system in which milpa, coffee plantations, pasture, and home gardens strengthen each other. The farm is perceived as an organism, where productive activities benefit from and contribute to each other, generating resistance and resilience in the face of crises, whatever their nature.	E3.1 Beekeeping complements and does not compete with other agricultural activities, such as coffee. E3.2 The time devoted to beekeeping is manageable for all family members who are interested in beekeeping. E3.3 Beekeepers manage an "optimal" and sustainable number of hives that is proportional to the physical, human, natural and economic resources available.	The agricultural calendar showing the annual cycle of coffee production, *milpa* production, and beekeeping. Monthly surveys with 25 beekeepers: sections on time use and factors affecting the profitability of beekeeping

4.4.2.2 Beekeeping's contributions to nutrition and health

Nutritional and medicinal benefits from beekeeping are integrated in principles #4 and #5 of the *Agroecological Principles for Beekeeping* framework. In our study with beekeepers of ART, we examined the consumption of honey and other beehive products in beekeeping families and communities. We found that all beekeeping families saved some honey for family or local consumption, and some beekeepers (44 %) also consumed pollen or propolis for medicinal purposes. In addition to saving honey for family needs, it was common to share honey with family and neighbors and/or exchange it for other products. Little over half (56 %) of the producers also sold honey in local markets. These results suggest that honey and other beehive products were available to many people in the communities and surrounding communities of beekeepers from ART.

Table 4-5. Expressions/manifestations of principle 4.

PRINCIPLE	EXPRESSIONS/MANIFESTATIONS OF THE PRINCIPLE		
	From the framework	**Expressions/manifestations emerging from the case study**	**Supporting data**
#4 - Generates healthy beehive products for everyone	Beekeepers, families and consumers know about and benefit from the nutritional and medicinal qualities of beehive products (honey, pollen, jelly, propolis). Clean practices during harvesting, transfer, processing, and marketing contribute to having a quality honey for consumption by families and consumers. Chemicals and antibiotics are not used, since hive health is based on prevention.	E4.1 The honey that beekeeping families save for consumption meets their needs for the whole year. E4.2 Beehive products (honey, propolis, pollen, etc) are available and accessible to surrounding community members.	Monthly surveys with 25 beekeepers: sections on nutritional and non-material benefits from beekeeping Interviews with a subset of the 25 beekeepers participating in the study.

However, commercialization still takes precedence over family and local consumption. On average, 92 % of the honey produced was sold to ART for commercialization, meaning that the amount of honey staying in the communities was relatively low (see Table 4-2). ART considered it important to make sure that honey and other beehive products were widely available in rural communities of the immediate region, and that families saved enough honey for their consumption. These reflections prompted the team to include two new contextualized expressions/manifestations to principle 4 ("E4.1 The honey that beekeeping families save for consumption meets their needs for the whole year" and "E4.2 Beehive products (honey, propolis, pollen, etc) are available and accessible to surrounding community members"; see Table 4-5).

4.4.2.3 Non-material benefits of beekeeping

Principle #5 focuses on the wellbeing of peasant families and communities, which was a central dimension in our study with beekeepers of ART. In addition to material benefits (nutrition and income) our study revealed a variety of other ways in which beekeeping contributed to the wellbeing of families and communities. One important theme that emerged was beekeeping as a source of joy, emotional wellbeing, and learning. Beekeepers described how they enjoyed going to their apiaries "to relax" and to observe the bees. As one farmer summarized, *"It's beautiful that one is always learning something [from beekeeping]"* ('Es bonito que siempre se está aprendiendo algo'). Many beekeepers liked bringing their children to the apiary so that they could share their knowledge about the bees and their role in nature. Observing bees also served as a means of learning about ecological interactions in their farms and guided the farmers to improve their management practices in coffee. The role of beekeeping as a vehicle for fostering relational values, emotional wellbeing, and learning led to the development of three new manifestations/expressions (E5.1, E5.2, and E5.4), described in Table 4-6.

Beekeeping facilitated learning and knowledge exchange also beyond the family sphere. Intergenerational learning occurred within the communities and among members of ART, as young people or less experienced beekeepers learned from their older peers. A comment from a young beekeeper in a focus group illustrates the importance of intergenerational learning to the continuity of beekeeping:

> *"… as young people, it's [good to] learn from the older producers and help each other out [--] The elders have a lot of experience and knowledge, and if as young people we let them help us, soak in that knowledge, maybe someday we can share what we have learned with our children, siblings, nephews or nieces… and that's how we foster beekeeping, right?".*

Additionally, beekeepers typically enjoyed sharing their knowledge with others, and in many communities, beekeepers were respected for their specialized skills. Promoting the role of beekeepers as educators – and potentially advocates – in their communities was perceived as important for agroecological transitions, which inspired the research team to develop E5.3 ("Beekeeping activity contributes to collective decision making, as beekeepers assume the role of educators and advocates in their communities.").

Table 4-6. Expressions/manifestations of principle 5.

PRINCIPLE	EXPRESSIONS/MANIFESTATIONS OF THE PRINCIPLE		
	From the framework	**Expressions/manifestations emerging from the case study**	**Supporting data**
#5 - Strengthens the wellbeing of peasant families and their communities	Beekeeping contributes to establishing dignified conditions within farming families by allowing respect and freedom for all, women as well as men, young as well as old. Beekeepers know how to determine their production costs, which allows them to sell their products at prices proportionate to the work invested, and to seek a balance between specialization and diversification. Thanks to the associativity, beekeeping establishes a symmetrical relationship with the market, generating a fair income for the families, and in addition to its economic contributions, it contributes to the health and nutrition of the families. The products generated from beekeeping are consumed by the beekeeper, his family and community, contributing to health and quality food. This is a priority over commercialization.	5.1 Beekeeping helps to strengthen the physical, mental, and emotional health of beekeepers and their families. 5.2 Beekeeping allows producers to develop new knowledge, skills, abilities, and values. 5.3 Beekeeping contributes to collective decision making, as beekeepers assume the role of educators and advocates in their communities. 5.4 The apiary is a space for reflection among family members on various topics, such as environmental care, generational change, forms of organization, and gender.	Monthly surveys with 25 beekeepers: sections on nutritional and non-material benefits from beekeeping Interviews with a subset of the 25 beekeepers participating in the study Focus group discussions

4.4.3 Proposal for an Agroecology transitions approach to beekeeping

Figure 4-4 illustrates early ideas for an agroecological transitions approach for beekeepers that was collectively developed by participants from ART, Food 4 Farmers, and UVM. It represents an integration and adaptation of the transition frameworks by Caswell et al. (2021) and Anderson et al. (2022), described in section 4.3.2. Following the proposed three-phase approach of these frameworks, the first phase of a transition process is centered around collective reflections. In this phase, members of a group or an organization come together to discuss their values and understanding of agroecology, and to find common ground[24]. Each group should ideally develop their guiding questions, and with ART discussions around questions included: *How do we understand agroecology? What aspects of agroecology are important to us as beekeepers (and coffee farmers)? What are our values and how do they align with agroecology? Who should be part of the transition process and in what capacity?* Materials like *Agroecological Principles for Beekeeping* and a poster on the contributions of bees and other pollinators (see Chapter 3) can help facilitate discussions around what agroecology means specifically for beekeeping, as well as exploring the potential role of principles in the process (Caswell et al., 2021).

[24] As Caswell et al. (2021, p. 13) note, in this phase participants define a common language and introduce concepts that ideally are "both flexible enough to allow for individual interpretation, and robust enough to provide an anchor for comprehension across different perspectives" and can also "contribute toward identifying indicators that resonate with, and reflect the beliefs of, all participants in a given process".

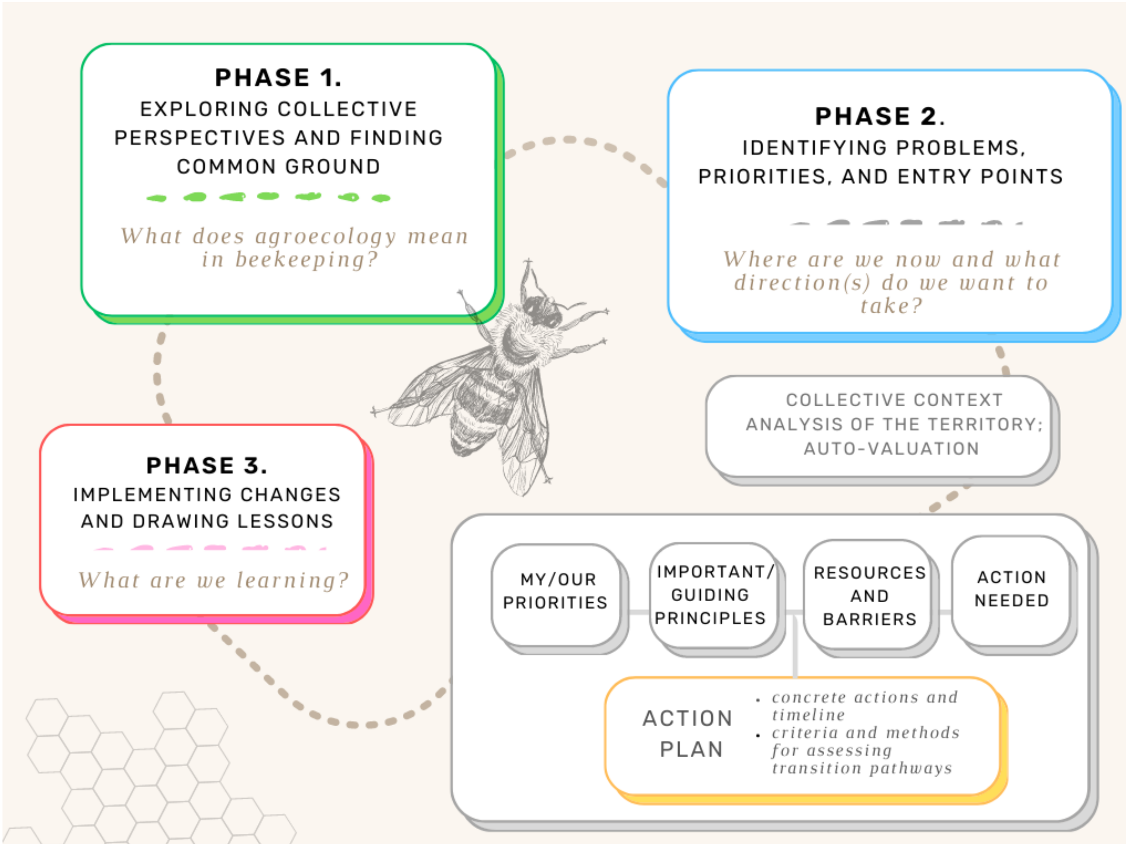


Figure 4-4. Proposal for an agroecological transitions framework for beekeeping, which was developed through an integration and adaptation of the frameworks by Caswell et al., 2021 and Anderson et al., 2022.

The second phase focuses on recognizing and defining problems (Caswell et al., 2021) and "mapping out a change process" (Anderson et al., 2022). It consists of performing a collective analysis of the context and history of a territory to gain a better understanding of the current situation and to identify enabling and disabling factors for agroecology transitions (Anderson et al., 2022; Caswell et al., 2021). For ART, a collective analysis could include a reflection on how beekeeping fits into the agricultural landscape where coffee production has become the dominant land use over the past decades. In this phase, individual beekeepers could also engage in an analysis of their management practices and apiaries, and use this as a starting point for thinking about agroecological transition pathways at the household level. There are methods that can be applied to facilitate the analysis of the "agroecological situation" (Patton, 2021) at both the organizational and household levels. For instance, *Agroecological auto-valuation of beekeeping initiatives* is a tool developed by Inana A.C., the Center for Eco-dialogue at the University of Veracruz ('el Centro Ecodiálogo de la Universidad Veracruzana'), and *Equipo Abejas* of ECOSUR in Mexico, which supports individual beekeepers or groups to assess their agroecological situation from ecological, socio-cultural, and economic perspectives (Inana A.C. et al., n.d.). In the case of ART, findings from the PAR case study can also provide useful elements for the collective and individual analysis.

Both Caswell et al., (2021) and Anderson et al. (2022) propose that reflections on the context and current situation can then inform the definition of problems, priority setting, and identification of entry points and actions (Caswell et al., 2021; Anderson et al., 2022). Similarly, we believe that tying the goals and priorities explicitly to agroecological principles can be powerful and help accommodate the diverse needs and aspirations of farmers. In Figure 4-5, we provide an example to illustrate what the process could look like for beekeepers - from setting the goals/priorities, defining important principles, identifying actions, available resources, and barriers, to crafting a detailed action plan.

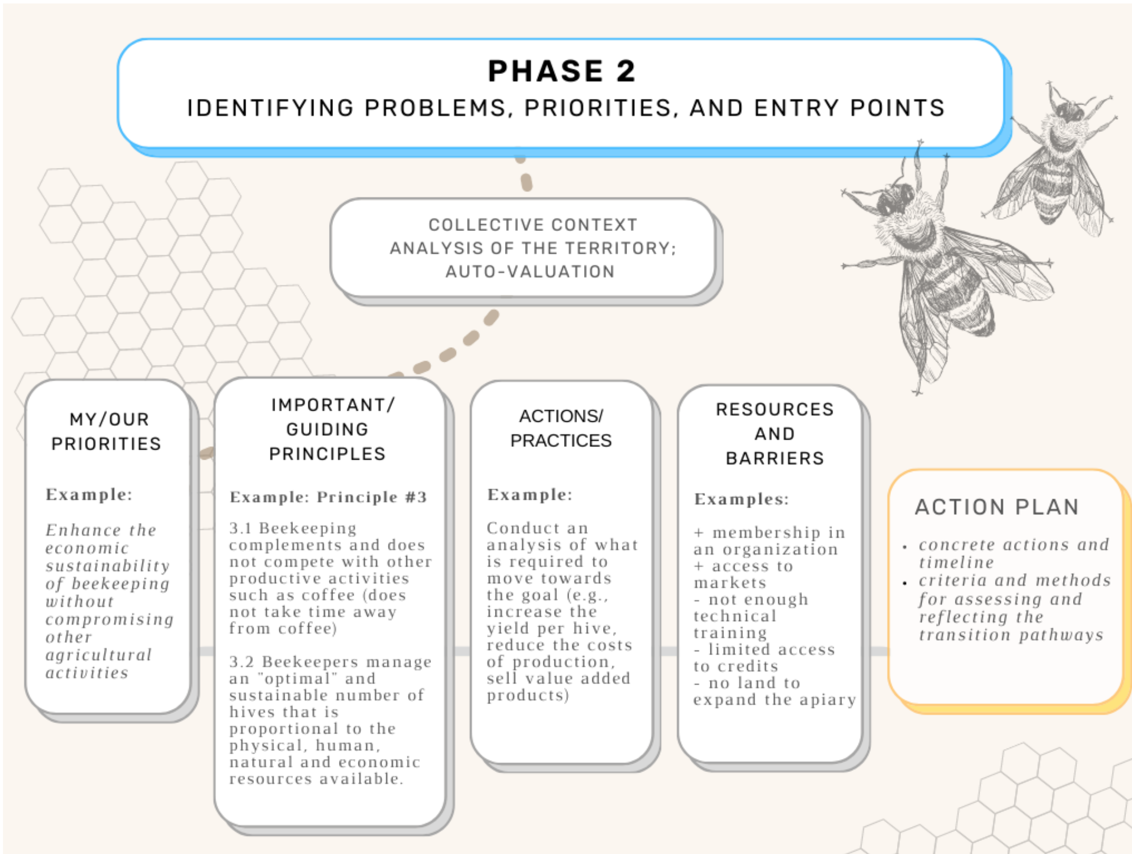


Figure 4-5. Mapping out elements of Phase 2 using an example inspired by the case study findings.

In the next phase, ideas and plans are tested, evaluated, and reflected upon. As for evaluation of the transition process(es), there are many methods and approaches available, and each group should consider criteria and methods that are suitable for their context. We encourage testing participatory evaluation methods that are creative and facilitate dialogue among all participants (see e.g., Dumont et al., 2021; https://evalparticipativa.net/en/about-us/). Anderson et al. (2022) propose that in this phase “action becomes a topic for reflection and reflection orients subsequent action”, suggesting that the agroecological transition process is iterative. Ideally, the actors will visit the first two phases periodically to reflect on the collective learning, discuss if priorities and the understanding of agroecology has evolved or if the priorities shifted, and adjust the action plan accordingly.

4.5. Discussion

In this chapter, we have shared experiences of applying *Agroecological Principles for Beekeeping* framework to a case study with beekeepers of ART through a participatory process of co-learning, and proposed a beekeeping-oriented agroecology transition approach integrating principles. We have also compared the *Agroecological Principles for Beekeeping* with two widely used principles frameworks (CIDSE and HLPE) to better understand the similarities and differences between the three, and to assess where the beekeeping-specific principles fit in the landscape of agroecology principles approaches. In the following sections we discuss the key findings and how they contribute to narrowing the gap between theory and praxis on agroecological principles.

4.5.1 Different principles frameworks reflect plurality in agroecology

Comparison among two “general” agroecology principles frameworks (CIDSE, 2018 and HLPE, 2019) and *Agroecological Principles for Beekeeping* by *Equipo Abejas* showed many alignments in their focus and scope, while also revealing some differences. All three frameworks share a holistic understanding of agroecology by considering its ecological, social, economic, cultural, and political dimensions. In the historical continuum, they represent the latest phase in the evolution of agroecology in which many actors are framing agroecology as a multi-scalar, transformative approach covering a variety of issues and also addressing questions of rights, justice, and equity (Wezel et al., 2020; Anderson & Anderson, 2020; Mason et al., 2020).

A unique characteristic of the *Agroecological Principles for Beekeeping* framework is its explicitly non-anthropocentric view of nature, which is rooted in the indigenous cosmovision of the region. The principles reflect an understanding of humans as *sentipensantes* (i.e., as both thinking and feeling beings), underlining the importance of feelings, emotions, and spirituality in human-nature interactions. The framework also places a strong emphasis on non-utilitarian approaches to beekeeping, community autonomy, and organizational wellbeing. These elements link the *Agroecological Principles for Beekeeping* closely to Latin American expressions and traditions of agroecology which, as described by Rosset et al. (2020), are grounded in ancestral knowledge and spirituality, emphasize *dialogo de saberes* ('dialogue among different types of knowledge"), link agroecology with the notion of *Buen Vivir* ('living well'), and have a strong political outlook. These same aspects are also central to many transformative social movements that align themselves with political agroecology, such as *Via Campesina* (see Anderson & Anderson, 2020).

The co-existence of multiple agroecology principles frameworks, with each adding their unique flavor and perspectives, supports the notion that there is a multiplicity of 'agroecologies' (Méndez et al., 2016). We argue that a framework like *Agroecological Principles for Beekeeping*, grounded in Latin American epistemologies and tailored for a specific agricultural activity, is likely to resonate better with peasants in Latin American contexts than other principles frameworks with a different origin and scope. Therefore, efforts to contextualize existing principles frameworks – or to develop new approaches that better reflect the users' realities – should be supported and prioritized. So far, there are few documented examples of how such processes can unfold (but see Juncos, 2021; Namirembe et al., 2022).

4.5.2 Grounding agroecological principles is an essential step

Applying agroecological principles to the case study with beekeepers of ART produced many interesting insights, and pointed to various possibilities of developing and testing the approach further to expand its scope and uses. First, principles provided a useful lens for deepening our analysis of the findings emerging from the research. While the study with beekeepers of ART was not originally developed with agroecological principles in mind, the principles lens helped identify strengths and obstacles related to beekeeping in the context of diversified coffee systems, and discover connections between emerging themes. It also allowed us to assess to what extent the beekeepers are "oriented towards agroecology" (Dumont et al., 2021), and to initiate conversations about agroecological transitions with the ART staff. Frank et al (2022, p. 14) found similar benefits of applying agroecological principles in their qualitative study with food producers in Argentina. They noted that the principles permitted them to uncover “characteristics, potentials and constraints of local actions for transitions in order to better grasp agroecological pathways enacted in real territories”.

Second, our exploratory exercise of adopting the *Agroecological Principles for Beekeeping* to the context of beekeeper-coffee farmers of ART generated evidence of how empirical findings from a case study can inform the process of ‘grounding’ agroecological principles. Through participatory reflections on the findings and experiences from the case study, our team developed a set of 15 contextualized expressions/manifestations for selected socio-economic principles. The aim was to provide ART and its members with a wider array of examples of the meanings and potential applications of the principles to guide planning and action. The staff of ART found this exercise useful, as it helped them look at the beekeeping activity from a broader perspective and expand their understanding of sustainability in beekeeping. Juncos (2021) describes similar experiences from her work with urban farmers in Burlington, Vermont. For the participating farmers, the process of grounding agroecological principles and using these to analyze their farms was “eye-opening”. It helped “connect the dots” in a new way that allowed them to better see their farms as part of a socio-economic and ecological system. Additionally, as observed by Juncos (2021) and Namirembe et al. (2022), the contextualization or ‘localization’ of principles is important for defining the most suitable approaches and methods for evaluating agroecological transitions and lessons learned.

Teixeira et al. (2018, p. 2) remind us that the “challenges towards agroecological transitions are not the same for all farmers as farmers differ in objectives and values”. The possibilities of addressing differing objectives and values for farmers were other benefits that the ART team associated with the principles-approach. Our case study findings provided further evidence of what the ART team had observed in their work with the beekeepers over the years - that producers expressed different goals and priorities for beekeeping, and thus had unique needs and challenges related to these. Agroecological principles were seen as a potentially useful tool for navigating and articulating multiple objectives and values with beekeepers at the farm and organizational levels, and for planning agroecological transition pathways that are sensitive to farmers’ aspirations and available resources. Therefore, our proposal for an agroecological transition approach in beekeeping, building on the frameworks by Caswell et al. (2021) and Anderson et al. (2022), integrates agroecological principles in its Phase 2 that focuses on setting priorities and goals, making plans for action, and evaluating the transition. We believe that providing concrete examples of how the principles could be applied in this phase will be very useful to guide planning (and dreaming).

Some of the limitations of this study include the following. First, the experiences shared here represent the early stages of the exploration and have not been tested with other groups of beekeepers. As the idea of applying agroecological principles to the case study emerged from participatory reflections on the study findings in 2022, the team has not had the opportunity yet to work with groups of beekeepers to "ground-truth" and further develop the ideas. This phase, which we hope to start in the near future, is essential for understanding how farmers make sense of the principles (Dumont et al., 2021), and whether these principles are "adaptable to real-world dynamics, providing a way to navigate the turbulence of complexity and uncertainty" (Patton, 2021, p. 4). Additionally, a long-term process is needed to assess to what extent the incremental agroecological transitions proposed here could contribute to food systems transformations on a larger scale (Caswell et al., 2021). Second, as there are few documented examples of how the contextualization of agroecological principles occurs on the ground, the approach we assumed here is 'exploratory'. As we continue to co-learn, we are hoping to develop and adapt other methodologies for applying agroecological principles.

4.6. Conclusions

The processes of 'grounding' agroecological principles in different socio-economic and ecological contexts and territories are understudied. While there is a shared understanding within the field of agroecology that principles are useful for providing direction for agroecological transitions and transformations, there are relatively few documented experiences of how this 'contextualization' happens on the ground. The exploratory study described in this chapter contributes to the literature by providing one example of how principles can be applied and adopted. We used findings from a PAR study with beekeeper-coffee farmers of ART in Chiapas, Mexico, as well as participatory reflections to apply and adapt *Agroecological Principles for Beekeeping.* Some of the key lessons learned from this exploration include:

- Agroecological principles are a useful lens for assessing the "agroecological situation" of a farm or system. Principles can help see connections among elements in a socio-ecological system and identify opportunities for and barriers to change.
- Grounding agroecological principles through participatory processes is an important step that can help build a shared understanding of the many meanings and manifestations of the principles in a specific context. In our case, findings from a case study informed the exercise of grounding the principles. Yet, the ideas emerging from this exercise need to be tested and validated with groups of beekeepers.
- In planning for agroecological transitions, agroecological principles can facilitate the process of identifying priorities and goals.

We propose that future research pays attention to the diverse approaches and practices that actors on the ground use for making sense of the principles, contextualizing them, and applying them to inform transformative learning. Sharing such experiences could inspire more actors to work on adaptations of principles that reflect the dreams, aspirations, and socio-ecological conditions of their territories.

4.7 Acknowledgments

Thank you to all PAR collaborators who contributed to this study in different ways: Rigobero Hernandez Jonapá, Susi Marconi Muños Roblero, and José Antonio López Pérez from ART; Beatriz Ocampo from Food 4 Farmers; and Rémy Vandame, Yliana Delfín Fuentes, Omar Argüello Nájera, and Luis Mondragón Muñoz from Equipo Abejas at ECOSUR. I would also like to thank Colin Anderson and Ernesto Méndez (from UVM) for helping give form to the chapter.

4.8 References

Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., Pimbert, M. P. (2021). *Agroecology Now! Transformations towards more just and sustainable food system*. Palgrave Macmillan. https://www.palgrave.com/gp/book/9783030613143.

Anderson, C., & Anderson, M. (2020). Resources to Inspire a Transformative Agroecology: A Curated Guide. In H. R. Herren, B. Haerlin, & IAASTD. A. G. (Eds.), *Transformation of Our Food Systems: The making of a paradigm shift*, Zukunftsstiftung Landwirtschaft (Foundation on Future Farming), pp. 169-180.

Anderson, C.R., McCune, N., Buccini, G., Mendez, V.E., Carasco, A., Caswell, M., Blume, S., and Ahmed, F. (2022). *Working Together for Agroecology Transitions*.

Perspectives on Agroecology Transitions – No. 3. Agroecology and Livelihoods Collaborative (ALC), University of Vermont.

Anderson, Colin Ray, Bruil, J., Chappell, M. J., Kiss, C., & Pimbert, M. P. (2019). From Transition to Domains of Transformation: Getting to Sustainable and Just Food Systems through Agroecology. *Sustainability*, *11*(19), 5272. https://www.mdpi.com/2071-1050/11/19/5272

Anderzén, J., Guzmán Luna, A., Luna-González, D. V., Merrill, S. C., Caswell, M., Méndez, V. E., Hernández Jonapá, R., and Mier y Terán Giménez Cacho, M. (2020). Effects of on-farm diversification strategies on smallholder coffee farmer food security and income sufficiency in Chiapas, Mexico. *Journal of Rural Studies 77*, 33-46. https://doi.org/10.1016/j.jrurstud.2020.04.001

Bell, M. M., and Bellon, S. (2018). Generalization without universalization: Towards an agroecology theory. *Agroecology and Sustainable Food Systems*, *42*(6), 605-611. DOI: 10.1080/21683565.2018.1432003.

Bezner Kerr, R. B., Liebert, J., Kansanga, M., and Kpienbaareh, D. (2022). Human and social values in agroecology: A review. *Elementa*, *10*(1), 1–24. https://doi.org/10.1525/elementa.2021.00090.

Biovision. (n/a). *Farm-level Agroecology Criteria Tool*. Agroecology Info Pool. https://www.agroecology-pool.org/fact/

Caswell, M., Méndez, V. E., Juncos-Gautier, M. A., Hurley, S. E., Gould, R. K., Márquez Sánchez, D., and Lewis, S. (2021). Agroecological transformations in urban contexts: transdisciplinary research frameworks and participatory approaches in Burlington, Vermont. In M. Egerer and H. Cohen (Eds), *Urban agroecology: interdisciplinary research and future directions* (pp. 299-319). CRC Press, Taylor and Francis Group.

Coopération Internationale pour le Développement et la Solidarité (2018). *The principles of agroecology: Towards just, resilient and sustainable food systems*. CIDSE, Belgium. https://www.cidse.org/2018/04/03/the-principles-of-agroecology/.

Cuéllar-Padilla, M., and Calle-Collado, A. (2011). Can we find solutions with people? Participatory action research with small organic producers in Andalusia. *Journal of Rural Studies, 27*(4), 372-383.

Declaration of the International forum for Agroecology, Nyéléni, Mali. (2015). February 27. *Developments* 58, 163-168. https://doi.org/10.1057/s41301-016-0014-4.

Dumont, A. M., Vanloqueren, G., Stassart, P.M., and Baret. P.V. (2016). Clarifying the socioeconomic dimensions of agroecology: Between principles and practices. *Agroecology and Sustainable Food Systems*, 40 (1), 24–47. https://doi.org/10.1080/21683565.2015.1089967

Dumont, A. M., Wartenberg, A. C., & Baret, P. V. (2021). Bridging the gap between the agroecological ideal and its implementation into practice. A review. *Agronomy for Sustainable Development*, *41*(3). https://doi.org/10.1007/s13593-021-00666-3.

Duru, M., Therond, O., & Fares, M. (2015). Designing agroecological transitions; A review. *Agronomy for Sustainable Development*, *35*(4), 1237–1257. https://doi.org/10.1007/s13593-015-0318-x

Equipo Abejas. (2020). *Principios Agroecológicos de la Apicultura – Mayo 2020*. El Colegio de la Frontera Sur (ECOSUR).

Fals Borda, O. (1979). Investigating Reality in Order to Transform it: The Colombian Experience. *Dialectical Anthropology*, 4(1), 33-55. https://www.jstor.org/stable/29789952.

FAO (2018). *The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems.* FAO, Rome. http://www.fao.org/documents/card/en/c/I9037EN/

Frank, M., Kaufmann, B., Ejarque, M., Lamaison, M. G., Nessi, M. V., and Amoroso, M. M. (2022). Changing Conditions for Local Food Actors to Operate Towards Agroecology During the COVID-19 Pandemic. *Frontiers in Sustainable Food Systems*, *6*(June). https://doi.org/10.3389/fsufs.2022.866004.

Giraldo, O. F., & Rosset, P. M. (2022). Emancipatory agroecologies: social and political principles. *Journal of Peasant Studies*. https://doi.org/10.1080/03066150.2022.2120808.

Gliessman, S.R. (2015). *Agroecology: the ecology of sustainable food systems*. 3rd Edition. CRC Press/Taylor & Francis, Boca Raton, Florida.

Gliessman, S.R., Méndez, V.E., Izzo, V.M., Engles, E.W., and Gerlicz, A. (2022). *Agroecology: Leading the Transformation to a Just and Sustainable Food System*. 4th Edition. CRC Press, Boca Raton.

Guzmán Luna, A., Bacon, C. M., Méndez, V. E., Flores Gómez, M. E., Anderzén, J., Mier y Terán Giménez Cacho, M., Hernández Jonapá, R., Rivas, M., Duarte Canales, H. A., and Benavides González, Á. N. (2022). Toward Food Sovereignty: Transformative Agroecology and Participatory Action Research With Coffee Smallholder Cooperatives in Mexico and Nicaragua. *Frontiers in Sustainable Food Systems, 6(August)*. https://doi.org/10.3389/fsufs.2022.810840.

High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. HLPE Report 14. HLPE, Rome. https://www.fao.org/agroecology/database/detail/en/c/1242141/.

Inana A.C., el Centro Ecodiálogo de la Universidad Veracruzana, and Equipo Abejas of ECOSUR. (n.d.) *Autovaloración agroecológica de proyectos de apicultura*.

INKOTA. (2019). *Strengthening agroecology. For a fundamental transformation of agri-food systems*. Position paper directed at the German Federal Government. https://webshop.inkota.de/node/1565

IPES Food. (2018). *Breaking away from industrial food and farming systems: Seven case studies of agroecological transition*. International Panel of Experts in Sustainable Food Systems Brussels.

Juncos-Gautier, M.A. (2021). *Assessing Agroecological Principles at the Intervale in Burlington, Vermont: A Case Study and Multimethod Research with a Participatory Approach in a Peri-Urban Socioecological System*. Doctoral Dissertation, University of Toronto.

Kapgen, D., and Roudart, L. (2020). Proposal of a principle cum scale analytical framework for analyzing agroecological development projects. *Agroecology and Sustainable Food Systems*, *44*(7), 876–901. https://doi.org/10.1080/21683565.2020.1724582

López Garcia, D., and Tendero Acín, G. (2023). *Towards Agroecological Futures. How to Facilitate local Agroecological Transitions.* Common Ecologies.

Mason, R., White, A., Bucini, G., Anderzen, J., Mendez, V. E., & Merrill, S. C. (2020). The evolving landscape of agroecological research. *Agroecology and Sustainable Food Systems*, *45*(4), 551-591, doi:10.1080/21683565.2020.1845275

Méndez V.E., Bacon C.M., Cohen R. (2016). Introduction: Agroecology as a transdisciplinary, participatory and action-oriented approach In: V. E. Méndez, et al. (Eds.), *Agroecology: a transdisciplinary, participatory and action-oriented approach*, CRC Press/Taylor and Francis. pp. 1-22.

Méndez, V.E., Caswell, M., Gliessman, S.R., and Cohen, R., 2017. Integrating Agroecology and Participatory Action Research (PAR): Lessons from Central America. *Sustainability*, *9*(5). https://doi.org/10.3390/su9050705.

Milgroom J., Bruil J., and Leeuwis C. (2016) Co-creation of knowledge in the practice, science and movement of agroecology. *Farming Matters, 32,* 6-9.

Morgan, C.B, and Trubek, A.B. (2020). Not yet at the table: The absence of food culture and tradition in agroecology literature. *Elementa: Science of the Anthropocene,* 8:40. https://doi.org/10.1525/elementa.437.

Nicholls, C.I., Altieri, M.A., and Vazquez, L. (2016). Agroecology: Principles for the Conversion and Redesign of Farming Systems. *Journal of Ecosystem & Ecography*, *01*(s5). https://doi.org/10.4172/2157-7625.s5-010

Nyeleni, M. (2015). *Declaration of the International Forum for Agroecology*.

Patton, M. Q. (2021). Principles-focused evaluation for agroecology. *Elementa*, *9*(1), 1–6. https://doi.org/10.1525/elementa.2021.00052

Peeters, A., and Wezel, A. (2017) Agroecological principles and practices for grass-based farming systems. In A. Wezel (ed) *Agroecological practices for sustainable agriculture: principles, applications, and making the transition.* World Scientific, New Jersey, USA, pp 293–354.

Rosset , P.M., Pinheiro Barbosa, L., Val, V., and McCune, N. (2020). Pensamiento Latinoamericano Agroecológico: the emergence of a critical Latin American agroecology, *Agroecology and Sustainable Food Systems*, 45(1), 42-64. DOI: 10.1080/21683565.2020.1789908.

Soini Coe, E., and Coe, R. (2023). Agroecological transitions in the mind. *Elementa: Science of the Anthropocene*, 11 (1): 00026. https://doi.org/10.1525/elementa.2022.00026

Teixeira, H. M., Berg, L. Van Den, Cardoso, I. M., Vermue, A. J., Bianchi, F. J. J. A., Peña-claros, M., & Tittonell, P. (2018). *Understanding Farm Diversity to Promote Agroecological Transitions*. *Sustainability 10*(12), 4337. https://doi.org/10.3390/su10124337

Tittonell, P. (2019). Las transiciones agroecológicas: Múltiples escalas, niveles y desafíos. *Revista de la facultad de ciencias agrarias 51*(1), 231-246. http://revistas.uncu.edu.ar/ojs3/index.php/RFCA/article/view/2448/1766

Tittonell, P. (2020). Assessing resilience and adaptability in agroecological transitions. *Agricultural Systems*, *184*(August 2019), 102862. https://doi.org/10.1016/j.agsy.2020.102862.

Toffolini, Q., Cardona, A., Casagrande, M., Dedieu, B., Girard, N., and Ollion, E. (2019). Agroecology as farmers' situated ways of acting: a conceptual framework. In *Agroecology and Sustainable Food Systems 43*(5), 514–545. https://doi.org/10.1080/21683565.2018.1514677.

Utter, A. White, A., Méndez, V. E., and Morris, K. (2021). Co-creation of knowledge in agroecology. *Elementa: Science of the Anthropocene, 9* (1): 00026. doi:https://doi.org/10.1525/elementa.2021.00026.

Wezel, Alexander, Herren, B. G., Kerr, R. B., Barrios, E., Goncalves, A. L. R., and Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agronomy for Sustainable Development*, *40*(6), 40.

CHAPTER 5: CONCLUSIONS

5.1 (Some) lessons learned

I close my eyes, and my mind takes me back to the highlands of the Sierra Madre de Chiapas. The memories are vivid, touching all senses. The lush mountain slopes with coffee plants blossoming under a canopy of shade trees, the taste of fresh tortillas and coffee around a kitchen table with heavy rain falling on the tin roof, and the magnificent scents of the flowers growing in the home garden. This dissertation, emerging from several years of transdisciplinary Participatory Action Research (PAR) with farmer families of *Campesinos Ecológicos de la Sierra Madre de Chiapas* (CESMACH) and *Apicultores Real del Triunfo* (ART), has attempted to capture some elements of the agricultural diversity/diversification in these multifunctional landscapes to understand opportunities and limitations of this agroecological strategy.

In Chapter 2, we used data from household surveys and focus groups to describe characteristics of diversified coffee farms and examine how different diversification alternatives are associated with food and livelihood security outcomes. We found that beekeeping for honey, especially when combined with *milpa* production, proved to be a promising strategy for supporting the economic well-being of farmer families and reducing the impacts of seasonal food insecurity. However, our findings also showed that various factors regulate diversification's effects on farmers' well-being, calling for non-generic conclusions.

Figure 5-1: Expressions of agricultural diversity in Sierra Madre de Chiapas – wild leafy greens and other local ingredients, landrace varieties of maize, and a diversified *cafetal* (coffee plot).

Chapter 3 built on the findings and reflections of the study discussed in Chapter 2 and took a closer look at the multiple values of beekeeping as an element of diversified coffee farms. Two years of knowledge co-creation with 25 beekeepers from ART demonstrated 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 emotional well-being. Our findings also showed that beekeeping can generate economic gains, but profitability hinges on various factors, such as the price of honey, yield per hive, and the number of beehives. We argue that efforts to support beekeeping as a diversification strategy should take a holistic approach, emphasizing the multiple benefits that beekeeping can generate for families and communities.

Finally, Chapter 4 examined the opportunities of applying agroecological principles to the case study discussed in Chapter 3 and of integrating a principles-based approach to map out possible agroecological transition pathways for coffee farmer-beekeepers. The findings from this exploratory study suggest that agroecological principles can be a valuable lens for assessing the "agroecological situation" of a farm or system. Principles can also help discover connections among elements in a socio-ecological system and identify opportunities and barriers to change.

Grounding agroecological principles through participatory processes is an important step that can help build a shared understanding of the many meanings and manifestations of the principles in a specific context.

Together, the findings and experiences emerging from the three studies confirm what other studies from agrobiodiverse landscapes have shown - agricultural diversity and diversification are dynamic and complex, with a range of factors interacting to create unique constellations of diversity on farms and territories. Long-term PAR processes provide opportunities to understand change over time in these diversified landscapes and uncover nuances that could be overlooked in shorter research projects. We propose that future research continue exploring farmers' decision-making processes around agricultural diversification, structural factors that enable or pose barriers (or 'lock-ins') to diversification, and gendered dimensions of agricultural diversification. We also hope further research in the future will focus on diverse approaches used by farmers and other food system actors to make sense of agroecological principles, and ground them into their socioeconomic and ecological contexts to inform agroecological transitions.

5.2 Transformative learning through PAR

PAR processes resemble the art of painting. In the beginning, there is a sketch or a plan; as the process moves forward and the knowledge and experiences accumulate, the image on the canvas grows and evolves. More layers and details are added as the PAR partners change angle, pause, reflect, and adjust. The studies in this dissertation represent a section of the collective painting, created through a participatory process of knowledge co-creation among academics, farmers, and other PAR partners since 2017. There are many more important lessons learned, many of which have been captured in other publications and materials (e.g., Guzmán Luna et al., 2022, Guzmán Luna & Hernandez Jonapá, *in press*). Together, they represent a more complete story of our evolved understanding of agricultural diversification and the opportunities to promote agroecological approaches for strengthening food sovereignty and livelihood security in smallholder coffee communities.

Our PAR process provides many examples of how our understanding of some of the main themes of the study has deepened and evolved through time. One such example starts with the baseline study, described in Chapter 2. One of the goals of the study was to examine if coffee farmer families of CESMACH were experiencing seasonal food insecurity, a phenomenon that several researchers had observed in different coffee regions in Mexico and Central America (e.g., Bacon et al., 2017, Fernandez & Méndez, 2018). Through our survey, we found that over 70 % of the families were experiencing between 1 and 8 months of food insecurity a year, mainly during the rainy season (Anderzén et al., 2020). Yet, our understanding of the so-called "thin months" started to shift over time. Through focus groups, surveys, interviews, and observation with families from CESMACH we came to realize that "thin months" did not necessarily imply food scarcity but rather a change in diet. During the rainy season, families were eating more wild foods and other locally available foods while reducing the consumption of, e.g., processed food (Guzmán Luna et al., 2022). As reflected in Guzmán Luna et al., 2022, this is not necessarily the preferred diet for some, but it may be healthier and more nutritious. Partly as a result of these observations, the PAR team decided to co-create a 'Healthy Eating Plate' (or 'Nourishment Plate') with farmer families, highlighting local and seasonally available food sources (Guzmán Luna et al., 2022; Figure 2). In her recent essay, Alejandra Guzmán Luna, a colleague and friend, beautifully describes this and other examples from our PAR process (Guzmán Luna, *in press*).

Figure 5-2: 'Healthy Eating Plate' (or 'Nourishment Plate') adapted to Sierra Madre de Chiapas (the poster was published in Guzmán Luna et al., 2022, design: Daniela Gallardo Olimón)

Additionally, the chapters in this dissertation have focused on describing the findings and the methods of knowledge co-creation. What they have *not* captured in depth, though, are the many little (and big) things contributing to and spicing up the collective PAR process - laughs on the back of a pickup truck, strong friendships that have been formed, hundreds (maybe thousands?) of post-it notes filled with ideas. Or the many challenges emerging from doing PAR across continents, the complexities of navigating power and gender dynamics among a diverse group of collaborators, the frustrations arising from differing expectations (see Guzmán Luna & Hernandez Jonapá, *in press*; Figure 5-3). All these elements make PAR something that not only challenges the intellect but also touches emotions deeply, reminding us that we are *sentipensantes* (Fals Borda, 1979) with an unlimited capacity to use our minds, heart, and creativity in research.

Figure 5-3: Building friendships through PAR. Left: Janica with Rigoberto Hernandez Jonapá in an apiary (photo: Martha Caswell). Top right: conducting surveys with a team of young people from CESMACH (photo: J. Anderzén). Bottom right: outside the CESMACH office with Bety Ocampo (Food 4 Farmers) and Susi Marconi Muños Roblero (coordinator of ART) (photo: S. Marconi Muños Roblero).

I am grateful and humbled to have had the opportunity to do my dissertation work as part of this PAR process. It has transformed my thinking and being in more ways that I can describe here (or even understand at this point) and hopefully made me a better social scientist. The process has also solidified my belief that PAR – in its many shapes and forms – is a great framework and approach for doing action-oriented and transformative research in agroecology. Moving forward, I will continue to explore the possibilities and limitations of PAR, building on what I have learned (and unlearned) so far.

Finally, wherever I go, I will try to remember the wisdom of a dear friend and colleague, Rigoberto Hernandez Jonapá, who always reminds us that *"No se puede bailar más rapido que la música"* ('You can't dance faster than the music').

Figure 5-4: Lunch after a focus group in the community of Emiliano Zapata (left); and technical difficulties during a meeting with PAR partners (right) (Photos: J. Anderzén).

5.3 References

Anderzén, J., Guzmán Luna, A., Luna-González, D. V., Merrill, S. C., Caswell, M., Méndez, V. E., Hernández Jonapá, R., and Mier y Terán Giménez Cacho, M. (2020). Effects of on-farm diversification strategies on smallholder coffee farmer food security and income sufficiency in Chiapas, Mexico. *Journal of Rural Studies 77*, 33-46. https://doi.org/10.1016/j.jrurstud.2020.04.001

Bacon, C. M., Sundstrom, W. A., Stewart, I. T., Maurer, E., and Kelley, L. C. (2021). Towards smallholder food and water security: Climate variability in the context of multiple livelihood hazards in Nicaragua, *World Development 143*: 105468. https://doi.org/10.1016/j.worlddev.2021.105468.

Fals Borda, O. (1979). Investigating Reality in Order to Transform it: The Colombian Experience. *Dialectical Anthropology*, 4(1), 33-55. https://www.jstor.org/stable/29789952.

Fernandez, M. and Méndez, V. E., 2018. Subsistence under the Canopy: Agrobiodiversity's Contributions to Food and Nutrition Security amongst Coffee Communities in Chiapas, Mexico. Agroecology and Sustainable Food Systems, pp. 1–23. https://doi.org/10.1080/21683565.2018.1530326.

Guzmán Luna, A., Bacon, C. M., Méndez, V. E., Flores Gómez, M. E., Anderzén, J., Mier y Terán Giménez Cacho, M., Hernández Jonapá, R., Rivas, M., Duarte Canales, H. A., and Benavides González, Á. N. (2022). Toward Food

Sovereignty: Transformative Agroecology and Participatory Action Research With Coffee Smallholder Cooperatives in Mexico and Nicaragua. *Frontiers in Sustainable Food Systems*, *6(August)*. https://doi.org/10.3389/fsufs.2022.810840.

Guzmán Luna, A. & Jonapá Hernández, R. (in press). Agroecología desde la base: acompañamiento en las transiciones desde la Investigación Acción Participativa en comunidades cafeticultoras en la Sierra Madre de Chiapas. In Hernández Moreno, *Desiertos y Óasis en la transición agroecológica de México*. Análisis regionales comparativos. CIAD.

COMPREHENSIVE BIBLIOGRAPHY

Agroecology and Livelihoods Collaborative (ALC), and the Gund Institute for Environment. (2020). *Agroecology and livelihoods in global coffee systems. Diverse, multifunctional farms key to sustainability*. Research brief, December.

Albertin, A., and Nair, P.K.R. (2014). Farmers' Perspectives on the Role of Shade Trees in Coffee Production Systems: An Assessment from the Nicoya Peninsula, Costa Rica. *Human Ecology 32*(4), pp. 443-463. https://doi.org/10.1023/B:HUEC.0000043515.84334.7**.**

Altieri, M.A. (2009). Agroecología, pequeñas fincas y soberanía alimentaria. *Ecología Política 38*, pp. 25-35.

Amekawa, Y. (2011). Agroecology and Sustainable Livelihoods: Towards an Integrated Approach to Rural Development. *Journal of Sustainable Agriculture 35*(2), pp. 118–62.

Ament, J., Tobin, D., Merrill, S. C., Morgan, C., Morse, C., Liu, T. L., and Trubek, A. (2022). From Polanyi to policy: A tool for measuring embeddedness and designing sustainable agricultural policies. *Frontiers in Sustainable Food Systems 6*. https://doi.org/10.3389/fsufs.2022.983016

Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., Pimbert, M. P. (2021). *Agroecology Now! Transformations towards more just and sustainable food system*. Palgrave Macmillan. https://www.palgrave.com/gp/book/9783030613143.

Anderson, C., & Anderson, M. (2020). Resources to Inspire a Transformative Agroecology: A Curated Guide. In H. R. Herren, B. Haerlin, & IAASTD. A. G. (Eds.), *Transformation of Our Food Systems: The making of a paradigm shift,* Zukunftsstiftung Landwirtschaft (Foundation on Future Farming), pp. 169-180.

Anderson, C.R., McCune, N., Buccini, G., Mendez, V.E., Carasco, A., Caswell, M., Blume, S., and Ahmed, F. (2022). *Working Together for Agroecology Transitions*. Perspectives on Agroecology Transitions – No. 3. Agroecology and Livelihoods Collaborative (ALC), University of Vermont.

Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., & Pimbert, M. P. (2019). From Transition to Domains of Transformation: Getting to Sustainable and Just Food Systems through Agroecology. *Sustainability 11*(19), 5272. https://www.mdpi.com/2071-1050/11/19/5272

Anderzén, J., Guzmán Luna, A., Luna-González, D. V., Merrill, S. C., Caswell, M., Méndez, V. E., Hernández Jonapá, R., and Mier y Terán Giménez Cacho, M. (2020). Effects of on-farm diversification strategies on smallholder coffee farmer food security and income sufficiency in Chiapas, Mexico. *Journal of Rural Studies 77,* 33-46. https://doi.org/10.1016/j.jrurstud.2020.04.001

Anderzén, J., Méndez, V.E., Griffeth, M., McHugh, C., Gilman, C., Barahona, C., & Peyser, R. (2021). *State of the Smallholder Coffee Farmer: An Initiative Towards a More Equitable and Democratic Information Landscape*. Research Report. Agroecology and Livelihoods Collaborative (ALC), University of

Vermont/Statistics for Sustainable Development (Stats4SD)/Heifer International/Lutheran World Relief (LWR). Burlington, Vermont, U.S.A.

Appendini, K., and Quijada, M.G. (2016). Consumption strategies in Mexican rural households: pursuing food security with quality. *Agriculture and Human Values 33*, pp. 439–454. DOI 10.1007/s10460-015-9614-y.

Baca, M., Liebig, T., Caswell, M., Castro-Tanzi, S., Méndez, V.E., Läderach, P., Morris, B., and Aguirre, Y. (2014). *Thin months revisited*. Final report (October 16). International Center for Tropical Agriculture (CIAT) and Agroecology and Rural Livelihoods Group (ARLG), University of Vermont, Vermont.

Bacon, C. M., Flores Gomez, M. E., Shin, V., Ballardo, G., Kriese, S., McCurry, E., Martinez, E., and Rivas, M. (2023). Beyond the bean: Analyzing diversified farming, food security, dietary diversity, and gender in Nicaragua's smallholders coffee cooperatives. *Agroecology and Sustainable Food Systems*, *47*(4), 579-620. https://doi.org/10.1080/21683565.2023.2171172

Bacon, C. M., Mendez, E., and Brown, M. (2005). *Participatory action research and support for community development and conservation: examples from shade coffee landscapes in Nicaragua and El Salvador.* The Center for Agroecology & Sustainable Food Systems, Research Brief #6, pp. 1-12.

Bacon, C. M., Sundstrom, W. A., Stewart, I. T., Maurer, E., and Kelley, L. C. (2021). Towards smallholder food and water security: Climate variability in the context of multiple livelihood hazards in Nicaragua, *World Development 143*: 105468. https://doi.org/10.1016/j.worlddev.2021.105468.

Bacon, C. M., Sundstrom, W. M., Flores Gómez, M. A., Méndez, V. E., Santos, R., Goldoftas, B., and Dougherty, I. (2014). Explaining the 'hungry farmer paradox': Smallholders and fair trade cooperatives navigate seasonality and change in Nicaragua's corn and coffee markets. *Global Environmental Change 25*, pp. 133–49.

Baena-Díaz, F., Chévez, E., Ruiz de la Merced, F., and Porter-Bolland, l. (2022). Apis mellifera in Mexico: honey production, melliferous flora and pollination aspects. Review. *Revista mexicana de ciencias pecuarias 13*(2). https://doi.org/10.22319/rmcp.v13i2.5960

Bathfield, B., Gasselin, P., García-Barrios, L., Vandame, R., and López-Ridaura, S. (2016). Understanding the long-term strategies of vulnerable small-scale farmers dealing with markets' uncertainty. *Geographical Journal*, *182*(2), 165–177. https://doi.org/10.1111/geoj.12142

Bathfield, B., Gasselin, P., López-Ridaura, S., and Vandame, R. (2013). A flexibility framework to understand the adaptation of small coffee and honey producers facing market shocks. *The Geographical Journal 179*(4), pp. 356–368.

Bell, M. M., and Bellon, S. (2018). Generalization without universalization: Towards an agroecology theory. *Agroecology and Sustainable Food Systems*, *42*(6), 605-611. DOI: 10.1080/21683565.2018.1432003

Bezner Kerr, R. B., Liebert, J., Kansanga, M., & Kpienbaareh, D. (2022). Human and social values in agroecology: A review. *Elementa, 10*(1), 1–24. https://doi.org/10.1525/elementa.2021.00090.
Bielecki, C. D., and Wingenbach, G. (2019). Using a livelihoods framework to analyze farmer identity and decision making during the Central American coffee leaf rust outbreak: implications for addressing climate change and crop diversification. *Agroecology and Sustainable Food Systems 43*(4), pp. 457-480. DOI: 10.1080/21683565.2019.1566191.
Bilinsky, P., and Swindale, A. (2010). *Months of Adequate Household Food Provisioning (MAHFP) for Measurement of Household Food Access: Indicator Guide (v.4)*. Washington, D.C.: FHI 360/FANTA.
Biovision. (n/a). *Farm-level Agroecology Criteria Tool*. Agroecology Info Pool. https://www.agroecology-pool.org/fact/
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
Caswell, M., Maden, R., McCune, N., Méndez, V.E., Bucini, G., Anderzén, J., Izzo, V., Hurley, S.E., Gould, R.K., Faulkner, J., and Juncos-Gautier, M.A. (2021). *Amplifying Agroecology in Vermont: Principles and Processes to Foster Food Systems Sustainability. White Paper. Agroecology and Livelihoods Collaborative.* University of Vermont: Burlington, Vermont, USA.
Caswell, M., Méndez, V. E., Hayden, J., Anderzén, J., Cruz, A., Merritt, P., Izzo, V., Castro, S., and Fernandez, M. (2016). *Assessing Resilience in Coffee-Dependent Communities of Honduras, Nicaragua and Haiti*. Research Report. Agroecology and Rural Livelihoods Group (ARLG), University of Vermont, Burlington, Vermont.
Caswell, M., Méndez, V. E., Juncos-Gautier, M. A., Hurley, S. E., Gould, R. K., Márquez Sánchez, D., and Lewis, S. (2021). Agroecological transformations in urban contexts: transdisciplinary research frameworks and participatory approaches in Burlington, Vermont. In M. Egerer and H. Cohen (Eds), *Urban agroecology: interdisciplinary research and future directions* (pp. 299-319). CRC Press, Taylor and Francis Group.
[CEDRESSA] Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria. (2018). *El café en México. Diagnóstico y perspectiva*. Report. Retrieved from: http://www.cedrssa.gob.mx/files/10/30El%20caf%C3%A9%20en%20M%C3%A9xico:%20diagn%C3%B3stico%20y%20perspectiva.pdf
Cely-Santos, M., and Lu, F. (2019). Intersections between rural livelihood security and animal pollination in Anolaima, Colombia. *Geoforum 104*, 13-24.
[CESMACH] Campesinos Ecológicos de la Sierra Madre de Chiapas. (2019). *La Cesmach: su origen, desarrollo y perspectivas de futuro. Sistematización de*

experiencias. Quiroga Carapia, A. A. and Hernández Lleaven, J. A. (eds.). (*manuscript in preparation*).
[CIDSE] Coopération Internationale pour le Développement et la Solidarité (2018). *The principles of agroecology: Towards just, resilient and sustainable food systems.* CIDSE, Belgium. https://www.cidse.org/2018/04/03/the-principles-of-agroecology/.
[CONAPO] Consejo Nacional de Población. (2015). *Índice de marginación por entidad federativa y municipio 2015*. Retrieved from: https://www.gob.mx/cms/uploads/attachment/file/459287/06_Anexo_B1.pdf
Contreras Uc, L.C., and Magaña Magaña, M.A. (2017). Costos y rentabilidad de la apicultura a pequeña escala en comunidades mayas del Litoral Centro de Yucatán, México. *Investigación y Ciencia 25*(71), 52-58.
Coopération Internationale pour le Développement et la Solidarité (2018). *The principles of agroecology: Towards just, resilient and sustainable food systems*. CIDSE, Belgium. https://www.cidse.org/2018/04/03/the-principles-of-agroecology/.
Cortina Villar, S., Plascencia-Vargas, H., Vaca, R., Schroth, G., Zepeda, Y., Soto-Pinto, L., and Nahed-Toral, J. (2012). Resolving the conflict between ecosystem protection and land use in protected areas of the Sierra Madre de Chiapas, Mexico. *Environmental Management 49*(3), pp. 649-662.
Crane, E. (1999). *The world history of beekeeping and honey hunting*. New York: Routledge.
Cuéllar-Padilla, M., and Calle-Collado, A. (2011). Can we find solutions with people? Participatory action research with small organic producers in Andalusia. *Journal of Rural Studies* 27(4), pp. 372-383.
Dasgupta, P., and Ray, D. (1986). Inequality as a determinant of malnutrition and unemployment: Theory. *Economic Journal 96*, pp. 1011–1034
de Roest, K., Ferrari, P., and Knickel, K. (2018). Specialisation and economies of scale or diversification and economies of scope? Assessing different agricultural development pathways. *Journal of Rural Studies 59*, 222–231. https://doi.org/10.1016/j.jrurstud.2017.04.013.
Declaration of the International forum for Agroecology, Nyéléni, Mali. (2015). February 27. *Developments* 58, 163-168. https://doi.org/10.1057/s41301-016-0014-4.
Delgado, Y. L. (2022). Crianza de abejas nativas : una pedagogía agroecológica con raíces. *Revista Brasileira de Educação do Campo*, pp. 1–27.
Dolores-Mijangos, G. de Jesús Santiago-Cruz, MA, Arana-Coronado, J., and Utrera-Quintana, F. (2017). Estudio del impacto de la actividad apícola en el Istmo de Tehuantepec, Oaxaca, México. *Agricultura Sociedad y Desarrollo, 14*, 187-203.
Donovan, J., and Poole, N. (2014). Changing asset endowments and smallholder participation in higher value markets: Evidence from certified coffee producers in Nicaragua. *Food Policy 44*, pp. 1–13.
Dumont, A. M., Vanloqueren, G., Stassart, P.M., and Baret. P.V. (2016). Clarifying the socioeconomic dimensions of agroecology: Between principles and practices.

Agroecology and Sustainable Food Systems, 40 (1), 24–47. https://doi.org/10.1080/21683565.2015.1089967
Dumont, A. M., Wartenberg, A. C., & Baret, P. V. (2021). Bridging the gap between the agroecological ideal and its implementation into practice. A review. *Agronomy for Sustainable Development*, *41*(3). https://doi.org/10.1007/s13593-021-00666-3.
Duru, M., Therond, O., & Fares, M. (2015). Designing agroecological transitions; A review. *Agronomy for Sustainable Development*, *35*(4), 1237–1257. https://doi.org/10.1007/s13593-015-0318-x
Eakin, H., Appendini, K., Sweeney, S., and Perales, H. (2015). Correlates of Maize Land and Livelihood Change Among Maize Farming Households in Mexico. *World Development 70*, pp. 78-91. http://dx.doi.org/10.1016/j.worlddev.2014.12.012.
Eakin, H., Benessaiah, K., Barrera, J. F., Cruz-Bello, G. M., and Morales, H. (2012). Livelihoods and landscapes at the threshold of change: disaster and resilience in a Chiapas coffee community. *Regional Environmental Change 12*, pp. 475–488.
Ellis, F., 2000. *Rural livelihoods and diversity in developing countries*. Oxford University Press, Oxford.
Ellis, R. (2022). Social reproduction, playful work, and bee-centred beekeeping. *Agriculture and Human Values* 39, pp. 1329–1340. https://doi.org/10.1007/s10460-022-10319-0.
Equipo Abejas at El Colegio de la Frontera Sur (ECOSUR), Campesinos Ecológicos de la Sierra Madre de Chiapas (CESMACH), Agroecology and Livelihoods Collaborative (ALC) at the University of Vermont (UVM). (2022). *Aporte de los polinizadores al Cafetal en la Sierra Madre de Chiapas*. Educational poster. https://bit.ly/3lh4ylN.
Equipo Abejas. (2020). *Principios Agroecológicos de la Apicultura – Mayo 2020*. El Colegio de la Frontera Sur (ECOSUR).
Fals Borda, O. (1979). Investigating Reality in Order to Transform it: The Colombian Experience. *Dialectical Anthropology*, 4(1), 33-55. https://www.jstor.org/stable/29789952.
[FAO] The Food and Agriculture Organization of the United Nations (2018). *The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems.* FAO, Rome. http://www.fao.org/documents/card/en/c/I9037EN/.
Fernandez, M., and Méndez, V. E. (2018). Subsistence under the Canopy: Agrobiodiversity's Contributions to Food and Nutrition Security amongst Coffee Communities in Chiapas, Mexico. *Agroecology and Sustainable Food Systems* 43(5), pp. 1–23. https://doi.org/10.1080/21683565.2018.1530326.
Frank, M., Kaufmann, B., Ejarque, M., Lamaison, M. G., Nessi, M. V., and Amoroso, M. M. (2022). Changing Conditions for Local Food Actors to Operate Towards Agroecology During the COVID-19 Pandemic. *Frontiers in Sustainable Food Systems*, *6*(June). https://doi.org/10.3389/fsufs.2022.866004.

Gerlicz, A., Méndez, V. E., Conner, D., Baker, D., and Christel, D. (2018). Use and Perceptions of Alternative Economic Activities among Smallholder Coffee Farmers in Huehuetenango and El Quiché Departments in Guatemala. *Agroecology and Sustainable Food Systems 43*(3), pp. 310–28. https://doi.org/10.1080/21683565.2018.1532480.

Giraldo, O. F., & Rosset, P. M. (2022). Emancipatory agroecologies: social and political principles. *Journal of Peasant Studies*. https://doi.org/10.1080/03066150.2022.2120808.

Gliessman, S.R. (2015). *Agroecology: the ecology of sustainable food systems*. 3rd Edition. CRC Press/Taylor & Francis, Boca Raton, Florida.

Gliessman, S.R., Méndez, V.E., Izzo, V.M., Engles, E.W., and Gerlicz, A. (2022). *Agroecology: Leading the Transformation to a Just and Sustainable Food System*. 4th Edition. CRC Press, Boca Raton.

Guevara, F., and Romero, M. (2016). *La crianza de abejas como estrategia de diversificación: análisis de las cadenas de miel en El Tuma-La Dalia*. Cuaderno de investigación 54. UCA Publicaciones, Managua, Nicaragua.

Guzmán Luna, A. & Jonapá Hernández, R. (in press). Agroecología desde la base: acompañamiento en las transiciones desde la Investigación Acción Participativa en comunidades cafeticultoras en la Sierra Madre de Chiapas. In Hernández Moreno, *Desiertos y Óasis en la transición agroecológica de México*. Análisis regionales comparativos. CIAD.

Guzmán Luna, A., Bacon, C. M., Méndez, V. E., Flores Gómez, M. E., Anderzén, J., Mier y Terán Giménez Cacho, M., Hernández Jonapá, R., Rivas, M., Duarte Canales, H. A., and Benavides González, Á. N. (2022). Toward Food Sovereignty: Transformative Agroecology and Participatory Action Research With Coffee Smallholder Cooperatives in Mexico and Nicaragua. *Frontiers in Sustainable Food Systems, 6(August)*. https://doi.org/10.3389/fsufs.2022.810840.

Guzmán Luna, A., Ferguson, B. G., Schmook, B., Giraldo, O., and Aldasoro Maya, E. M. (2019). Territorial Resilience the Third Dimension of Agroecological Scaling: Approximations from Three Peasant Experiences in the South of Mexico. *Agroecology and Sustainable Food Systems 43* (7-8), pp. 764-784. https://www.tandfonline.com/doi/full/10.1080/21683565.2019.1622619.

Hannah, L., Donatti, C.I., Harvey, C.A., Alfaro, E., Rodriguez, D. A., Bouroncle, C., Castellanos, E., Diaz, F., Fung, E., Hidalgo, H. G., Imbach, P., Läderach, P., Landrum, J. P., and Solano, A. L. (2017). Regional modeling of climate change impacts on smallholder agriculture and ecosystems in Central America. *Climatic Change* 141, 29–45. https://doi.org/10.1007/s10584-016-1867-y

Harvey, C.A., Pritts, A.A., Zwetsloot, M.J., Jansen, K., Pulleman, M. M., Armbrecht, I., Avelino, J., Barrera, J.F., Bunn, C., Hoyos Garcia, J., Isaza, C., Muñoz-Ucros, J., Pérez-Alemán, J.C., Rahn, E., Robiglio, V., Somarriba, E., and Valencia, V. (2021). Transformation of coffee-growing landscapes across Latin America. A

review. *Agronomy for Sustainable Development* 41(62). https://doi.org/10.1007/s13593-021-00712-0.
Hausermann, H. (2014). Maintaining the Coffee Canopy: Understanding Change and Continuity in Central Veracruz. *Human Ecology 42*, pp. 381–394.
Hinton, J., Schouten, C., Austin, A., and Lloyd, D. (2020). An Overview of Rural Development and Small-Scale Beekeeping in Fiji. *Bee World*, *97*(2), 39–44. https://doi.org/10.1080/0005772x.2019.1698104.
[HLPE] High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. (HLPE Report 14). HLPE, Rome. https://www.fao.org/agroecology/database/detail/en/c/1242141/.
Himes, A., & Muraca, B. (2018). Relational values: the key to pluralistic valuation of ecosystem services. *Current Opinion in Environmental Sustainability 35*, 1–7. https://doi.org/10.1016/j.cosust.2018.09.005.
Imbach, P., Fung, E., Hannah, Navarro-Racinesa, C. E., Roubikd, D. W., Ricketts, T. H., Harvey, C. A., Donatti, C. I., Läderach, P., Locatelli, B. and Roehrdanz, P. R., 2017. Coupling of pollination services and coffee suitability under climate change, *PNAS*, *114*(39), 10438-10442.
Inana A.C., el Centro Ecodiálogo de la Universidad Veracruzana, and Equipo Abejas of ECOSUR. (n.d.) *Autovaloración agroecológica de proyectos de apicultura*.
INKOTA. (2019). *Strengthening agroecology. For a fundamental transformation of agri-food systems*. Position paper directed at the German Federal Government. https://webshop.inkota.de/node/1565
IPBES (2016). T*he assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production*. S.G. Potts, V. L. Imperatriz-Fonseca, and H. T. Ngo (eds). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 552 pages. https://doi.org/10.5281/zenodo.3402856
IPES-Food. (2018). *Breaking away from industrial food and farming systems: Seven case studies of agroecological transition*. International Panel of Experts in Sustainable Food Systems Brussels.
IPES-Food. (2016). *From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems.* International Panel of Experts on Sustainable Food systems. http://www.ipes-food.org/_img/upload/files/UniformityToDiversity_FULL.pdf
Isakson, R. S. (2009). No hay ganancia en la milpa: the agrarian question, food sovereignty, and the on-farm conservation of agrobiodiversity in the Guatemalan highlands. *The Journal of Peasant Studies 36*(4), pp. 725-759. DOI: 10.1080/03066150903353876
Jaffee, D. (2014). *Brewing justice: Fair trade coffee, sustainability, and survival*. Updated edition. University of California Press, Berkeley, California.

Jha, S., Bacon, C. M., Philpott, S. M., Rice, R. A., Méndez, V. E., and Läderach P. (2011). A Review of Ecosystem Services, Farmer Livelihoods, and Value Chains in Shade Coffee Agroecosystems. In: Campbell, W. B. and López Ortíz, S., Editors, 2011. *Integrating Agriculture, Conservation and Ecoturism: Examples from the Field.* Springer: Sacramento, California.

Jones, A.D. 2017. Critical review of the emerging research evidence on agricultural biodiversity, diet diversity, and nutritional status in low- and middle-income countries. *Nutrition Reviews, 75*(10), 769–782. doi:10.1093/nutrit/nux040.

Juncos-Gautier, M.A. (2021). *Assessing Agroecological Principles at the Intervale in Burlington, Vermont: A Case Study and Multimethod Research with a Participatory Approach in a Peri-Urban Socioecological System*. Doctoral Dissertation, University of Toronto.

Kapgen, D., and Roudart, L. (2020). Proposal of a principle cum scale analytical framework for analyzing agroecological development projects. *Agroecology and Sustainable Food Systems*, *44*(7), 876–901. https://doi.org/10.1080/21683565.2020.1724582

Keleman, A., Hellin, J., and Bellon, M. R. (2009). Maize diversity, rural development policy, and farmers' practices: Lessons from Chiapas, Mexico. *Geographical Journal 175*(1), pp. 52–70. https://doi.org/10.1111/j.1475-4959.2008.00314.x.

Klein, A., Vaissière, B., Cane, J., Steffan-Dewenter, I., Cunningham, S., Kremen, C., and Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society. B, *Biological Sciences, 274*(1608), 303-313.

Läderach, P., Ramirez-Villegas, J., Navarro-Racines, C., Zelaya, C., Martinez-Valle, A., and Jarvis, A. (2017). Climate change adaptation of coffee production in space and time. *Climatic Change* 141(1), pp. 47-62. https://doi.org/10.1007/s10584-016-1788-9

Lentz, E., Bezner Kerr, R., Patel, R., Dakishoni, L., and Lupafya, E. (2019). The Invisible Hand that Rocks the Cradle: On the Limits of Time Use Surveys. *Development and Change*, *50*(2), 301–328. https://doi.org/10.1111/dech.12426.

Lewin, K. (1946). Action research and minority problems. *Journal of Social Issues 2*(4), pp. 34–46. https://doi.org/10.1111/j.1540-4560.1946.tb02295.x

López Garcia, D., and Tendero Acín, G. (2023). *Towards Agroecological Futures. How to Facilitate local Agroecological Transitions.* Common Ecologies.

Luna-González, D. V, and Sørensen, M., 2018. Higher agrobiodiversity is associated with improved dietary diversity, but not child anthropometric status, of Mayan Achí people of Guatemala. *Public Health Nutrition*, *21*(11), 2128-2141. https://doi.org/10.1017/S1368980018000617.

Magaña Magaña, M. A., and Leyva Morales, C. E. (2011). Costos y rentabilidad del proceso de producción apícola en México. *Contaduría y Administración 235*, pp. 99-119.

Magaña, M. A., Tavera, M. E., Salazar, L. L., and Sanginés, J. R. (2016). Productividad de la apicultura en México y su impacto sobre la rentabilidad. *Revista Mexicana de Ciencias Agrícolas* 7(February), pp. 1103–1115.

Martinez-Salinas, A., Chain-Guadarrama, A., Aristizabal, N., Vilchez-Mendoza, S., Cerda, R., and Ricketts, T. H. (2022). Interacting pest control and pollination services in coffee systems. *Proceedings of the National Academy of Sciences of the United States of America*119(15), pp. 1–7. https://doi.org/10.1073/pnas.2119959119.

Mason, R., White, A., Bucini, G., Anderzen, J., Mendez, V. E., & Merrill, S. C. (2020). The evolving landscape of agroecological research. *Agroecology and Sustainable Food Systems*, *45*(4), 551-591, doi:10.1080/21683565.2020.1845275

McCune, N., Perfecto, I., Avilés-Vázquez, K., Vázquez-Negrón, J., & Vandermeer, J. (2019). Peasant balances and agroecological scaling in Puerto Rican coffee farming. *Agroecology and Sustainable Food Systems 43*(7–8), pp. 810–826. https://doi.org/10.1080/21683565.2019.1608348

Méndez V.E., Bacon C.M., Cohen R. (2016). Introduction: Agroecology as a transdisciplinary, participatory and action-oriented approach In: V. E. Méndez, et al. (Eds.), *Agroecology: a transdisciplinary, participatory and action-oriented approach*, CRC Press/Taylor and Francis. pp. 1-22.

Méndez, V.E., Caswell, M., Gliessman, S.R., and Cohen, R., 2017. Integrating Agroecology and Participatory Action Research (PAR): Lessons from Central America. *Sustainability, 9*(5). https://doi.org/10.3390/su9050705.

Milgroom J., Bruil J., and Leeuwis C. (2016) Co-creation of knowledge in the practice, science and movement of agroecology. *Farming Matters*, *32,* 6-9.

Morett Sánchez, J. C. and Ruiz, C. C. (2017). Panorama de Los Ejidos Y Comunidades Agrarias En México. *Agricultura, Sociedad y Desarrollo 14*(1), pp. 125–52.

Morgan, C.B, and Trubek, A.B. (2020). Not yet at the table: The absence of food culture and tradition in agroecology literature. *Elementa: Science of the Anthropocene,* 8:40. https://doi.org/10.1525/elementa.437.

Morris, K. S., Mendez, V. E., and Olson, M. B. (2013). 'Los Meses Flacos': Seasonal Food Insecurity in a Salvadoran Organic Coffee Cooperative. *Journal of Peasant Studies 40*(2), pp. 423–446. DOI: 10.1080/03066150.2013.777708.

Myers, R. and Pilegaard Hansen, C. (2019). Revisiting A Theory of Access: A review. *Society & Natural Resources*. DOI: 10.1080/08941920.2018.1560522.

Nicholls, C.I., Altieri, M.A., and Vazquez, L. (2016). Agroecology: Principles for the Conversion and Redesign of Farming Systems. *Journal of Ecosystem & Ecography*, *01*(s5). https://doi.org/10.4172/2157-7625.s5-010

Niehof, A., 2004. The significance of diversification for rural livelihood systems. *Food Policy 29*, 321-338.

Nyeleni, M. (2015). *Declaration of the International Forum for Agroecology*.

Pasupuleti, V. R., Sammugam, L., Ramesh, N., and Gan, S. H. (2017). Honey, Propolis, and Royal Jelly: A Comprehensive Review of Their Biological Actions and

Health Benefits. *Oxidative Medicine and Cellular Longevity*, Article ID 1259510. https://doi.org/10.1155/2017/1259510.
Patton, M. Q. (2021). Principles-focused evaluation for agroecology. *Elementa*, *9*(1), 1–6. https://doi.org/10.1525/elementa.2021.00052
Peeters, A., and Wezel, A. (2017) Agroecological principles and practices for grass-based farming systems. In A. Wezel (ed) *Agroecological practices for sustainable agriculture: principles, applications, and making the transition.* World Scientific, New Jersey, USA, pp 293–354.
Perfecto, I., and Vandermeer, J., 2015. *Coffee Agroecology: A New Approach to Understanding Agricultural Biodiversity, Ecosystem Services and Sustainable Development.* Routledge, Abingdon, UK.
Ponette-González, A. G. (2007). 2001: A Household Analysis of Huastec Maya Agriculture and Land Use at the Height of the Coffee Crisis. *Human Ecology 35* (3), pp. 289-301.
QSR International Pty Ltd. (2018). *NVivo (Version 12)*. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home
Quezada-Euán, J. J. G., May-Itzá, W. de J., and González-Acereto, J. A. (2001). Meliponiculture in Mexico: Problems and perspective for development. *Bee World*, *82*(4), 160–167. https://doi.org/10.1080/0005772X.2001.11099523.
R Core Team (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.
Radel, C. (2012). Gendered livelihoods and the politics of socio- environmental identity: women's participation in conservation projects in Calakmul, Mexico. *Gender, Place & Culture 19*(1), pp. 61-82, DOI: 10.1080/0966369X.2011.617905.
Ribot, J., and Peluso, N. L. (2003). A Theory of Access. *Rural Sociology 68*(2), pp. 153–181.
Rice, R. (2008). Agricultural intensification within agroforestry: The case of coffee and wood products. *Agriculture, Ecosystems & Environment 128*(4), pp. 212-218.
Ricketts, T. H., Daily, G. C., Ehrlich, P. R., & Michener, C. D. (2004). Economic value of tropical forest to coffee production. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(34), 12579–12582. https://doi.org/10.1073/pnas.0405147101
Robles Berlanga, H. M. (2011). *Los productores de café en México: problemática y ejercicio del presupuesto*. Mexican Rural Development Research Reports 14. Woodrow Wilson International Center for Scholars.
Rodríguez Padrón, B. ,and Burger, K. (2015). Diversification and Labor Market Effects of the Mexican Coffee Crisis. *World Development 68*, pp. 19–29.
Rosset, P.M., Pinheiro Barbosa, L., Val, V., and McCune, N. (2020). Pensamiento Latinoamericano Agroecológico: the emergence of a critical Latin American agroecology, *Agroecology and Sustainable Food Systems*, 45(1), 42-64. DOI: 10.1080/21683565.2020.1789908.

Ruiz Meza, E. (2015). Adaptive capacity of small-scale coffee farmers to climate change impacts in the Soconusco region of Chiapas, Mexico. *Climate and Development 7*(2), pp. 100–109.

[SCA] Specialty Coffee Association. (2019, December). *Price Crisis Response Initiative Summary of Work.* https://sca.coffee/availableresearch.

Schouten, C. N. (2020). Factors influencing beekeepers income, productivity and welfare in developing countries: a scoping review. *Journal of Apicultural Research, 60*(2), 204–219. https://doi.org/10.1080/00218839.2020.1844464

Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies 36*(1), pp. 171-196.

Secretaría de Agricultura y Desarrollo Rural. (2020). La apicultura en México. Retrieved from: https://www.gob.mx/agricultura/articulos/la-apicultura-en-mexico?idiom=es

Sherfey, J (2017). The Cost of Financially Sustainable Coffee Production. *Roast Magazine* (May/June), pp. 71–82.

Soini Coe, E., and Coe, R. (2023). Agroecological transitions in the mind. *Elementa: Science of the Anthropocene*, 11 (1): 00026. https://doi.org/10.1525/elementa.2022.00026

Soto-Pinto, L., Perfecto, I., Castillo-Hernandez, J., and Caballero-Nieto, J. (2000). Shade effect on coffee production at the northern Tzeltal zone of the state of Chiapas, Mexico. Agriculture, *Ecosystems and Environment 80*, pp. 61–69.

Tacconi, F., Waha, K., Ojeda, J. J., & Leith, P. (2022). Drivers and constraints of on-farm diversity. A review. *Agronomy for Sustainable Development, 42*(1). https://doi.org/10.1007/s13593-021-00736-6.

Teixeira, H. M., Berg, L. Van Den, Cardoso, I. M., Vermue, A. J., Bianchi, F. J. J. A., Peña-claros, M., & Tittonell, P. (2018). *Understanding Farm Diversity to Promote Agroecological Transitions*. *Sustainability 10*(12), 4337. https://doi.org/10.3390/su10124337

Tittonell, P. (2019). Las transiciones agroecológicas: Múltiples escalas, niveles y desafíos. *Revista de la facultad de ciencias agrarias 51*(1), 231-246. http://revistas.uncu.edu.ar/ojs3/index.php/RFCA/article/view/2448/1766

Tittonell, P. (2020). Assessing resilience and adaptability in agroecological transitions. *Agricultural Systems*, *184*(August 2019), 102862. https://doi.org/10.1016/j.agsy.2020.102862.

Toffolini, Q., Cardona, A., Casagrande, M., Dedieu, B., Girard, N., and Ollion, E. (2019). Agroecology as farmers' situated ways of acting: a conceptual framework. In *Agroecology and Sustainable Food Systems 43*(5), 514–545. https://doi.org/10.1080/21683565.2018.1514677.

Toledo, V. M., and Moguel, P. (2012). Coffee and Sustainability: The Multiple Values of Traditional Shaded Coffee. *Journal of Sustainable Agriculture 36*(3), pp. 353–77.

Tucker C., Eakin, H., and Castellanos, E. J. (2010). Perceptions of risk and adaptation: Coffee producers, market shocks, and extreme weather in Central America and Mexico. *Global Environmental Change 20*, pp. 23–32.

Utter, A. White, A., Méndez, V. E., and Morris, K. (2021). Co-creation of knowledge in agroecology. *Elementa: Science of the Anthropocene, 9* (1): 00026. doi:https://doi.org/10.1525/elementa.2021.00026.

Yusuf, S., Lategan, F., & Ayinde, I. (2014). Creating youth employment through modern beekeeping: Case study of selected youth trained in Moro Local Government Kwara State, Nigeria. South African Journal of Agricultural Extension, 42(2), 1–9.

van der Ploeg, J. D. (2021). *Peasants and the Art of Farming: A Chayanovian Manifesto.* 2021 edition. Practical Action Publishing.

Vandame, R. (2008). *Determinación de los costos de producción y de las utilidades de los pequeños apicultores en organizaciones de Guatemala y México*. Equipo Abejas, ECOSUR.

Vandame, R., Ayala, R., Guzmán, M., Balboa, C., Esponda, J., and Mérida, J. (2012). *Diversidad de abejas (Hymenoptera: Apoidea) de la Reserva de la Biosfera El Triunfo, Chiapas.* El Colegio de la Frontera Sur. Unidad Tapachula. Informe final SNIB-CONABIO, proyecto No. BK063. México D. F

Vellema, W., Buritica Casanova, A., Gonzalez, C., and D'Haese, M. (2015). The effect of specialty coffee certification on household livelihood strategies and specialization. *Food Policy 57*, pp. 13-25.

Vercelli, M., Novelli, S., Ferrazzi, P., Lentini, G., & Ferracini, C. (2021). A Qualitative Analysis of Beekeepers' Perceptions and Farm Management Adaptations to the Impact of Climate Change on Honey Bees. *Insects 12*, 228. https://doi.org/10.3390/insects12030228

Westphal, S. M. (2008). Coffee Agroforestry in the Aftermath of Modernization: Diversified Production and Livelihood Strategies in Post-Reform Nicaragua. In: Bacon, C. M., Méndez, V. E., Gliessman, S. R., Goodman, D., and Fox, J. (Editors), 2008. *Confronting the Coffee Crisis: Fair Trade, Sustainable Livelihoods and Ecosystems in Mexico and Central America*. MIT Press, Cambridge.

Wezel, Alexander, Herren, B. G., Kerr, R. B., Barrios, E., Goncalves, A. L. R., and Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agronomy for Sustainable Development*, *40*(6), 40.

Wickham, H., François, R., Henry, L., and Müller, K., (2018). dplyr: A Grammar of Data Manipulation. R package version 0.7.8. https://CRAN.R-project.org/package=dplyr.

Wolff, L. F., and Gomes, J. C. C. (2015). Beekeeping and Agroecological Systems for Endogenous Sustainable Development. *Agroecology and Sustainable Food Systems 39*(4), 416–435. https://doi.org/10.1080/21683565.2014.991056.

APPENDIX 1. METHODS AND ANALYSIS

In this appendix, we describe in detail the methods for collecting and analyzing beekeeping-related data with the beekeepers from ART, discussed in Chapters 3 and 4.

Household survey on costs and benefits of beekeeping

In this study, we conducted household surveys with 25 beekeeper families of ART between August 2018 and August 2019. The survey instrument was an adaptation of a methodology that *Equipo Abejas* ('Bee Team') at ECOSUR university had designed and used in focus groups to estimate costs and benefits associated with beekeeping (Vandame, 2008). Through a participatory process, we - members of ART, UVM team, *Equipo Abejas*, and Food 4 Farmers – modified the original instrument to better fit a survey approach and to add sections. For instance, we expanded the list of equipment. We also added sections on nutrition, bee ecology, and social benefits.

After piloting the survey, the members of the local research team visited each of the participating beekeeper families every month for 12 months to collect data. The team members used Kobo Toolbox, a free, open-source software, to document the survey responses on a tablet. To ensure the quality and reliability of the survey, the local team met up once a month or bi-monthly with the UVM/ALC team members to revise and 'clean' the survey responses and discuss any concerns or issues.

The survey consisted of seven sections. Sections with questions on the variable costs of production and family labor were repeated every month, while sections with questions related to the apiary and farmer experience, field and processing equipment (i.e., fixed costs), honey sales, bee ecology, nutrition, and social benefits of beekeeping were conducted once. To calculate the fixed costs, we included all equipment and materials, including the ones that beekeepers had received as donations. While this likely resulted in higher costs of production than what occurred in reality, we wanted to include the cost of the donated materials/equipment to communicate the 'true' cost of production. The costs of production did not include those associated with the warehouse or operational costs of ART, as they are deducted directly from the amount paid to the beekeepers for their honey (e.g. in 2019, the price per kilogram of honey was 26 Mexican pesos, and 2 pesos were charged by ART to help cover operational costs, leaving the farmer with 24 pesos per kg).

Table 1. Items included to calculate the fixed and variable costs

FIXED COSTS
Field equipment
Hive body
Shallow supers
Beekeeping suit (coverall, veil, gloves)
Smoker
Hive tool
Grafting tool
Feeder
Cell cup
Knife
Spur embedder (Pegador de cera)
Pollen traps
Honey strainer

Cappings scratcher
Other
Processing equipment
Honey extractor
Uncapping tank
Honey settling tank (or a bucket)
Honey extraction tent
Vehicles
Car
Motorcycle
(the cost of car/motorcycle was calculated considering
the percentage of their use in beekeeping)
Land rent
Annual rent
VARIABLE COSTS
Inputs
Sugar
Stamped wax
Treatment against varroa mites
Queen bees
Other
Transport
Gas
'Flete' (paying someone to give a ride)
Labor
Days of family labor

Analysis of the survey

As the first step, we systematized all data per beekeeper on an Excel spreadsheet. For the variable costs, we calculated a monthly average (for example, for sugar we summed the different price points and then divided the sum by the number of months in which sugar had been bought). For the fixed costs, we took into consideration the asset depreciation by dividing the value of each equipment by the average lifespan (to get the annual 'cost'). The lifespan was estimated with the help of beekeeping experts from *Equipo Abejas* in ECOSUR. For cars and motorcycles, we asked the beekeepers to estimate how much they use them for beekeeping (%). To calculate 'yield per hive', we used the number of colonies in production.

After the data collection and cleaning, we prepared a summary of the results for each beekeeper and used it to validate the data individually with all participants. After this round of validations, we adjusted the data on the spreadsheet (e.g., if families noted differences between the shared data and their own data, we adjusted the data to reflect this), and used the revised version of the data set for the statistical analysis. We used Excel for descriptive statistics, and R software for statistical tests (R Core Team, 2022).

<u>Note about family labor</u>

We think it is important to consider the time and effort family members put into beekeeping. Through the survey, we know how many occasions beekeepers and their family members visited the apiary. Yet, we learned that there was a lot of variability in terms of the duration that they spent in their apiaries. Commonly, the visits lasted a few hours, not full days, and were combined with visits to coffee or other plots. Therefore, we did not include family labor in the costs of production in our calculations (as opportunity costs). Instead, we decided to divide the annual net revenue by days of family labor (again 'day' does not necessarily imply a full day) to give us an estimate how much each family member would earn per day in beekeeping. This is obviously a narrow way of assessing the value of one's labor. Additionally, it is important to keep in mind that beekeeping generates many benefits beyond money (nutrition, medicine, mental health benefits). These are discussed in section 3.4.4.

Sharing back the results

Once we had finalized our analysis, we organized sessions with members of ART to share back the results and have discussions on their implications. We also gave all participants a sheet with individualized calculations of their costs of production and earnings, along with management recommendations from a beekeeping expert from *Equipo Abejas*.

References

R Core Team (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Vandame, R. (2008). *Determinación de los costos de producción y de las utilidades de los pequeños apicultores en organizaciones de Guatemala y México*. Equipo Abejas, ECOSUR.

APPENDIX II. AGROECOLOGY PRINCIPLES FRAMEWORKS BY CIDSE, HLPE, AND *EQUIPO ABEJAS*

Coopération Internationale pour le Développement et la Solidarité (CIDSE): *The principles of agroecology: Towards just, resilient and sustainable food systems*

ECONOMIC

1. Promotes fair, short, distribution webs, producers and consumers working together

2. Increases resilience through diversification of farm incomes and strengthens community autonomy

3. Aims to enhance the power of local markets and build on a social and solidarity economy vision

POLITICAL

4. Aims to put control of seeds, land and territories in the hands of people

5. Encourages new forms of decentralized, collective, participatory governance of food systems

6. Requires supportive public policies and investments

7. Encourages stronger participation of food producers/consumers in decision making

ENVIRONMENTAL

8. Supports resilience and adaptation to climate change

9. Nourishes biodiversity and soils

10. Eliminates use of and dependence on agrochemicals

11. Enhances integration of various elements of agro-ecosystems (plants, animals, ...)

Figure 1. 15 agroecology principles by CIDSE (CIDSE, 2018)

SOCIO-CULTURAL

12. Promotes farmer to farmer exchanges for sharing knowledge together

13. Strengthens food producers, local communities, culture, knowledge, and spirituality.

14. Promotes healthy diets and livelihoods

15. Encourages diversity and solidarity among peoples, encourages women and youth empowerment

---

FAO - High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE): *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*

IMPROVE RESOURCE EFFICIENCY

1. **Recycling**: Preferentially use local renewable resources and close as far as possible resource cycles of nutrients and biomass.
2. **Input reduction**: Reduce or eliminate dependency on purchased inputs and increase self-sufficiency.

STRENGTHEN RESILIENCE

3. **Soil health**: Secure and enhance soil health and functioning for improved plant growth, particularly by managing organic matter and enhancing soil biological activity.
4. **Animal health**: Ensure animal health and welfare.
5. **Biodiversity**: Maintain and enhance diversity of species, functional diversity and genetic resources and thereby maintain overall agroecosystem biodiversity in time and space at field, farm and landscape scales.
6. **Synergy**: Enhance positive ecological interaction, synergy, integration and complementarity among the elements of agroecosystems (animals, crops, trees, soil and water).
7. **Economic diversification**: Diversify on-farm incomes by ensuring that small-scale farmers have greater financial independence and value addition opportunities while enabling them to respond to demand from consumers.

SECURE SOCIAL EQUITY/ RESPONSIBILITY

8. **Co-creation of knowledge**: Enhance co-creation and horizontal sharing of knowledge including local and scientific innovation, especially through farmer-to-farmer exchange.

9. **Social values and diets**: Build food systems based on the culture, identity, tradition, social and gender equity of local communities that provide healthy, diversified, seasonally and culturally appropriate diets.
10. **Fairness**: Support dignified and robust livelihoods for all actors engaged in food systems, especially small-scale food producers, based on fair trade, fair employment and fair treatment of intellectual property rights.

Figure 2. 13 agroecology principles by HLPE three operational principles of sustainable food systems (Biovision, n/a)

11. **Connectivity**: Ensure proximity and confidence between producers and consumers through promotion of fair and short distribution networks and by re-embedding food systems into local economies.
12. **Land and natural resource governance**: Land and natural resource governance: Strengthen institutional arrangements to improve, including the recognition and support of family farmers, smallholders and peasant food producers as sustainable managers of natural and genetic resources.
13. **Participation**: Encourage social organization and greater participation in decision-making by food producers and consumers to support decentralized governance and local adaptive management of agricultural and food systems.

Equipo Abejas at El Colegio de la Frontera Sur (ECOSUR): *Agroecological Principles for Beekeeping – May 2020.*

1. **Secures the wellbeing of bees**
   - Agroecological beekeeping promotes healthy, dignified and sustainable life of bees, with love and respect, through practices that consider their natural processes and support their life in the hives.

- It values the importance of bees for beekeeping, for nature and for territories, through pollination of both edible and wild plants.
- It contributes to maintaining habitat for all bee species.

2. Promotes autonomy in production

- Beekeeping is practised with as little dependence as possible on external inputs (wax, queen bees, hives, feed).
- Local bees are selected that have their own defense mechanisms against parasites and diseases, so as not to require the use of medicine against these.

3. Seeks diversification and integration in the production

- The apiary is part of a unique production system in which milpa, coffee plantations, pasture, and home gardens strengthen each other.
- The farm is perceived as an organism, where productive activities benefit from and contribute to each other, generating resistance and resilience in the face of crises, whatever their nature.
- Beekeepers are familiar with ecological benefits of the bees

4. **Generates healthy beehive products for everyone**

- Beekeepers, families and consumers know about and benefit from the nutritional and medicinal qualities of beehive products (honey, pollen, jelly, propolis).
- Clean practices during harvesting, transfer, processing, and marketing contribute to having a quality honey for consumption by families and consumers.
- Chemicals and antibiotics are not used, since hive health is based on prevention.

5. **Strengthens the wellbeing of peasant families and their communities**

- Beekeeping contributes to establishing dignified conditions within farming families by allowing respect and freedom for all, women and men, youth and the elderly.
- Beekeepers know how to determine their production costs, which allows them to sell their products at prices proportionate to the work invested, and to seek a balance between specialization and diversification.
- Thanks to the associativity, beekeeping establishes a symmetrical relationship with the market, generating a fair income for the families, and in addition to its economic contributions, it contributes to the health and nutrition of the families.

- The products generated from beekeeping are consumed by the beekeeper, his family and community, contributing to health and quality food. This is a priority over commercialization.

6. **Cares for the environment**

- Beekeeping uses good management practices that do not cause damage or pollute the environment, but rather benefits it.
- Beekeeping promotes an interest in conservation, restoration, and care for the environment, and encourages the restoration of native species that are beneficial to bees and people, thereby increasing the quality of the landscape.
- The role of the beekeeper as an environmentalist, carrying out this productive activity in harmony with nature, is valued.
- The presence of other pollinators and native plants in the landscape is valued as a heritage for future generations.

7. **Promotes organizational wellbeing**

- Beekeepers are part of collectives or organizations, where active participation of all members is encouraged, including young people and women, and where benefits are distributed in a fair, equitable and transparent way, and decisions are taken by all.
- Bonds of trust, solidarity and mutual help are generated.

- Practices that do not harm or go against the local culture or the way of life of the communities are supported; collective knowledge and the sharing of knowledge and experiences with other beekeeping and farming families are promoted.
- A political positioning on a local level is discussed, contributing to strengthening the collective identity, the autonomy of the communities, and the defense of the territories.

8. Respects and cultivates spirituality

- The spirituality developed as part of the cosmovision of the native peoples - marked by the relationship of human beings with living and non-living beings, as well as by the recognition of nature as the center of the universe that we are a part of - is the shared reference point, leading to respect for what exists.
- Relations with Mother Earth form part of the historical and present identity of the native peoples, recognizing an essential relationship that nourishes the being.
- Spirituality is cultivated with tolerance, respecting freedom and diversity of thought.
- To respect and cultivate spaces to touch emotions, feelings and expressions that allow connection with the environment, recognizing people as sentients and not only thinking beings.

Table 1. Applications/expressions of selected *Agroecological Principles for Beekeeping*

PRINCIPLE	EXPRESSIONS/MANIFESTATIONS OF THE PRINCIPLE	
	From the framework	**Expressions/manifestations emerging from the case study**
#3 - Seeks diversification and integration in the production	The apiary is part of a unique production system in which milpa, coffee plantations, pasture, and home gardens strengthen each other. The farm is perceived as an organism, where productive activities benefit from and contribute to each other, generating resistance and resilience in the face of crises, whatever their nature.	3.1 Beekeeping complements and does not compete with other productive activities such as coffee (does not take time away from coffee). 3.2 The time devoted to beekeeping is manageable for all family members who are interested in beekeeping. 3.3 Beekeepers manage an "optimal" and sustainable number of hives that is proportional to the physical, human, natural and economic resources available. 3.4 Beekeepers are aware of the effects of climate change and develop activities according to shifting climatic conditions
#4 - Generates healthy beehive products for everyone	Beekeepers, families and consumers know about and benefit from the nutritional and medicinal qualities of beehive products (honey, pollen, jelly, propolis). Clean practices during harvesting, transfer, processing, and marketing contribute to having a quality honey for consumption by families and consumers. Chemicals and antibiotics are not used, since hive health is based on prevention.	4.1 The honey that beekeeping families save for consumption meets their needs for the whole year. 4.2 Beehive products (honey, propolis, pollen, etc) are available and accessible to the community members.
#5 - Strengthens the wellbeing of peasant families and their communities	Beekeeping contributes to establishing dignified conditions within farming families by allowing respect and freedom for all, women as well as men, young as well as old. Beekeepers know how to determine their production costs, which allows	5.1 Beekeeping helps to strengthen the physical, mental, and emotional health of beekeepers and their families. 5.2 Beekeeping allows producers to develop new knowledge, skills, abilities, and values.

	them to sell their products at prices proportionate to the work invested, and to seek a balance between specialization and diversification. Thanks to the associativity, beekeeping establishes a symmetrical relationship with the market, generating a fair income for the families, and in addition to its economic contributions, it contributes to the health and nutrition of the families. The products generated from beekeeping are consumed by the beekeeper, his family and community, contributing to health and quality food. This is a priority over commercialization.	5.3 Beekeeping activity contributes to collective decision making, as beekeepers assume the role of educators and advocates in their communities. 5.4 The apiary is a space for reflection among family members on various topics, such as environmental care, generational change, forms of organization, and gender. 5.5 Beekeeping strengthens the local economy and contributes to the solidarity economy in the rural communities. 5.6 Beekeeping generates employment in the communities. 5.7 Beehive products help to supplement the economic income of coffee farming families.
#7 - Promotes organizational wellbeing	Beekeepers are part of collectives or organizations, where active participation of all members is encouraged, including young people and women, and where benefits are distributed in a fair, equitable and transparent way, and decisions are taken by all. Bonds of trust, solidarity and mutual help are generated. Practices that do not harm or go against the local culture or the way of life of the communities are supported; collective knowledge and the sharing of knowledge and experiences with other beekeeping and farming families are promoted. A political positioning on a local level is discussed, contributing to strengthening the collective identity, the autonomy of the communities, and the defense of the territories.	7.1 Beekeeping organizations explicitly recognize/include non-material values of beekeeping in strategic planning and/or other spaces of reflection. 7.2 Beekeeping contributes to generational change in the organizations.

References

Biovision. (n/a). *Farm-level Agroecology Criteria Tool*. Agroecology Info Pool. https://www.agroecology-pool.org/fact/

Coopération Internationale pour le Développement et la Solidarité. (2018). *The principles of agroecology: Towards just, resilient and sustainable food systems*. CIDSE, Belgium. https://www.cidse.org/2018/04/03/the-principles-of-agroecology/.

Equipo Abejas. (2020). *Principios Agroecológicos de la Apicultura – Mayo 2020*. El Colegio de la Frontera Sur (ECOSUR).

High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. HLPE Report 14. HLPE, Rome. https://www.fao.org/agroecology/database/detail/en/c/1242141/.